MESQUITE DRAINAGE MASTER PLAN

FINAL SUBMITTAL

DOÑA ANA COUNTY FLOOD COMMISSION

GRANT NO. 2989 - CIF

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August 2017
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Smith Project No.: 817102

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The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal as a professional engineer licensed to practice in the state of New Mexico, is affixed below.

EDWARD CHRISTIAN NAIDU
NEW MEXICO
22997
PROFESSIONAL ENGINEER

E. Christian Naidu, PE

Solutions for Today…

Vision for Tomorrow

August 25, 2017

John Gwynne, PE
Michael Garza, EI
Doña Ana County Flood Commission
County Government Center
845 N. Motel Blvd Room 1-250
Las Cruces, New Mexico 88007

Re: Mesquite Drainage Master Plan

Smith #: 817102

Dear Mr. Gwynne and Mr. Garza:

I am pleased to submit the final report prepared for the Mesquite Drainage Master Plan for the Doña Ana County Flood Commission (DACFC). This report concludes findings based on analyses of the existing watershed conditions. It identifies areas of elevated risk and includes options for proposed improvements. The selected options have been refined and cost estimates for the recommended facilities are included. All comments from the 90% review have been incorporated into this final report.

Please feel free to contact us at any time with questions.

Sincerely,
Smith Engineering Company

E. Christian Naidu, PE
Project Manager

Enclosure: Mesquite Drainage Master Plan final Submittal

cc: Francisco Urueta, PE, Smith Engineering, Carl Lukesh, DACFC

ACKNOWLEDGMENTS

DACFC for providing necessary digital files to perform the drainage study and local insight into the watershed.

Elephant Butte Irrigation District (EBID) for information and discharge requirements into EBID facilities.

EXECUTIVE SUMMARY

DESCRIPTION AND PURPOSE OF PROJECT

This Drainage Master Plan was prepared by Smith Engineering Company (**Smith**) for the Doña Ana County Flood Commission (DACFC) to study the Mesquite watershed. The Mesquite watershed is approximately 10 miles south of Las Cruces. An existing conditions hydrologic model was developed. Based on the results of the existing conditions model, areas of potential flooding were identified and proposed drainage improvement options were developed to mitigate flooding. The plan also contains conceptual level engineer's opinions of probable costs (EOPC). The hydrologic conditions were evaluated using the HEC-HMS hydrologic modeling software. Simulations were run for four storms as follows: 5 year, 10 year, 50 year and 100 year return periods of 24 hour duration. The DACFC's design criteria for flood mitigation is the 10 year - 24 hour storm and for the purposes of this submittal, the emphasis and results are focused primarily on the design storm. HEC-RAS 2D modeling was also performed for parts of the watershed to determine flow concentration points.

SUMMARY OF EXISTING BASIN AND EXISTING DRAINAGE INFRASTRUCTURE

The Mesquite watershed has a total drainage area of 3.68 square miles. The basin is divided into two distinct sections by Interstate-10 (I-10). The subbasins located east of I-10 are undeveloped range lands with fair to steep topography. The subbasins located west of I-10 consist of residential areas, some commercial areas, and large agricultural fields. The subbasins west of I-10 are predominantly flat and in most cases, parcels are lower in elevation than adjacent roads and irrigation canals and drains. There are four culverts under I-10 that convey flows from the east side of I-10 to west side of the watershed. These structures were evaluated for their maximum discharge capacity and the structures are shown on **Figure 1.1**.

SUMMARY OF EXISTING PROBLEM AREAS AND PROPOSED OPTIONS

The existing conditions analysis indicate that most flooding issues within the Mesquite watershed may be localized and often occur on private property. Most subbasins delineated do not drain out due to parcels being lower then adjacent roads and irrigation features. However, several facilities such as road side ponding, retention and detention ponds were proposed.

CONCLUSIONS AND RECOMMENDATIONS

Based on input from the DACFC after 60% review meeting and Mesquite area residents, the most feasible proposed facilities were evaluated and summarized including the estimated construction costs.

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LIST OF FIGURES

LIST OF TABLES

A DVD including digital files is provided with this Drainage Master Plan.

SECTION 1. GENERAL PROJECT INFORMATION

1.1 DESCRIPTION AND PURPOSE OF PROJECT

This Drainage Master Plan was prepared by Smith Engineering Company (**Smith**) for the Doña Ana County Flood Commission (DACFC) to study the Mesquite watershed. The Mesquite watershed is approximately 10 miles south of Las Cruces. The purpose of this plan is to develop a drainage analysis that will support the development of drainage improvement options, recommendations, and conceptual level engineer's opinions of probable costs (EOPC) for the community of Mesquite. The hydrologic conditions were evaluated using the HEC-HMS hydrologic modeling software. Simulations were run for four storms as follows: 5 year, 10 year, 50 year and 100 year return periods of 24 hour duration. The DACFC's design criteria for flood mitigation is the 10 year - 24 hour storm and for the purposes of this submittal the emphasis and results are focused primarily on the design storm. **Figure 1** shows the project vicinity map.

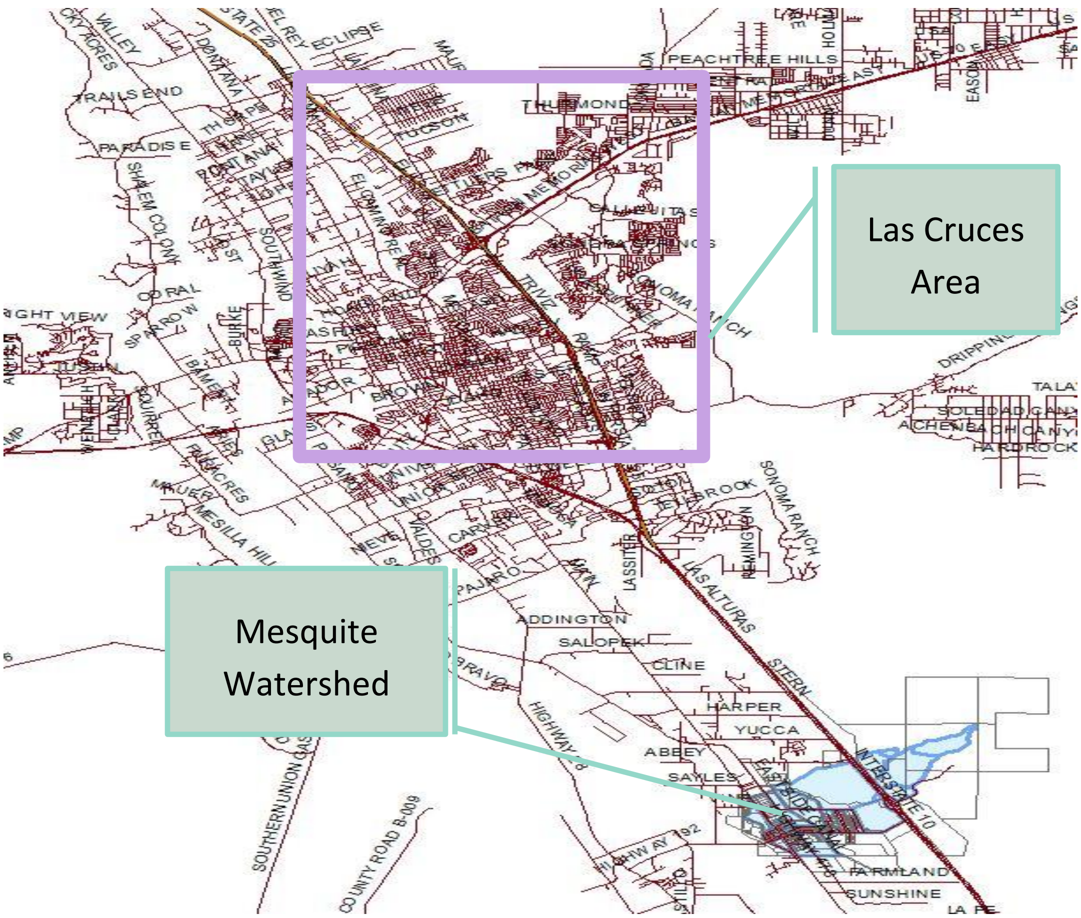


Figure 1: Project Vicinity Map

1.2 FIELD OBSERVATION

Smith conducted three field observations in March 2017. **Appendix A** contains annotated photographs of the various locations in the Mesquite watershed and I-10 culvert crossings. The Mesquite area contains two dams which are shown on **Figure 2,** included in Map Pocket. These dams are outside the study area. However, photographs of the unnamed dam located south of the Apache Mesquite Brazito Site 2 (Pena Blanca) Dam and its principal spillway are included in **Appendix A**.

SECTION 2. EXISTING HYDROLOGIC AND HYDRAULIC ANALYSES

2.1 PREVIOUS STUDIES

No previous drainage studies were available for review for the Mesquite watershed.

2.2 EXISTING FLOOD CONTROL STRUCTURES

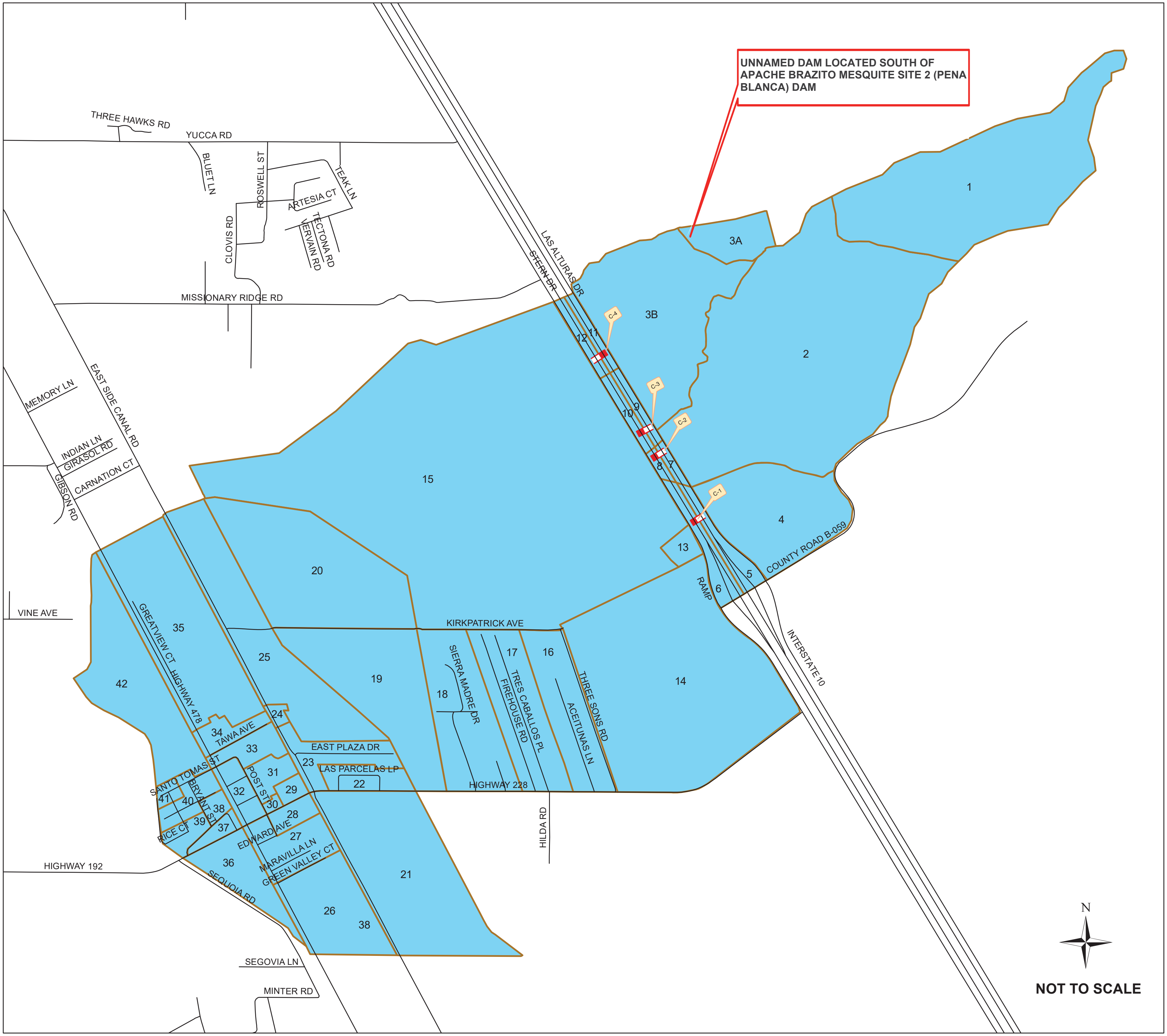
The Mesquite area contains two dams (see **Figure 2** in Map Pocket) which are outside the study area. However, an unnamed dam is located south of the Apache Mesquite Brazito Site 2 (Pena Blanca) Dam. This dam has a dead storage area below the principal spillway pipe. The principal spillway structure is made of a 2-ft. diameter perforated CMP stand pipe. The only subbasin contributing to this dam is 3A. Since subbasin 3A's 100 year – 24 hour direct runoff volume is 2.2 ac-ft. and the dead storage area in the unnamed dam is 2.6 ac-ft, subbasin 3A was modeled as a closed subbasin. The volume comparisons are documented in **Table C5-1** in **Appendix C**. A small dam downstream of culvert C1 was also observed in the field. This dam has no principal spillway so once it's storage volume is exceeded, the emergency spillway will discharge excess flows into the fields of subbasin 15.

There are four culvert crossings under I-10. These were observed in the field and their critical dimensions were recorded. Maximum headwater depth was also estimated. Maximum discharge capacity for each of the observed structures was computed. The hydraulic calculations are presented in **Table E1** in **Appendix E**. The culvert structures are shown on **Figure 1.1** and on **Figure 2** (Map Pocket).

2.3 DRAINAGE BASIN DESCRIPTION AND BASIN DELINEATION

A. Drainage Basin Description

The Mesquite watershed has a total drainage area of 3.68 square miles. The basin is divided into two distinct sections by I-10. The basin east of I-10 is undeveloped semi-arid rangeland with fair to extremely steep and rocky areas, particularly on the uppermost parts of the basin. The west side of the basin consists primarily of a mixture of agricultural fields and low density residential areas. Heavy industrial commercial areas are minimal. Several Elephant Butte Irrigation District facilities are interspersed throughout the western part of the watershed. West of I-10, the Mesquite watershed demonstrates true valley characteristics which makes it unique. Parcels are predominantly lower in elevation than adjacent roads, railroad tracks and irrigation drains. As a result, none of the residential subbasins or agricultural fields drain from one subbasin to another. Careful field investigation was made to validate this observation. **Figure 1.1** presents the drainage basin map. A detailed drainage basin map (**Figure 2**) is included in the map pocket.



Legend

- Existing Culvert
- Mesquite Subbasins
- 10 SUBBASIN ID

MESQUITE DRAINAGE MASTER PLAN FINAL SUBMITTAL

FIGURE 1.1

DRAINAGE BASIN MAP

SMITH ENGINEERING

DOÑA ANA COUNTY NEW MEXICO

AUGUST, 2017

B. FEMA Floodplains

FEMA floodplains (FEMA Map No. 35013C1325G, dated July 6, 2016) were downloaded from the FEMA website. The panel is included in **Appendix B**.

C. Drainage Basin Delineation

The total study area for this project is 3.68 square miles. The Mesquite Watershed contains 43 subbasins and generally drains from east to west. The subbasins located east of I-10 are undeveloped range lands with fair to steep topography. Subbasins were delineated using topographic data provided by the DACFC. The subbasins located west of I-10 consist of residential areas, some commercial areas, and large agricultural fields. The subbasins west of I-10 are predominantly flat parcels and lower in elevation than adjacent roads and irrigation canals and drains. The topographic data (LIDAR 2010) provided by DACFC is at a 2-ft resolution and does not provide sufficient relief to delineate basins. Visual observations during field visits were used to supplement LIDAR data for delineation of all subbasins located west of I-10. The irrigation drains, roads, and railroad acts as hard boundaries.

Figure 1.1 shows the overview of the subbasins for Mesquite. **Figure 2** (included in Map Pocket) presents the subbasins in more detail and better scale.

2.4 DRAINAGE ANALYSIS CRITERIA

A. Storms Evaluated

The DACFC requested that 5 year, 10 year, 50 year and 100 year - 24-hour duration storms be simulated.

B. Design Storm

The DACFC requested that the design storm shall be 10 year 24-hour storm. The proposed options will not include design for the 50 year and 100 year - 24 hour storms, although the results will be included. However, reservoir routing results for all ponds include the 50 and 100 year storms.

C. Hydrologic Computer Program

The U.S. Army Corps of Engineers "HEC-HMS - Hydrologic Modeling System" program or commonly called "HEC-HMS" (Version 4.2.1) was selected for hydrologic modeling.

2.5 RAINFALL DATA

A. Rainfall Distribution

The study basin is located within the USDA Natural Resources Conservation Service (NRCS) (previously the Soil Conservation Service (SCS)) Type II rainfall distribution area as defined by the NRCS. Please refer to **Appendix C** for Figure B-2 that illustrates the Type II boundaries. However, the DACFC dictated that the 25% Frequency Storm Distribution be adopted. That distribution is available in the HEC-HMS program and it places peak intensity of the rainfall in at 25% of the storm duration, or at 6 hours for a 24-hour storm.

B. Areal Reduction Factors

Since the watershed area is only 3.68 square miles, no areal reduction was required.

C. Point Rainfall Data

Point rainfall data for was obtained from NOAA Atlas 14 website. **Table C1** documents the appropriate point precipitation depths required as input for the HEC-HMS model. **Appendix C** contains the printouts from the NOAA Atlas 14 point rainfall data results.

2.6 SOILS DATA AND RUNOFF CURVE NUMBERS (CNs)

Resources Conservation Service (NRCS) internet site Web Soil Surveys as follows:

http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Appendix C contains the Web Soil Survey information. The Figures in **Appendix C** illustrate the soil map unit locations and tables that summarize the hydrologic soil groups and cover types for the various soil map units.

Table C2 (**Appendix C**) contains a summary of the CNs for each sub-basin and the areal weighted CN data and results for all sub-basins. The data and assumptions applied to develop **Table C2** are based on the following:

A. Antecedent Runoff Condition II (ARC II) is defined as the soil average runoff condition (moisture condition) by the NRCS. Antecedent Runoff Condition III (ARC III) is defined as the wetter soil condition. For all sub-basins denoted as “Arid and Semiarid Rangelands” with “Desert Shrub Cover Type” a composite (average) CN value between ARC II CN and ARC III CN was adopted.

B. Hydrologic Soil Group (A, B, C, or D) – Determined by the NRCS per soil map unit (**Appendix C** contains the Web Soil Survey Data).

C. Land Use Type is either – arid rangeland (most sub-basins), urban (within the community of Mesquite) or cultivated agricultural land. The orthophotography as presented on the Drainage Basin Maps (map pocket) was used to make the land use type determinations. The CN tables are obtained from “Urban Hydrology for Small Watersheds, US Dept. of Agricultural Soil Conservation Service, Technical Release 55 (TR-55), June 1986. *

D. The TR-55 CN tables are listed here:
   Table 2-2a Runoff Curve Numbers for Urban Areas. *
   Table 2-2b Runoff Curve Numbers for Cultivated Agricultural Land. *
   Table 2-2c Runoff Curve Numbers for Other Agricultural Lands. *
   Table 2-2d Runoff Curve Numbers for Arid and Semiarid Rangelands. *

   *Copies are included in **Appendix C**

E. Cover Type, Hydrologic Condition and Percent Imperviousness

   Arid Rangeland - assumed Cover Type and Hydrologic Condition – Desert Shrub, etc., poor hydrologic condition (Table 2-2d applies)

   Urban - assumed Cover Type and Average Impervious Area – 1/8 acre., 65% impervious (Table 2-2a applies)

   Cultivated Agricultural Land - assumed Cover Type and Hydrologic Condition – Row Crops – Straight Row. 65%, poor hydrologic condition (Table 2-2b applies)

F. CN selections were based on the previous data, assumptions and NRCS soils data / and Tables.

G. Areal weighted CNs were computed by areal weighting the CN per soil map unit by the acreage of that map unit relative to the total sub-basin acreage.

2.7 TRAVEL TIME (T_t), TIME OF CONCENTRATION (T_C), AND UNIT HYDROGRAPH LAG TIME (T_L) COMPUTATIONS AND UNIT HYDROGRAPH

A water course may have up to three sub-reaches that comprise the longest flow path. The upper overland flow reach, then a shallow concentrated flow reach followed by a channel reach. The NRCS TR-55 (Tt) and (Tc) method was applied to each water course. The time of concentration (Tc) for the watercourse equals the summation of travel times (Tt) from each sub-reach. **Appendix C** contains the TR-55 description and procedures.

The NRCS Unit Hydrograph Lag Time Method (TL) was applied to the Tc to compute the unit hydrograph Time to Peak (Tp). Note that Lag Time = 0.6 Tc. **Appendix C** contains the reference pages from Part 630 Hydrology, National Engineering Handbook, May 2015, Chapter 15 that describes the lag time concept and method.

When subbasins become flat and without defined flow paths or lack of concentration points, the Tc parameter is no longer important as the system becomes a volume bound system which makes peak discharges not as critical. This was true for predominantly all subbasins west of I-10. As such, a typical longest flow path was computed and applied to all the subbasins.

Manning's Roughness Coefficients "n" assumptions were obtained from TR-55, by experience and by review of "n" value tables by Chow, 1959 (copies include in **Appendix C**).

Channel slopes were computed from elevations and length measurements from the drainage basin maps using the DACFC supplied imagery and LIDAR data (map pocket). Typical channel widths were also measured from the drainage basin maps and / or with Google Earth.

Tables C3 (**Appendix 3**) summarizes the travel time, time of concentration and lag time data and results and **Figure 2** shows the longest flow paths delineated for all the subbasins.

2.8 CHANNEL ROUTING

The "Muskingum-Cunge" channel routing method was applied to route hydrographs. Manning's "n" values were assumed based on experience and the Manning's "n" values from Chow, 1959 and locations of routing reaches as observed on the drainage basin maps. Bottom width assumptions were determined as the typical channel width from the Digital Elevation Model (DEM). **Table C4 (Appendix 3)** presents the Muskingum-Cunge channel routing input data summary. Channel routing parameters were computed using topographic information provided by DACFC. Runoff losses to channel bed infiltration and percolation were assumed to be small and were not simulated.

2.9 SEDIMENT BULKING

The HEC-HMS models simulate clear water hydrographs unless a "Flow Ratio" is applied to simulate sediment volume within hydrographs that is also called sediment bulking. Note that a sediment bulking value of about 17% is considered the limit before mud flow would occur. Due to lack of site specific data, a sediment bulking factor of 10% or a factor of 1.10 was assumed for all undeveloped sub-basin hydrographs and a value of 1.05 was assumed for urbanized subbasin hydrographs. That assumption is based on review of information presented in Sediment and Erosion Design Guide, Nov. 2008, Mussetter Engineering Inc. **Appendix C** contains a copy of relevant pages from that document.

2.10 HYDROLOGIC DATA SUMMARY

Tables C2, C5-1, C5-2, C6-1, and C-6-2 in **Appendix C** provide all the input data required for the HEC-HMS model.

2.11 COMPUTATION TIME INCREMENT FOR HEC-HMS MODELS

While various procedures are available for assigning the computational time increment, the DACFC prefers to use a time step of one minute. All simulations were run at a one minute time increment.

2.12 INFLOW-DIVERSION FUNCTIONS & UPSTREAM DETENTION AT CULVERT STRUCTURES

A. Inflow-Diversion Functions

No inflow-diversion functions were required for this study.

B. Upstream Detention at Culvert Structures

Typically, culvert structures that cross under major highways are built up against elevated embankments. This allows water to pond against the inlet structure. In some instances, the culverts are under capacity and cannot convey the peak discharges and as such, the embankments act as detention ponds where the water pools and spreads laterally**. Consequently, the discharge rates to the downstream analysis points at these locations are purely a function of maximum culvert capacity**. In past versions, the program required an outflow curve that would include stage-storage-discharge data to perform reservoir routings. The discharge rating curve for the outlet structure had to be computed externally to HMS and then input as a paired data set. With the latest version of HEC-HMS V4.2.1, there are new features developed for reservoirs. The program now allows users to designate an outlet structure, for example a culvert outlet, as an outflow method. With the correct culvert parameters, HEC-HMS can compute an internal discharge rating curve based on inlet or outlet control flow regimes. However as in the past versions, the stage storage data must be computed externally. As such, upstream ponding was simulated using reservoirs culverts: C2 and C4. Stage data was assigned based on measured maximum available headwater depth, storage was artificially manipulated so that the outlet discharge matched the computed discharge capacity of the culverts.

Upstream ponding due to under capacity culverts provides a significant benefit especially in the higher return period storms when the high peak discharges could significantly affect downstream areas. The locations of the culverts are presented on **Figure 2 (Map Pocket)** and **Figure 1.1.**

2.13 RESERVOIR ROUTING DATA

The reservoir routings were applied to a small pond downstream of culvert C1. Elevation-Storage-Discharge rating curves were developed from topographic data. This pond has no principal spillway and it acts as a retention pond up to the 10 year storm. Excess discharges are passed through the emergency spillway.

2.14 HEC-HMS HYDROLOGIC MODELS AND SUMMARY RESULTS

Unit peak discharges computed and evaluated to ensure that the numbers fell in the acceptable range for a watershed exhibiting the characteristics of semi-arid rangeland mixed with low density urban development. Unit peak discharges were in the range of 1.1 – 3.5 cfs/acre which falls well within the acceptable range. **Table D-1** through **Table D-8** included in **Appendix D** present HEC-HMS summary results for existing and proposed conditions for each representative storm event.

2.15 EXISTING DRAINAGE INFRASTRUCTURE HYDRAULIC CAPACITIES

A. Existing Culvert Capacities

All existing culverts that convey flows under I-10 were evaluated for maximum discharge capacity. A 20% clogging factor was applied to account for debris. See **Appendix E** for CulverMaster calculation reports.

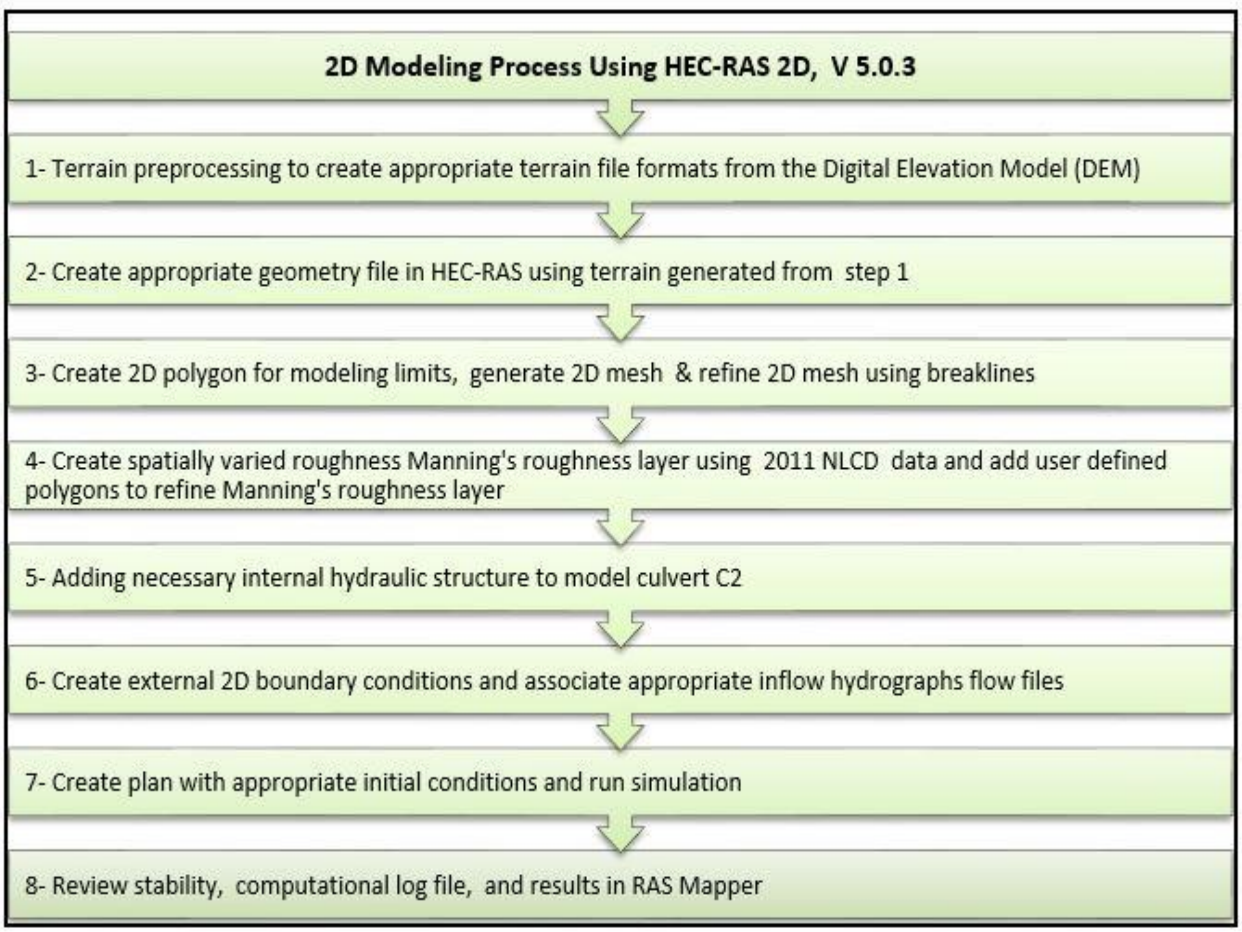
The peak inflow at these culverts was compared against their peak discharge capacity to determine the flow could be passed to the west side in the various storms. For some culverts, upstream ponding was simulated as discussed in Section 2.12. Culverts C2 and C4 are under capacity to convey all flows from the east side of I-10.

B. Existing Dams

The unnamed dam south of the Apache Mesquite Brazito Site 2 (Pena Blanca) Dam fully retains the 100 year peak discharge in the retention area of the pond. The small pond downstream of culvert C1 controls up to the 10 year storm but discharges through the emergency spillway for all higher return period storms.

SECTION 3. 2-DIMENIONAL SURFACE WATER MODELING

Due to the flat nature of the Mesquite watershed, very little channelization and flow concentration points are observed throughout the watershed. As a result, a HEC-RAS 2-dimensional surface water model (2D) was constructed to simulated surface flow directions and concentration points throughout select subbasins on the west side of I-10. The following flow chart illustrates the critical processes implemented to build a 2D model.



A. 2D Mesh Generation

2D areas were created for individual subbasins to determine where surface flows would concentrate. Terrain preprocessing as outlined in Chapter 2 of the HEC-RAS user manual was performed after which the data was incorporated as part of the geometry file in HEC-RAS. Using the bounding polygon, a 2D mesh was generated that consists of grids that are defined by the user at a certain size. The grid size is a function of the level of detail of the analysis. Since the topography is extremely flat, a 50 ft. X 50 ft. grid size was chosen. The terrain model was further refined using break lines to simulate the high points in the terrain that would act as a barrier to flow. The 2D mesh is then saved as geometry file to be used within HEC-RAS. **Figure 1.2** shows a typical 2D mesh created for subbasin 34.

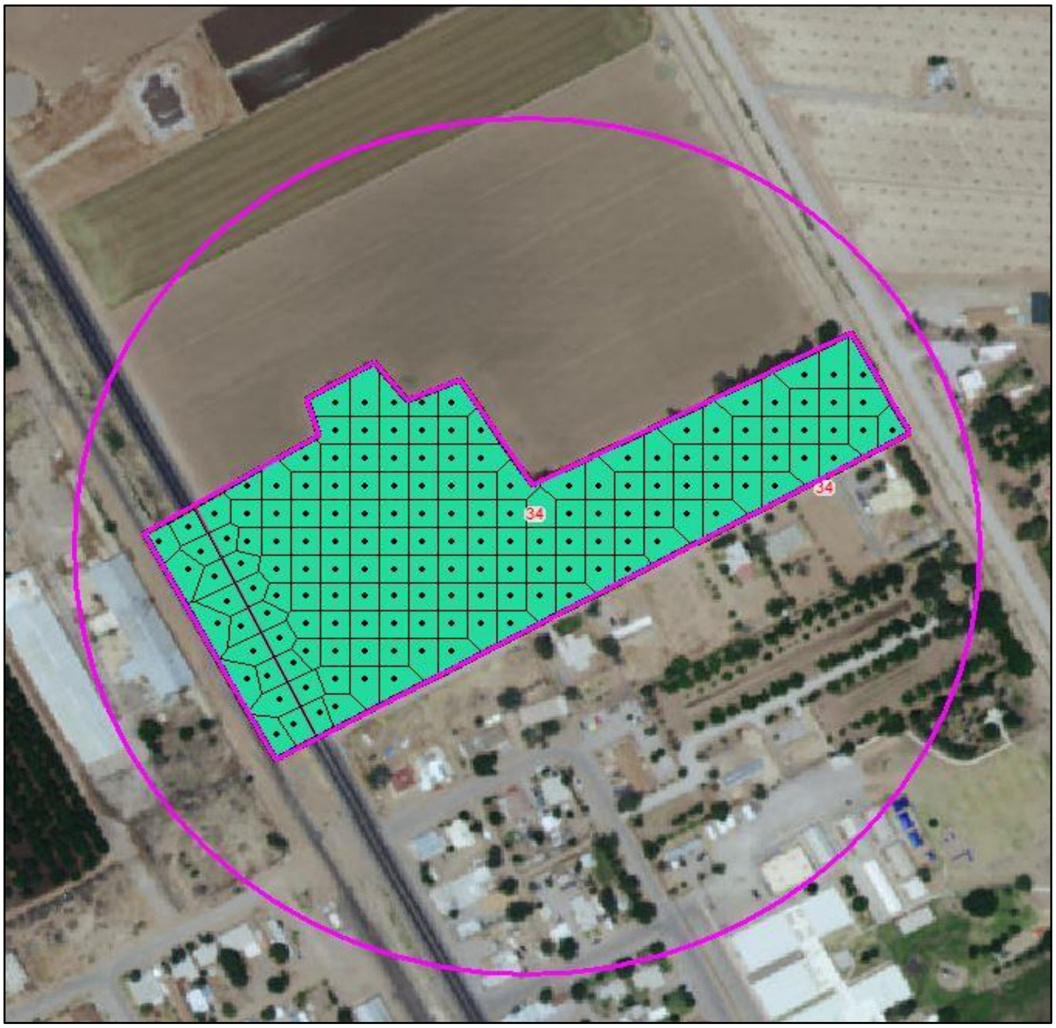


Figure 1.2: Typical 2D Mesh

B. Spatially Varied Manning's Roughness Layer

The 2011 National Land Cover Dataset (NLCD_2011) for the Mesquite area was downloaded from the Natural Resources Conservation Service geospatial data gateway website. This raster data set provides a spatially varying the ‘n’ value based on land use and classification created from a unique Value and Name assigned within the raster data set. The program is than able to apply the data to the 2D mesh as it performs the 2D flow computations. The table below summarizes the NLCD_2011 data. The data distribution available for Mesquite reflected landcover accurately enough to where no further refinement was performed. The table below shows the default NLCD_2011 that were utilized in the model.

Table 1: NLCD 2011 Land Cover Default Manning’s n Values

Color	Value	Name	Default Manning's n
	0	nodata	
	1	128	0.055
	2	barren land rock/sand/clay	0.055
	3	cultivated crops	0.055
	4	developed, high intensity	0.035
	5	developed, low intensity	0.06
	6	developed, medium intensity	0.04
	7	developed, open space	0.06
	8	pasture/hay	0.06
	9	shrub/scrub	0.06
	10	woody wetlands	0.06

C. Internal Hydraulic Structures

No internal hydraulic structures were modeled for the Mesquite area.

D. External 2D Flow Area Boundary Conditions

The 2D flow area must have upstream and downstream boundary conditions specified. For areas where flow leaves the model, normal depth was specified. Since the downstream areas are typically flat agricultural fields, a typical energy slope of 0.1% was specified. The upstream boundary conditions basically simulate locations where flows are added into the mesh. The upstream boundary conditions can be represented in several separate ways. Flows may be represented as a hydrograph, for instance to represent discharge from a culvert. This method was used to simulate discharges from culverts C1-C4.

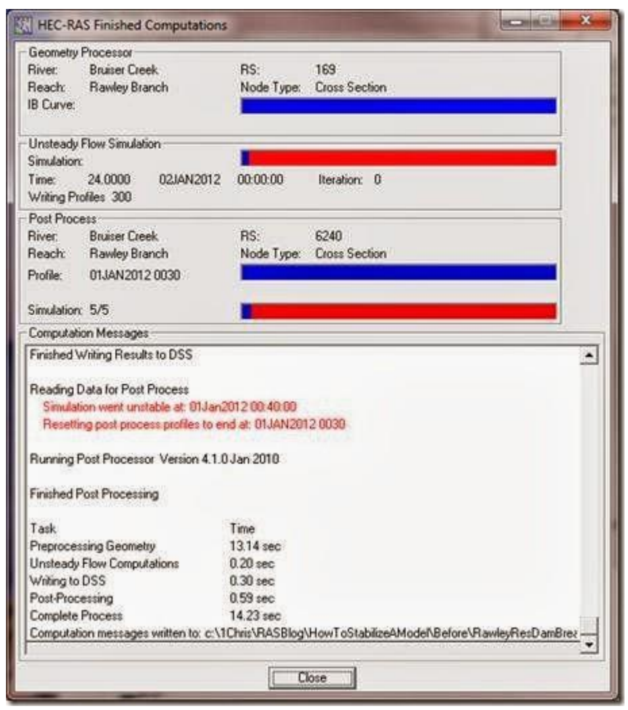
Flows can also be added as excess direct runoff in inches. This method takes the direct excess runoff and distributes it over the entire 2D mesh uniformly which would represent the temporal distribution of rainfall. Due to the flat nature of the study area, this method is appropriate and would reasonably represent surface flow distribution as it would occur in a real storm. Since the runoff hydrographs represent excess runoff, Smith employed the following method to convert the flow hydrograph to direct runoff. Every ordinate from the hydrograph time series was multiplied by the time interval to obtain volume and then divided by the subbasin area to get excess rainfall depth in inches. The computed total excess rainfall depth was summed and checked against the excess runoff depth generated in HEC-HMS to make sure continuity was preserved. The excel spreadsheets are provided in the digital files provided with this report.

E. Setting Up Plan Initial Conditions

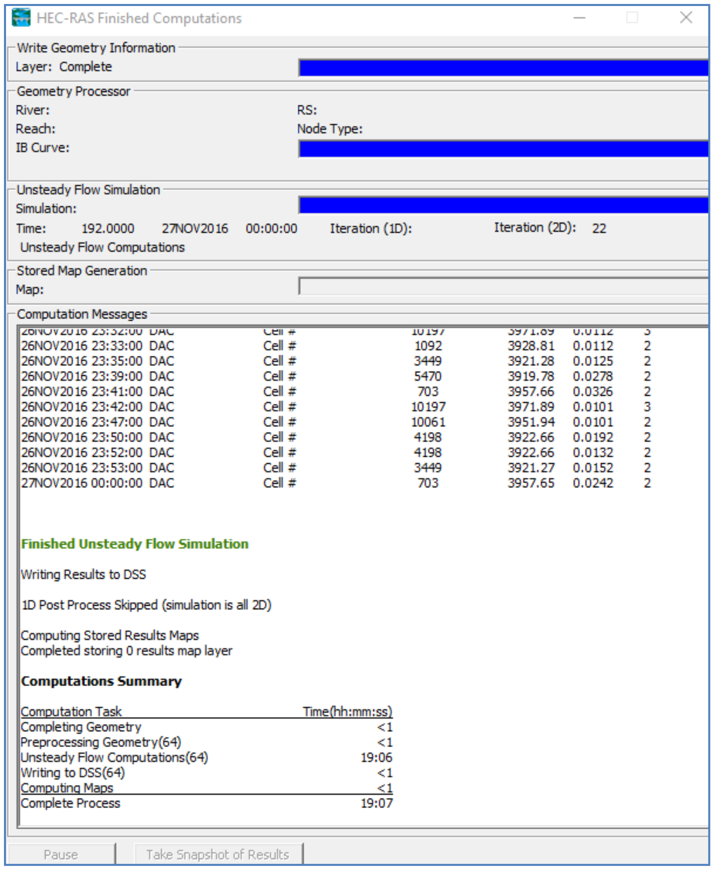
An unsteady analysis plan was then set up and initial conditions for the 2D analysis was defined. All the default values for 2D flow options were assumed. The 2D area was assumed to have dry initial conditions. The program allows the 2D computations to be based on either the Diffusion Wave equation or the Full Momentum equation. There are guidelines in the user manual when to reflect the Full Momentum equation vs. Diffusion Wave. In this instance, the diffusion wave equation was selected to solve for subbasins using direct runoff method whereas full momentum was used to compute subbasins with actual flow hydrographs from culverts C1-C4.

F. Simulation Run and Results

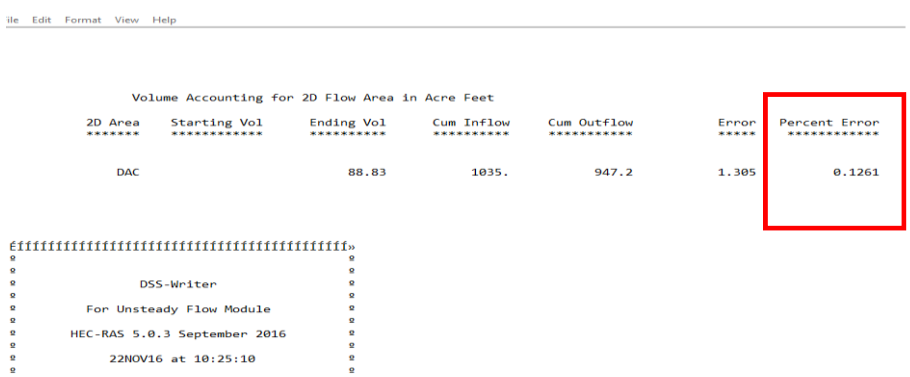
The results from the 2D analysis are best viewed dynamically in RAS Mapper to see how the flow distributes over the terrain over the duration of the hydrograph. There are many variables that can be queried within RAS Mapper. The 3 that are provided by default are depth, velocity and water surface elevation. Typically, if the model has 2D mesh errors or incorrect simulation time step interval it will be unable to converge the solution for the 2D mesh and become unstable and a message appears as shown.



In this case, this window did not occur proving the model was performing the computations and achieving convergence for all the cells. Upon completing the simulation run successfully, this window opens indicating that results are now ready to be viewed in RAS Mapper.



The next check was to view the computational log file which is accessed through the Options tab in the Unsteady Flow Analysis window. This does a volume continuity check for the simulation. The key number here is the percent error during the run shown in the red box shown below. This number should be very small if the model is running correctly. The Mesquite 2D model had minimal errors. The log should look like below:



The flow depths generated from the 10 and 100 year return periods indicated that the Mesquite watershed truly has very few points of concentration. It also indicated that the surface flow will spread out over the entire watershed so that most flow depths rarely exceed 6 inches. The only exceptions are areas that already have man made depressions. Consequently, subbasins act as retention ponds throughout the watershed and surface flows do not drain from one subbasin to another.

This was validated at the first public meeting by a resident that experienced the Micro-burst in July 2016. As resident reported, approximately 9 inches of rain fell in a very short duration in this area. While the residents neighbor across White Oaks Rd. was flooded, he didn't experience any flooding himself. In comparison, the 100 year 24 hour rainfall depth is 3.6 inches, so the flow depths being predicted by the 2D model seem very reasonable. **Figures 3.1 and 3.2**, included in Map Pocket show the limits of inundation from the 10 and 100 year storms.

SECTION 4. PROPOSED OPTIONS HYDROLOGIC AND HYDRAULIC ANALYSES

4.1 PROPOSED OPTIONS HYDROLOGIC DATA

The HEC-HMS model was modified to simulate two proposed detention ponds. Pond 1 is located north-east side of Kirkpatrick Ave. and Tres Caballos in a large agricultural field. Pond 2 is located at the north-east side of Santo Tomas St. and Bryant St. Elevation storage data were computed based on conceptual level grading plans and incorporated into the proposed HEC-HMS model.

4.2 MOST SIGNIFICANT DRAINAGE PROBLEM AREAS

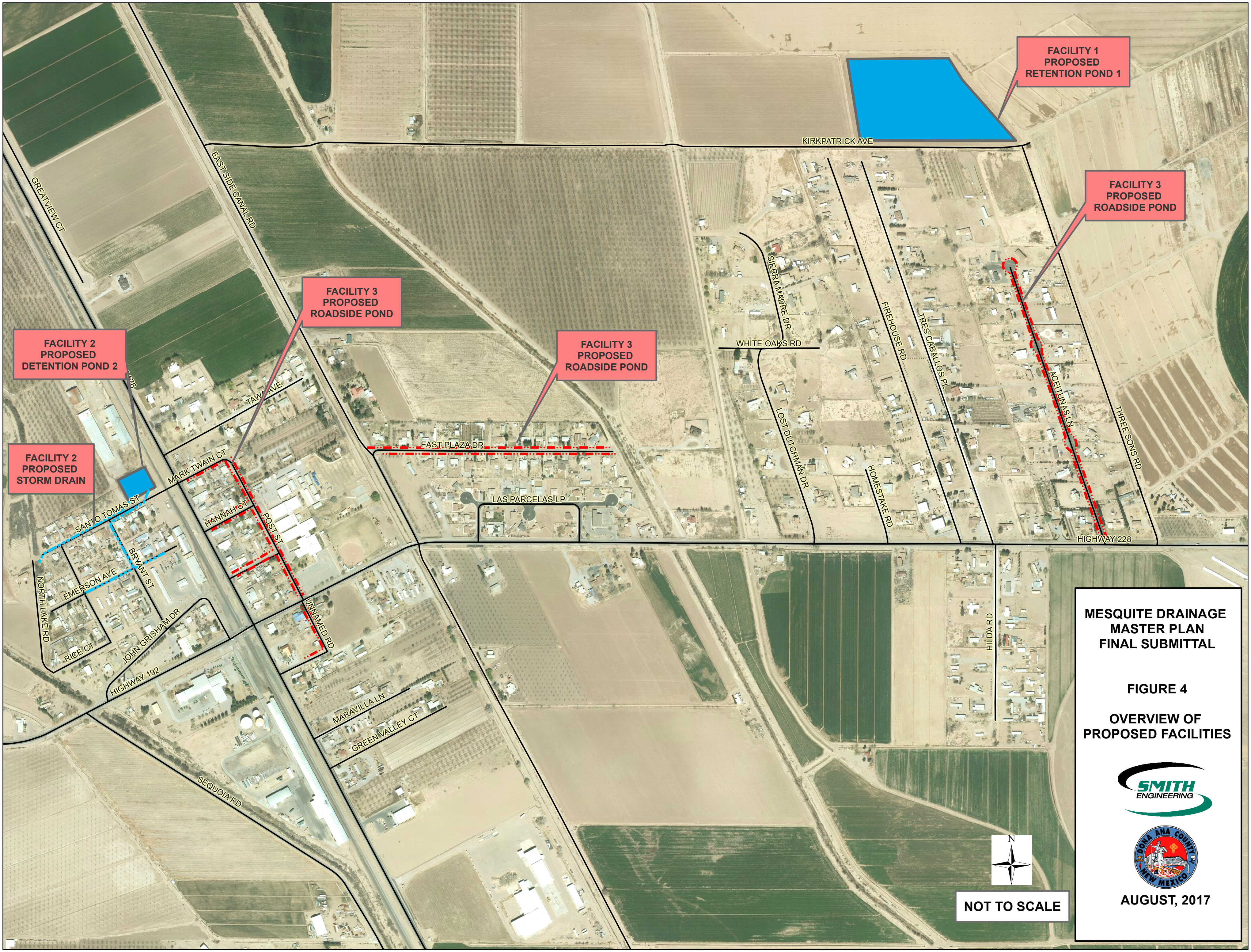
The existing conditions analysis of the Mesquite watershed in light of the 10 year design storm indicates that no major improvements are required. This is largely due to no flow concentration points on the west side of I-10. Shallow ponding will be very common in most rain storms however this will occur largely in residential parcels that are already depressed and the water depths will be very minor. Considering the lack of flooding data from extreme historical events and the predictions from the 2D surface water model, most ponding areas will be within residential parcels as these are lower in elevation than the adjacent streets and irrigation drains.

4.3 ANALYSES AND OPTIONS SUMMARY

Smith evaluated 2 options for mitigation. However, after analyzing hydrologic and hydraulic data considering historical rain events, the first option is the 'do nothing' option. Furthermore, since the watershed is so flat, gravity options are limited due to the lack of slope. Smith does not recommend options that require forcemains and pump stations due to the huge capital cost and long-term operations and maintenance cost. Since most of the ponding occurs in private property in localized areas with no distinct concentration points, the DACFC cannot apply public funds to private properties for flood mitigation. The second option is comprised of 3 facilities. **Figure 4** shows an overview of proposed options.

A. Facility 1: Pond 1

Pond 1 is located north-east side of Kirkpatrick Ave. and Tres Caballos in a large agricultural field. The 2D model predicts that discharges from culverts C1-C3 will concentrate at this point. Pond 1 will serve as a retention pond as there are no gravity outfalls available for discharge. Pond 1 has a large footprint that will be refined should the DACFC feel that it is a viable option. The existing footprint allows the pond to retain up to approximately 44 ac-ft. However, since it's only 4 ft. deep it's well below jurisdictional limits. The pond is graded to have 4H:1V side slopes. **Figure 5** shows the preliminary grading limits and storage volumes for pond 1.


FACILITY 1
PROPOSED
RETENTION POND 1
FACILITY 3
PROPOSED
ROADSIDE POND
FACILITY 3
PROPOSED
ROADSIDE POND
FACILITY 3
PROPOSED
ROADSIDE POND
FACILITY 2
PROPOSED
DETENTION POND 2
FACILITY 2
PROPOSED
STORM DRAIN
KIRKPATRICK AVE
GREATVIEW CT
EASTSIDE CANAL RD
SIERRA MADRE DR
WHITE OAKS RD
FIREHOUSE RD
TRES CABALLOS PL
ACEITUNAS LN
THREE SONS RD
LOST DUTCHMAN DR
HOMESTAKE RD
HIGHWAY 228
EAST PLAZA DR
LAS PARCELAS LP
TAWA AVE
MARK TWAIN CT
HANNAH CT
POST ST
UNNAMED RD
SANTO TOMAS ST
BRYANT ST
EMERSON AVE
NORTH LAKE RD
RICE CT
JOHN GRISHAM DR
HIGHWAY 192
MARAVILLA LN
GREEN VALLEY CT
SEQUOIA RD
HILDA RD
N
NOT TO SCALE
MESQUITE DRAINAGE
MASTER PLAN
FINAL SUBMITTAL
FIGURE 4
OVERVIEW OF
PROPOSED FACILITIES
SMITH
ENGINEERING
AUGUST, 2017

Proposed Retention Pond 1 Routing Summary

Mesquite Drainage Master Plan

Detention Pond Name	Existing or Proposed Pond	Basin Development / Model Condition	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	Inflow Runoff Volume	Outflow Runoff Volume	Maximum Design Storage Volume (top of embankment)	Peak Storage Volume for Storm Event	**Peak Water Surface Elevation**	Emergency Spillway Elevation	Pond Invert Elevation	Maximum Pond Depth	Peak Water Depth	Top of Pond Embankment Elevation	**Freeboard to Emergency Spillway Elevation**	**Freeboard to top of Pond Embankment**
		inches	yr / hr	sq mi	cfs	cfs	ac-ft	ac-ft	ac-ft	ac-ft	**ft**	ft	ft	ft	ft	ft	**ft**	**ft**
			a	a	a	a	a	b	a	a	b	b	b		b	b	c	c
Pond 1	Proposed	Proposed	100 / 24	1.7090	372	320	118.6	101.4	44.3	24.9	**3840.3**	3840.0	3838	4.0	2.3	3842.0	**-0.3**	**1.7**
Pond 1	Proposed	Proposed	50 / 24	1.7090	292	205	90.6	73.4	44.3	24.0	**3840.2**	3840.0	3838	4.0	2.2	3842.0	**-0.2**	**1.8**
Pond 1	Proposed	Proposed	10 / 24	1.7090	132	46	39.1	22.0	44.3	22.5	**3840.1**	3840.0	3838	4.0	2.1	3842.0	**-0.1**	**1.9**
Pond 1	Proposed	Proposed	5 / 24	1.7090	87	6	24.5	7.1	44.3	21.8	**3840.0**	3840.0	3838	4.0	2.0	3842.0	**0.0**	**2.0**

(a) Refer to Appendix D for the HEC-HMS model output for the pond routing results. Dead storage was simulated for 2ft. below the principal spillway to account coservatively for heavy sediment loads therefore inflow volume is not equal to outflow volume

(b) See this Appendix for all Elevation - Storage Volume - Discharge Data Tables (Table C6-1)

(c) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

LEGEND

- EXISTING PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED CONTOUR

NOTE: DIGITAL ORTHOPHOTOGRAPHY AND LIDAR COMPLETED IN 2010 BY DOÑA ANA COUNTY. THE CONTOUR INTERVAL IS 2-FOOT.

PROPOSED RETENTION POND 1	
TOP OF POND ELEVATION (FT)	3842
BOTTOM OF POND ELEVATION (FT)	3838
POND DEPTH (FT)	4
SIDE SLOPES (H:V)	4:1
POND CAPACITY (AC-FT)	44.31

SCALE: 1"=100' (0, 100', 200')

NOTE: SCALE ONLY APPLIES WHEN PRINTED TO 11"X17".

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1			
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MESQUITE DRAINAGE MASTER PLAN

FIGURE 5
FACILITY 1 - POND 1 GRADING PLAN AND SUB-FACILITIES

SMITH ENGINEERING

JOB NO: 817102
DATE: August 2017
SHEET NO: FIGURE 5

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B. Facility 2: Pond 2

Facility 2 consists of Pond 2 and the associated storm drain alignments that would divert roadway runoff from subbasin 40 into the pond located at the north-east side of Santo Tomas St. and Bryant St. The existing footprint allows the pond to control up to the 100 year storm. The pond is 8 feet deep graded at 4H:1V side slopes with a total design storage volume of 2.5 ac-ft. The proposed storm drain will have to be designed at 0.1% slopes due to the lack of grade in this area. **Figure 6** shows the layout of the storm drain network and Pond 2. **Figure 6** provides all the critical data for Facility 2.

C. Facility 3: Roadside Ponding

Facility 3 is a series of road side retention ponds that are one foot deep graded at 4H:1V. The primary function of these road side retention ponds is to capture roadway runoff and prevent it from draining into private property. **Figures 7, 8, and 9** show a typical section and a few locations in the watershed where this option would make sense.

Proposed Detention Pond 2 Routing Summary																		
Mesquite Drainage Master Plan																		
Detention Pond Name	Existing or Proposed Pond	Basin Development / Model Condition	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	Inflow Runoff Volume	Outflow Runoff Volume	Maximum Design Storage Volume (top of embankment)	Peak Storage Volume for Storm Event	**Peak Water Surface Elevation**	Emergency Spillway Elevation	Pond Invert Elevation	Maximum Pond Depth	Peak Water Depth	Top of Pond Embankment Elevation	**Freeboard to Emergency Spillway Elevation**	**Freeboard to top of Pond Embankment**
		inches	yr / hr	sq mi	cfs	cfs	ac-ft	ac-ft	ac-ft	ac-ft	**ft**	ft	ft	ft	ft	ft	**ft**	**ft**
			a	a	a	a	a	b	a	a	b	b	b		b	b	c	c
Pond 2	Proposed	Proposed	100 / 24	0.0180	11	4	1.1	1.1	3.8	0.4	**3833.9**	3838.0	3832	8.0	1.8	3840.0	**4.2**	**6.2**
Pond 2	Proposed	Proposed	50 / 24	0.0180	8	3	0.8	0.8	3.8	0.3	**3833.4**	3838.0	3832	8.0	1.4	3840.0	**4.6**	**6.6**
Pond 2	Proposed	Proposed	10 / 24	0.0180	3	1	0.4	0.4	3.8	0.1	**3832.5**	3838.0	3832	8.0	0.5	3840.0	**5.5**	**7.5**
Pond 2	Proposed	Proposed	5 / 24	0.0180	2	1	0.2	0.2	3.8	0.1	**3832.3**	3838.0	3832	8.0	0.3	3840.0	**5.7**	**7.7**

(a) Refer to Appendix D for the HEC-HMS model output for the pond routing results. Dead storage was simulated for 2ft. below the principal spillway to account coservatively for heavy sediment loads therefore inflow volume is not equal to outflow volume

(b) See this Appendix for all Elevation - Storage Volume - Discharge Data Tables (Table C7-1)

(c) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

LEGEND

- EXISTING PROPERTY LINE
- PROPOSED STORM DRAIN CENTERLINE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- EXISTING IRRIGATION CANAL
- PROPOSED STORM DRAIN MANHOLE

NOTE: DIGITAL ORTHOPHOTOGRAPHY AND LIDAR COMPLETED IN 2010 BY DOÑA ANA COUNTY. THE CONTOUR INTERVAL IS 2-FOOT.

PROPOSED DETENTION POND 2	
POND INVERT ELEVATION (FT)	3832
EMERGENCY SPILLWAY ELEVATION (FT)	3838
TOP OF POND ELEVATION (FT)	3840
SIDE SLOPES (H:V)	4:1
POND CAPACITY (AC-FT)	2.50

STORM DRAIN MANHOLE	RIM ELEVATION (FT)	INV IN (FT)	INV OUT (FT)	DEPTH (FT)
MH1	3840	3833.58	3833.58	6.42
MH2	3840	3833.87	3833.87	6.13
MH3	3840	3834.02	3834.02	5.98
MH4	3838	3834.20	3834.20	3.80
MH5	3838	3834.38	3834.38	3.62
MHW	3838	3834.56	3834.56	3.45
MHE	3838	3834.38	3834.38	3.62
MH6	3840	3832.87	3832.87	7.13
MH7	3840	3832.57	3832.57	7.43
MH8	3840	3832.27	3832.27	7.73

N

0 80' 160'

SCALE: 1"=80'

NOTE: SCALE ONLY APPLIES WHEN PRINTED TO 11" x 17"

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MESQUITE DRAINAGE MASTER PLAN

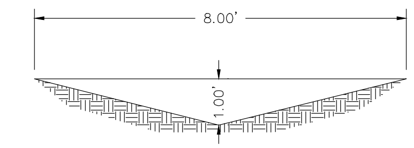
FIGURE 6
FACILITY 2 - POND 2 GRADING PLAN AND SUB-FACILITIES

SMITH ENGINEERING

JOB NO: 817102

DATE: August 2017

SHEET NO: FIGURE 6



ROADSIDE POND	
TOP OF POND ELEVATION (FT)	3838
BOTTOM OF POND ELEVATION (FT)	3837
TOTAL AVAILABLE LENGTH OF POND (FT)	2187
SIDE SLOPES (H:V)	4:1
POND CAPACITY (AC-FT)	0.20

DETAIL 1: TYPICAL POND CROSS SECTION

LEGEND

- EXISTING PROPERTY LINE
- EXISTING CONTOUR
- PROPOSED ROADSIDE POND
- EXISTING IRRIGATION CANAL

NOTE: DIGITAL ORTHOPHOTOGRAPHY AND LIDAR COMPLETED IN 2010 BY DOÑA ANA COUNTY. THE CONTOUR INTERVAL IS 2-FOOT.

0 100' 200'
SCALE: 1"=100'

NOTE: SCALE ONLY APPLIES WHEN PRINTED TO 11"X17".

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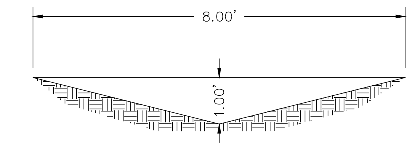
MESQUITE DRAINAGE MASTER PLAN

FIGURE 7
FACILITY 3 - ROADSIDE PONDING PLAN AND SUBFACILITIES

SMITH ENGINEERING

JOB NO: 817102
DATE: August 2017
SHEET NO: FIGURE 7



ROADSIDE POND*	
TOP OF POND ELEVATION (FT)	3838
BOTTOM OF POND ELEVATION (FT)	3837
TOTAL AVAILABLE LENGTH OF POND (FT)	3458
SIDE SLOPES (H:V)	4:1
POND CAPACITY (AC-FT)	0.32

DETAIL 1: TYPICAL POND CROSS SECTION

LEGEND

EXISTING CONTOUR

PROPOSED ROADSIDE POND

NOTE: DIGITAL ORTHOPHOTOGRAPHY AND LIDAR COMPLETED IN 2010 BY DOÑA ANA COUNTY. THE CONTOUR INTERVAL IS 2-FOOT.

SCALE: 1"=100'

NOTE: SCALE ONLY APPLIES WHEN PRINTED TO 11"X17".

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MESQUITE DRAINAGE MASTER PLAN

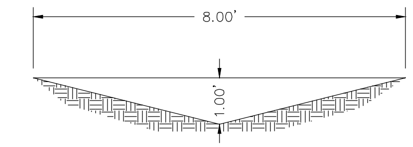
FIGURE 8
FACILITY 3 - ROADSIDE PONDING PLAN AND SUB-FACILITIES

SMITH ENGINEERING

JOB NO: 817102

DATE: August 2017

SHEET NO: FIGURE 8



ROADSIDE POND*	
TOP OF POND ELEVATION (FT)	3838
BOTTOM OF POND ELEVATION (FT)	3837
TOTAL AVAILABLE LENGTH OF POND (FT)	3324
SIDE SLOPES (H:V)	4:1
POND CAPACITY (AC-FT)	0.31

DETAIL 1: TYPICAL POND CROSS SECTION

LEGEND

------	EXISTING CONTOUR
▬ ▬ ▬	PROPOSED ROADSIDE POND
— · · —	EXISTING PROPERTY LINE

NOTE: DIGITAL ORTHOPHOTOGRAPHY AND LIDAR COMPLETED IN 2010 BY DOÑA ANA COUNTY. THE CONTOUR INTERVAL IS 2-FOOT.

0 80 160
SCALE: 1"=80

NOTE: SCALE ONLY APPLIES WHEN PRINTED TO 11"X17".

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4	####	####	####
5	####	####	####

MESQUITE DRAINAGE MASTER PLAN

FIGURE 9
FACILITY 3 - ROADSIDE PONDING PLAN AND SUB-FACILITIES

SMITH ENGINEERING

JOB NO: 817102
DATE: August 2017
SHEET NO: FIGURE 9

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SECTION 5. PRIORITIZATION OF OPTIONS

5.1 VIABLE OPTIONS

Figure 4 (page 14) presents an overall map of the most viable Facilities as previously presented. Note that priorities for selection and implementation will depend on the DACFC and the acceptance of proposed projects by the local community. The most promising Facilities to address problem locations and/or large discharges and the conceptual level cost estimate are listed here. Detailed conceptual level EOPC estimates are also included in **Appendix F**.

Table 2: Summary of Proposed Facilities and Conceptual Level Cost Estimates

Facility	Cost
Facility 1: Pond 1	\$1,108,000
Facility 2: Pond 2	\$678,000
Facility 3: Roadside Ponding	\$119,000
Total (including 30% Contingency and New Mexico Gross Receipts Tax Rates	\$1,905,000

5.2 CONCLUSIONS AND RECOMMENDATIONS

Smith, in conjunction with the DACFC and the residents of Mesquite, have determined that Facilities presented in **Table 2** are the most practical, efficient, and cost-effective approach to manage stormwater runoff and the associated problems within the community of Mesquite. The ponds presented in this report will provide significant flood mitigation for the design storm.

The results and recommendations within this Drainage Master Plan should be reviewed at least every five years or as existing or developed conditions change. In addition to the recommendations, the DACFC and residents of Mesquite area should take a proactive approach to maintaining the existing drainage conveyances and systems within the area.

Smith also recommends that any new development that changes the land use type in the watershed of Mesquite from existing to developed be required to implement stormwater detention to restrict developed site discharge to historic flow rates.

SECTION 6. REFERENCES

1. NOAA Atlas 14 Point Precipitation Frequency Estimates Output (printed from NOAA Atlas 14 internet site).

2. Figure 14, Depth-Area Curves (Source: NOAA Atlas 2 Vol. IV, New Mexico 1973).

3. Urban Hydrology for Small Watersheds, U.S. Department of Agricultural Soil Conservation Service, Technical Release 55, June 1986.

Approximate Geographic Boundaries for SCS Rainfall Distributions (FOR REFERENCE ONLY – The HEC-HMS Rainfall 25% Frequency Distribution was adopted).

Table 2-2a Runoff Curve Numbers for Urban Areas.

Table 2-2b Runoff Curve Numbers for Cultivated Agricultural Land.

Table 2-2c Runoff Curve Numbers for Other Agricultural Lands.

Table 2-2d Runoff Curve Numbers for Arid and Semiarid Rangelands.

Chapter 3 - Time of Concentration and Travel Time Computation Procedure

4. National Engineering Handbook, Part 630, Chapter 15 - Time of Concentration. Natural Resources Conservation Service. May 2010. (Documentation that Lag Time = 0.6 Time of Concentration).

5. Sediment Bulking Factors were assumed based select pages - Figure 3.8 within - Sediment and Erosion Design Guide, November 2008. Prepared by Mussetter Engineering Inc. Prepared for the Southern Sandoval County Arroyo Flood Control Authority.

6. HEC-HMS Computation Time Interval Guidance.

7. Manning's "n" Values from - Open Channel Hydraulics, Ven T. Chow, 1959.

8. Soils Data Summary for: Soil Map Unit Descriptions and Hydrologic Soil Groups from Natural Resources Conservation Service (NRCS) Web Soil Survey – National Cooperative Soil Survey.

APPENDIX A

ANNOTATED PHOTOGRAPHS

Photo 1

30” RCP Culvert full of silt

Photo 2

Clean 8’ X 8’ Concrete Box Culvert

Photo 3

30” CMP Culverts Partially Clogged

Photo 4

24” CMP Culvert

Completely Clogged

Photo 5

Unnnamd Dam with 24” perforated riser located south of Apache Brazito Mesquite Site 2 Dam

Photo 6

Berm Along West Side of 1-10 Frontage Rd. Creating Ponding within Road Right-of-Way

Photo 7

Existing Channel is Higher Than Adjacent Farming Lots

Photo 8

Flat Areas Without Drainage

APPENDIX B

PREVIOUS PLANS, TOPOGRAPHIC SURVEYS AND REPORTS (a)

Dona Ana County NM and Incorporated Areas
Flood Insurance Rate Map 35013C1325G
Dated 07/06/2016

(a) The DVD contains PDFs of this panel.

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map was New Mexico State Plane, Central Zone (FIPS 3002). The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit their website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided by the Dona Ana County Flood Commission, 2004 and 2010; Bureau of Land Management, 2004; U.S. Geological Survey, 1989 and 2005; NGS, 2004; and U.S. Census Bureau, 2009. Additional information was compiled from U.S. Department of Agriculture aerial photography, 2009 at a scale of 1:12,000.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for the Flood Insurance Study report may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

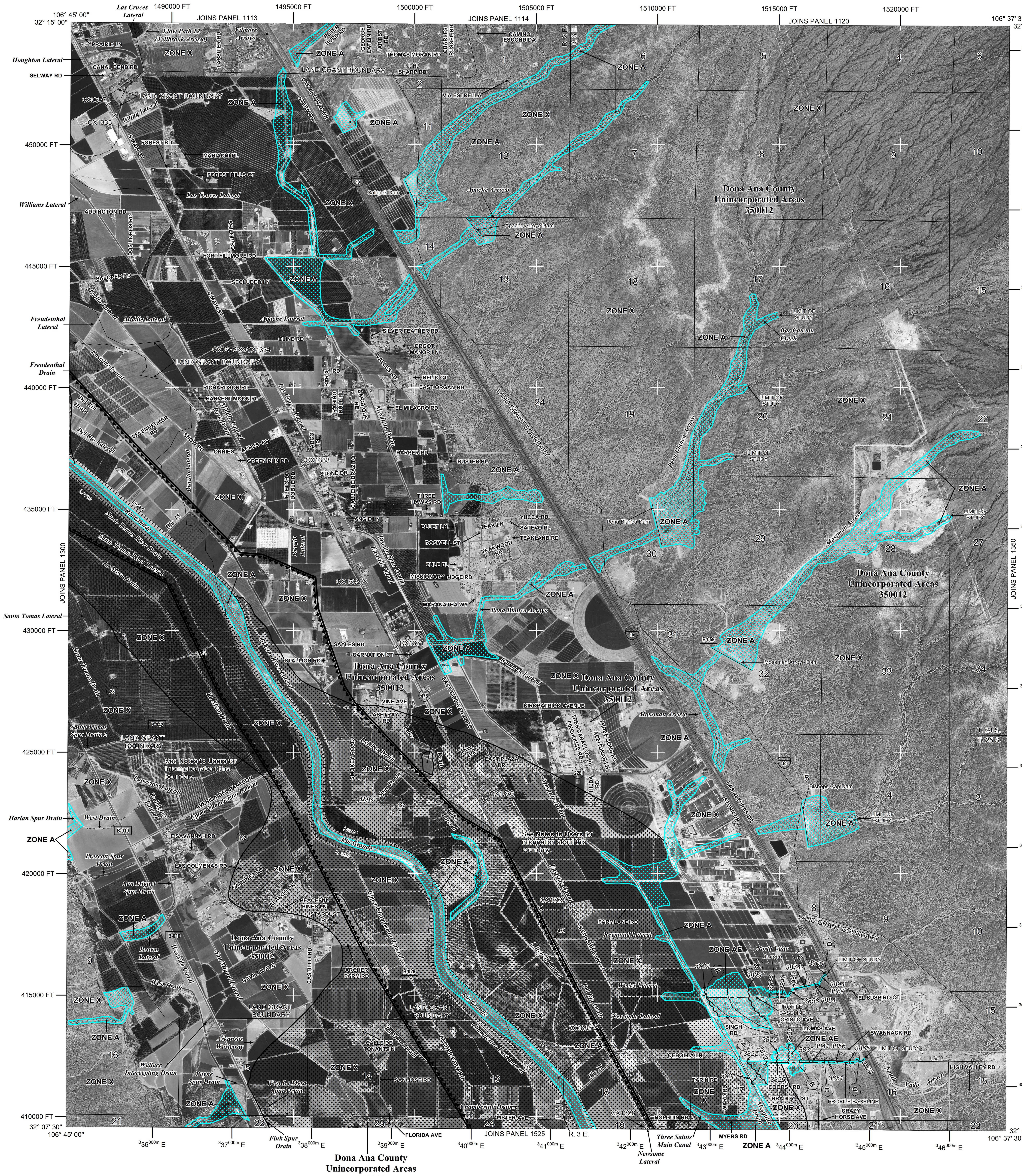
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at to http://www.fema.gov/national-flood-insurance-program

ATTENTION: The levee, dike, or other structure that impacts flood hazards inside this boundary has not been shown to comply with Section 65.10 of the NFIP Regulations. As such, this FIRM panel will be revised at a later date to update the flood hazard information associated with this structure.

The flood hazard data inside this boundary on the FIRM panel has been re-published from the previous effective (historic) FIRM for this area, after being converted from NGVD 29 to NAVD 88.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D Boundary
CBRS and OPA Boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A	Cross section line
23 - - - - 23	Transect line
97° 07' 30", 32° 22' 30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
42 76 000m E	1000-meter Universal Transverse Mercator grid values, zone 13N
600000 FT	5000-foot grid ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
● M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index.

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL
SEPTEMBER 27, 1991

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

SEPTEMBER 3, 1992 - to add Base Flood Elevations, to change Special Flood Hazard Areas, to change zone designations, and to relfect updated topographic information.
SEPTEMBER 6, 1995 - to update corporate limits, to change Base Flood Elevations, to add Base Flood Elevations, to add Special Flood Hazard Aresa, to change Special Flood Hazard Areas, to change zone designations, to advance the sufix, to add roads and road names, and to relfect updated topographic information.
JULY 6, 2016 - to update corporate limits, to change Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to add roads and road names, to incorporate previously issued Letters of Map Change, and to update map format.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 2000'

FEET: 1000, 0, 2000, 4000
METERS: 600, 0, 600, 1200

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1325G

FIRM
FLOOD INSURANCE RATE MAP
DONA ANA COUNTY, NEW MEXICO
AND INCORPORATED AREAS

PANEL 1325 OF 1925

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
DONA ANA COUNTY (UNINCORPORATED AREAS)	350012	1325	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 35013C1325G

MAP REVISED JULY 6, 2016

Federal Emergency Management Agency

APPENDIX C

HYDROLOGIC DATA TABLES (HEC-HMS Sub-Basin Input Data)
POND DATA, AND COMPUTATIONS
AND REFERENCES

HYDROLOGIC DATA TABLES

PROPSED RETENTION POND 1 DATA AND COMPUTATION

PROPSED DETENTION POND 2 DATA AND COMPUTATION

REFERENCES

1. NOAA Atlas 14 Point Precipitation Frequency Estimates Output (printed from NOAA Atlas 14 internet site).

2. Figure 14, Depth-Area Curves (Source: NOAA Atlas 2 Vol. IV, New Mexico 1973).

3. Urban Hydrology for Small Watersheds, US Dept of Agricultural Soil Conservation Service, Technical Release 55, June 1986.

   Approximate Geographic Boundaries for SCS Rainfall Distributions (FOR REFERENCE ONLY The HEC-HMS Rainfall 25% Frequency Distribution was adopted)

   Table 2-2a Runoff Curve Numbers for Urban Areas.
   Table 2-2b Runoff Curve Numbers for Cultivated Agricultural Land.
   Table 2-2c Runoff Curve Numbers for Other Agricultural Lands.
   Table 2-2d Runoff Curve Numbers for Arid and Semiarid Rangelands.

   Chapter 3 - Time of Concentration and Travel Time Computation Procedure

4. National Engineering Handbook, Part 630, Chapter 15 - Time of Concentration. Natural Resources Conservation Service. May 2010. (Documentation that Lag Time = 0.6 Time of Concentration).

5. Sediment Bulking Factors were assumed based select pages - Figure 3.8 within - Sediment and Erosion Design Guide, November 2008. Prepared by Mussetter Engineering Inc. Prepared for the Southern Sandoval County Arroyo Flood Control Authority.

6. HEC-HMS Computation Time Interval Guidance.

7. Manning's "n" Values from - Open Channel Hydraulics, Ven T. Chow, 1959.

8. Soils Data Summary for: Soil Map Unit Descriptions and Hydrologic Soil Groups from Natural Resources Conservation Service (NRCS) Web Soil Survey – National Cooperative Soil Survey and Dona Ana County Flood Commission, New Mexico.

TABLE C1
RAINFALL DEPTH DATA

Mesquite Drainage Master Plan

RAINFALL AREAL REDUCTION FACTORS - Basin total area is less than 3.68 sq. mi. , therefore, rainfall areal reduction factors were not applied as they would be very small, see Figure 14, Depth-Area Curves (NOAA Atlas 2 Vol. IV. New Mexico) within the References Section in Appendix C.

		Partial Duration - Point Precipitation Depths (inches) with 90% Confidence Intervals (a)							
Duration	2-yr. 24-hr.	5-yr. 6-hr.	5-yr. 24-hr.	10-yr. 6-hr.	10-yr. 24-hr.	50-yr. 6-hr.	50-yr. 24-hr.	100-yr.6-hr.	100-yr. 24-hr.
	inches	inches	inches	inches	inches	inches	inches	inches	inches
a	a	a	a	a	a	a	a	a	a
5 min.	0.284	0.382	0.382	0.458	0.458	0.643	0.643	0.729	0.729
10 min.	0.432	0.581	0.581	0.697	0.697	0.979	0.979	1.110	1.110
15 min.	0.535	0.720	0.720	0.864	0.864	1.210	1.210	1.380	1.380
30 min.	0.721	0.970	0.970	1.160	1.160	1.630	1.630	1.850	1.850
1 hour	0.892	1.200	1.200	1.440	1.440	2.020	2.020	2.290	2.290
2 hour	1.020	1.390	1.390	1.670	1.670	2.360	2.360	2.680	2.680
3 hour	1.070	1.440	1.440	1.720	1.720	2.420	2.420	2.750	2.750
6 hour	1.210	1.590	1.590	1.880	1.880	2.590	2.590	2.910	2.910
12-hour	1.320	1.720	1.720	---	2.020	---	2.730	---	3.040
24-hour	1.470	1.720	1.920	---	2.270	---	3.180	---	3.610

a - NOAA Atlas 14, Volume 1, Version 5 Rainfall Data - Included in Appendix C

TABLE C2													
RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS													
Mesquite Drainage Master Plan													
Basin No. a	Basin Area sq mi a	Basin Area acres a	Area of HSG A	Area of HSG B	Area of HSG C	Area of HSG D	Basin Description	CN Areal Weighting b	Runoff Curve Number Based on AMC II Condtions b	Runoff Curve Number Based on AMC III Conditions b	Runoff Curve Number Based on Average between AMC II & AMC III	Lag Time minutes c	Flow Ratio d
1	0.340	156.53	156.53	0	0	0	Desert Shrub-Poor Condition	63	63	80	72	43.5	1.1
2	0.613	281.89	281.89	0	0	0	Desert Shrub-Poor Condition	63	63	80	72	26.5	1.1
3A	0.041	19.05	19.05	0	0	0	Desert Shrub-Poor Condition	64	64	81	73	12.5	1.1
3B	0.244	112.35	112.35	0	0	0	Desert Shrub-Poor Condition	63	63	80	72	18.5	1.1
4	0.152	70.13	70.13	0	0	0	Desert Shrub-Poor Condition	63	63	80	72	8.3	1.1
5	0.025	11.66	11.66	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
6	0.029	13.30	13.30	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.9	1.05
7	0.007	3.07	3.07	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
8	0.005	2.45	2.45	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
9	0.012	5.46	5.46	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
10	0.013	6.08	6.08	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
11	0.012	5.64	5.64	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
12	0.013	6.19	6.19	0	0	0	Paved, Open Ditches, including ROW (HWY-85)	83	83	93	88	7.2	1.05
13	0.012	5.73	5.73	0	0	0	Desert Shrub-Poor Condition	63	63	80	72	9.0	1.1
14	0.454	208.63	207.61	0	1.02	0	Predominantly Agricultural Fields with Contoured & terraced (C&T) in Good Condition with Minor Industrial	64	64	81	72	43.3	1.1
15	1.166	536.22	471.46	10.93	51.82	2.02	Predominantly Agricultural Fields with Contoured & terraced (C&T) in Good Condition	64	64	81	72	54.0	1.1
16	0.095	43.79	1.54	0	32.36	9.88	Predominantly Residential 1 acre lots	79	79	91	85	20.1	1.05
17	0.110	50.66	0	4.31	23.74	22.61	Predominantly Residential 1 acre lots	80	80	91	86	20.1	1.05
18	0.133	61.24	14.96	12.76	31.31	2.21	Residential 1 acre lots with Open Space-Poor Condition	72	72	86	79	20.1	1.05
19	0.172	79.20	14.12	17.77	47.31	0	Agricultural Fields with Straight Row (SR) fields in Good Condition with Open Space in Poor Condition	81	81	92	87	43.3	1.1
20	0.228	105.03	34.26	29.40	41.37	0	Predominantly Agricultural Fields with SR - Good Condition	77	77	89	83	43.3	1.1
21	0.234	107.82	3.41	17.65	86.75	0	Predominantly Agricultural Fields with SR - Good Condition	83	83	93	88	43.3	1.1

TABLE 2
RUNOFF CURVE NUMBER (CN) ASSUMPTIONS AND CALCULATIONS
Mesquite Drainage Master Plan

Basin No. a	Basin Area sq mi a	Basin Area acres a	Area of HSG A	Area of HSG B	Area of HSG C	Area of HSG D	Basin Description	CN Areal Weighting b	Runoff Curve Number Based on AMC II Condtions b	Runoff Curve Number Based on AMC III Conditions b	Runoff Curve Number Based on Average between AMC II & AMC III	Lag Time minutes c	Flow Ratio d
22	0.028	13.10	1.64	0	9.88	1.58	Residential 1/3 acre lots with some Impervious Paved Roadway	79	79	91	85	20.1	1.05
23	0.046	21.37	2.82	4.28	10.45	3.83	Residential 1/3 acre lots with Open Space-Poor Condition	78	78	90	84	20.1	1.05
24	0.005	2.43	0	2.43	0	0	Residential 1 acre lots with Open Space-Poor Condition	74	74	88	81	20.1	1.05
25	0.185	85.24	5.07	40.08	40.08	0	Predominantly Agricultural Fields with SR Fields -Good Condition	81	81	92	86	43.3	1.1
26	0.099	45.46	11.30	32.36	1.81	0	Agricultural Fields with SR Fields -Good Condition with some Commercial	82	82	92	87	20.1	1.1
27	0.050	23.02	0	7.78	15.25	0	Residential 1/2 acre lots with SR Fields-Good Condition	81	81	92	87	20.1	1.05
28	0.015	6.80	0	0	6.16	0.64	Residential 1/3 acre lots Small Grain Fields-Good Condition	82	82	92	87	20.1	1.05
29	0.008	3.89	0	0.46	0	3.43	Open Space-Fair Condition with Impervious Areas	83	83	93	88	20.1	1.05
30	0.003	1.41	0	0.89	0	0.52	Impervious Area (Paved Parking Lot)	98	98	99	99	20.1	1.05
31	0.019	8.94	0	3.63	5.31	0	Commercial with some Open Space-Poor Condition	91	91	97	94	20.1	1.05
32	0.024	11.11	1.52	9.59	0	0	Residential 1/4 acre lots	73	73	87	80	20.1	1.05
33	0.024	11.04	0.32	4.62	6.11	0	Residential 1/4 acre lots with SR Fields-Good Condition	81	81	92	86	20.1	1.05
34	0.021	9.79	0	6.18	3.61	0	Residential 1/2 acre lots	74	74	88	81	20.1	1.05
35	0.211	96.97	0	32.35	64.62	0	Predominantly Agricultural SR Fields in Good Condition	83	83	93	88	43.3	1.1
36	0.055	25.28	3.17	13.05	7.46	1.59	Predominantly Commercial	92	92	97	95	20.1	1.05
37	0.011	5.05	4.07	0	0	0.98	Predominantly Commercial	90	90	96	93	20.1	1.05
38	0.009	4.06	0.51	3.55	0	0	Predominantly Commercial	92	92	97	94	20.1	1.05
39	0.015	7.05	2.43	4.50	0	0.11	Residential 1/3 acre lots	67	67	83	75	20.1	1.05
40	0.025	11.33	11.33	0	0	0	Residential 1/4 acre lots	61	61	78	70	20.1	1.05
41	0.007	3.24	3.24	0	0	0	Residential 1/4 acre lots	61	61	78	70	20.1	1.05
42	0.149	68.46	18.57	49.90	0	0	Predominantly Agricultural SR fields-Good Condition	75	75	88	82	43.3	1.1

(a) See Figures 2 for Drainage Basin Maps.
(b) Runoff curve numbers based on Tables 2-2A, 2-2B, and 2-2D from Urban Hydrology for Small Watersheds (TR-55).
(c) See Table 3 - Appendix 2 for Lag Time calculations
(d) Assumed by Smith Engineering as 10% or a 1.10 factor for undeveloped basins and 5% or 1.05 for developed basins. Note that a value of about 17% or 1.17 is considered the limit before mud flow would occur. Therefore, due to lack of site specific data Smith assumed 1.10.

TABLE C3

TIME OF CONCENTRATION AND LAG TIME COMPUTATIONS FOR MESQUITE SUBBASINS

Mesquite Drainage Master Plan

Subbasin Name		1	2	3A	3B	4	5	6	7-12	13	14	15	16	17-18,22-24,26-34,36-41	19-21,25,35,42
Number of Reaches		3	3	3	3	3	2	2	2	2	2	2	2	2	2
1 - SHEET FLOW															
Surface Description (a)		RANGE	RANGE	RANGE	RANGE	RANGE	SMOOTHSURFACE	SMOOTHSURFACE	SUBBASINS 7-12 DEMONSTRATE VERY SIMILAR PHYSICAL CHARACTERISTICS. SUBBASIN 5 HAS THE LONGEST FLOWPATH LENGTH 1500 FT RELATIVE TO SUBBASINS 7-12. SINCE THE TC FOR SUBBASIN 5 IS 12 MINUTES ASSUME THAT THE SMALLER SUBBASINS WITH SHORTER FLOWPATH LENGTHS WILL BE AT THE MINIMUM OF 12 MINUTES. NO FURTHER TC CALCULATIONS WERE PERFORMED BASED ON THIS DATA.	RANGE	RANGE	RANGE	RANGE	THE CLOSED BASINS 17-18,22-24,26-34,36-41 ARE TYPICALLY RESIDENTIAL AREAS WITH SOME AGRICULTURAL LAND AND OPEN SPACE AREAS WHICH DEMONSTRATE VERY SIMILAR PHYSICAL CHARACTERISTICS TO SUBBASIN 16. SUBBASIN 16 HAS THE LONGEST FLOWPATH LENGTH 1016 FT RELATIVE TO THE OTHER SUBBASINS. SINCE THE TC FOR SUBBASIN 16 IS 34 MINUTES ASSUME THAT THE SIMILAR SUBBASINS WITH SHORTER FLOWPATH LENGTHS WILL BE AT THE MINIMUM OF 34 MINUTES. NO FURTHER TC CALCULATIONS WERE PERFORMED BASED ON THIS DATA.	THE SUBBASINS 19-21,25-26,35,42 ARE TYPICALLY AGRICULTURAL FIELDS THAT IN MOST INSTANCES ARE LASER LEVELED. THE VOLUME OF RUNOFF RATHER THEN THE PEAK DISCHARGE IS MORE CRITICAL. THEREFORE THE TC FOR SUBBASIN 14 WAS ADOPTED AND ONLY THE FLOWPATH FOR SUBBASIN 14 IS SHOWN.
Manning's Coeff., n (a - Table 3-1)		0.13	0.13	0.13	0.13	0.13	0.011	0.011		0.13	0.13	0.13	0.13		
Flow Length (L) (b)	ft	300	300	172	300	136	100	100		100	300	300	100		
Highest Elevation (b)	ft	4197	4126	4036	4026	4018	3927	3912		3899	3900	3934	3842		
Lowest Elevation (b)	ft	4193	4111	4032	3994	3994	3926	3911		3894	3893	3928	3841		
Slope (S)	ft / ft	0.012	0.050	0.027	0.106	0.178	0.014	0.005		0.051	0.023	0.019	0.010		
2-year 24-hour rainfall depth (P2) (c)	inches	1.47	1.47	1.47	1.47	1.47	1.47	1.47		1.47	1.47	1.47	1.47		
Travel Time Tt = (0.007(n L)^0.8) / ((P2)^0.5 (S^0.4)) (a)	hours	0.63	0.36	0.30	0.27	0.11	0.03	0.05		0.15	0.49	0.53	0.28		
2 - SHALLOW CONCENTRATED FLOW															
Surface Description (a)		UNPAVED	UNPAVED	UNPAVED	UNPAVED	UNPAVED	PAVED	PAVED		UNPAVED	UNPAVED	UNPAVED	UNPAVED		
Flow Length (L) (b)	ft	4318	2138	128	1378	549	1400	1403		672	4456	6452	916		
Highest Elevation (b)	ft	4193	4111	4032	3994	3994	3926	3911		3894	3893	3928	3841		
Lowest Elevation (b)	ft	4091	4012	4024	3952	3963	3900	3893		3885	3842	3843	3838		
Slope (S)	ft / ft	0.024	0.046	0.060	0.031	0.057	0.019	0.013		0.013	0.011	0.013	0.003		
Average Velocity (e - Figure 15-4)	ft / sec	2.49	3.48	3.97	2.83	3.84	2.77	2.32		1.82	1.73	1.85	0.92		
Travel Time Tt = Tt = L / (3600*V) (a)	hours	0.48	0.17	0.01	0.14	0.04	0.14	0.17		0.10	0.72	0.97	0.28		
3 - OPEN CHANNELS															
Channel Description (a)		CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL	CHANNEL		CHANNEL	CHANNEL	CHANNEL	CHANNEL		
Manning's n (d)		0.04	0.04	0.055	0.055	0.055									
Channel Shape (b)		CHANNEL XS	CHANNEL XS	CHANNEL XS	CHANNEL XS	CHANNEL XS									
Side Slopes (b)	1V:XH	5	5	5	5	5									
Bottom Width (b)	ft	50	50	50	50	50									
Depth (D)	ft	1	1	1	1	1									
Top Width (T)	ft	60	60	60	60	60									
Wetted Perimeter (P)	ft	60.2	60.2	60.2	60.2	60.2									
Area (A)	sq ft	55	55	55	55	55									
Hyraulic Radius (A / P)	ft	0.91	0.91	0.91	0.91	0.91									
Hydraulic Depth (y) = A / T	ft	0.92	0.92	0.92	0.92	0.92									
Entire Flowpath Length	ft	6578	6545	964	3363	2144									
Open Channel Flow Length (L) (b)	ft	1960	4107	664	1685	1459									
Highest Elevation (b)	ft	4091	4012	4024	3952	3963									
Lowest Elevation (b)	ft	4039	3909	4006	3908	3900									
Slope (S)	ft / ft	0.026	0.025	0.027	0.026	0.043									
V = (1.49 R ^ 0.666 S ^ 0.5) / n (a)	ft / sec	5.69	5.55	4.21	4.11	5.30									
Froude Number Fr = V/ (g y)^0.5		1.05	1.02	0.78	0.76	0.98									
Travel Time Tt (a) = Tt = L / (3600*V) (a)	hours	0.10	0.21	0.04	0.11	0.08									
Total Flowpath Length	ft.	6578	6545	964	3363	2144	1500	1503		772	4756	6752	1016		
Total Subbasin Tc	hours	1.21	0.74	0.35	0.51	0.23	0.17	0.22		0.25	1.20	1.50	0.56		
Total Subbasin Tc	minutes	73	44	21	31	14	10	13		15	72	90	34		
If Tc < 12 min, assume 12 min. = 0.2 hours	minutes	73	44	21	31	14	12	13		15	72	90	34		
Lag Time Tlag (e) = 0.6 Tc	minutes	43.5	26.5	12.5	18.5	8.3	7.2	7.9		9.0	43.3	54.0	20.1		
Average Slope	ft/ft	2.07%	4.03%	3.81%	5.43%	9.28%	1.64%	0.91%		3.21%	1.74%	1.60%	0.66%		
Average Velocity (a)	ft./s	1.51	2.47	0.77	1.81	2.58	2.39	1.90		0.86	1.10	1.25	0.50		
Subbasin ID		1	2	3A	3B	4	5	6	7-12	13	14	15	16	17-18,22-24,26-34,36-41	19-21,25,35,42

(a) Urban Hydrology for Small Watersheds (TR 55), June 1986 (see Chapt. 3)
(b) Measured from 2 foot lidar contour drainage basin maps
(c) NOAA Atlas 14 rainfall data
(d) Open Channel Hydraulics Chow, 1959.
(e) Part 630 Hydrology, National Engineering Handbook, Chapter 15 Time of Concentration, NRCS May 2010

TABLE C4 CHANNEL ROUTING DATA									
Mesquite Drainage Master Plan									
Muskingum - Cunge Channel Routing Method									
Hydrograph Number	Upstream Sub-Basin or Location	Sub-Basin Routing Through	Top Elevation	Bottom Elevation	Routing Length	Routing Slope	Manning's Roughness Coefficient "n" (assumed)	Arroyo Cross-Section Assumption for Typical Cross-Section Description	Arroyo/Channel Examined
			(ft)	(ft)	(ft)	(ft/ft)	c d		
a b d	a b d	a b d	a	a	a				
Reach-1	Sub-1	Sub-2	4039	3909	5,026	0.02584	0.040	No Truly Defined Channel Section; assume trapezoid channel with 5V:1H sides slopes and 50-foot bottom width	Hydrograph Routed through a Downstream Basin

a- All routing lengths and elevations were measured on the Drainage Basin Maps. See Drainage Basin Map and Modeling schematic for locations.
b - Channel width, depth and side slopes and Manning's "n" vary therefore this is an assumed typical cross-section to represent the typical section throughout the entire routing reach.
c - Assumed based on visual observation, experience, and Chow "n" value tables (copies in Appendix C).
d - See HEC-HMS Modeling Shematic included in Appendix D.

TABLE C5-1

Elevation - Storage Volume Data and Computations - Existing Unnamed Dam located south of Apache Brazito Mesquite Site 2 Dam

Mesquite Drainage Master Plan

Grey box means must input elevation and area data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	Comment
(ft)	(ft)	(sq ft)	(cu ft)	(ac-ft)	(ac-ft)	
(a)		(a)				
4002	0.00	0	0	0.00	0.00	Dam bottom elevation
4004	2.00	684	684	0.02	0.02	It was determined that the unnamed dam acts like a closed basin with sufficient capacity to fully retain the 5yr-24-hr, 10yr-24-hr, 50yr-24-hr, and 100yr-24-hr storm rain. See Appendix D for Existing Conditions Hydrologic Summary Outputs.
4006	4.00	9893	10,577	0.24	0.26	
4008	6.00	25232	35,125	0.81	1.06	
4010	8.00	42056	67,289	1.54	2.61	
4012	10.00	59541	101,597	2.33	4.94	
4014	12.00	76471	136,012	3.12	8.06	
4016	14.00	111947	188,418	4.33	12.39	
4018	16.00	151414	263,361	6.05	18.44	
4020	18.00	196129	347,543	7.98	26.41	Dam top elevation

(a) Data Source : The topographic data (LIDAR 2010) provided by DACFC at a 2ft resolution.

TABLE C5-2
Elevation - Storage Volume - Discharge Data and Computations - Reservoir 3
Mesquite Drainage Master plan

Grey box means must input elevation and area data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	Emergency Spillway Discharge	Comment
(ft) (a)	(ft)	(sq ft) (a)	(cu ft)	(ac-ft)	(ac-ft)	(cfs) (b)	
3884	0.00	0	0	0.00	0.00	0.0	Pond bottom invert
3886	2.00	18726	18,726	0.43	0.43	0.0	
3888	4.00	47638	66,364	1.52	1.95	0.0	
3890	6.00	90754	138,392	3.18	5.13	0.0	Emergency Spillway
3892	8.00	90756	181,510	4.17	9.30	1471	Top of Dam

(a) Data Source : The topographic data (LIDAR 2010) provided by DACFC at a 2ft resolution.

(b) Emergency spillway flows were computed based on the following data used in the weir equation:

Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perp. to flow (ft), H = head (ft)

(b) Emergency Spillway C = 2.6 L = 200 Emer Spill Elev.= 3890

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1982.

TABLE C5-3
Reservoir Routing Summary - Existing Ponds
Mesquite Drainage Master Plan

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	Inflow Runoff Volume	Outflow Runoff Volume	Maximum Design Storage Volume (top of embankment)	Peak Storage Volume for Storm Event	Peak Water Surface Elevation	Emergency Spillway Elevation	Pond Invert Elevation	Maximum Pond Depth	Peak Water Depth	Top of Pond Embank ment Elevation	Freeboard to Emergency Spillway Elevation	Freeboard to top of Pond Embankment
		yr / hr a	sq mi	cfs a	cfs a	ac-ft a	ac-ft a	ac-ft b	ac-ft a	ft a	ft b	ft b	ft b	ft	ft b	ft c	ft c
Res-3	Existing	100 / 24	0.1580	245	108	13.5	8.4	9.3	5.4	3890.2	3890.0	3884	8.0	6.2	3892.0	-0.2	1.8
Res-3	Existing	50 / 24	0.1580	191	53	10.7	5.6	9.3	5.2	3890.1	3890.0	3884	8.0	6.1	3892.0	-0.1	1.9
Res-3	Existing	10 / 24	0.1580	91	1	5.5	0.4	9.3	5.1	3890.0	3890.0	3884	8.0	6.0	3892.0	0.0	2.0
Res-3	Existing	5 / 24	0.1580	57	0	3.8	0.0	9.3	3.8	3889.2	3890.0	3884	8.0	5.2	3892.0	0.8	2.8

(a) Refer to Appendix D for the HEC-HMS model output for the pond routing results. Dead storage was simulated for 2ft. below the principal spillway to account coservatively for heavy sediment loads therefore inflow volume is not equal to outflow volume

(b) See this Appendix for all Elevation - Storage Volume - Discharge Data Tables (Table C5-2)

(c) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

TABLE C6-1
Elevation - Storage Volume - Discharge Data and Computations - Proposed Pond 1
Mesquite Drainage Master plan

Grey box means must input elevation and area data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	Discharge	Comment
(ft) (a)	(ft)	(sq ft) (a)	(cu ft)	(ac-ft)	(ac-ft)	(cfs) (b)	
3838	0.00	458424	0	0.00	0.00	0.0	Pond Bottom Elevation
3840	2.00	482412	940,836	21.60	21.60	0.0	Emergency Spillway
3842	4.00	506998	989,410	22.71	44.31	0.0	Pond Top Elevation

(a) Data Source : The topographic data (LIDAR 2010) provided by DACFC at a 2ft resolution.
(b) Pond 1 is a retention pond. However to enable the model to run, ficticious discharge has to be assigned. This was done by using an outlet structure within HMS to simulate a 6-inch outlfow pipe and an emergency spillway length and elevation. This allows the model to compute it's own discharge rating curve.

TABLE C6-2
Proposed Retention Pond 1 Routing Summary
Mesquite Drainage Master Plan

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	Inflow Runoff Volume	Outflow Runoff Volume	Maximum Design Storage Volume (top of embank ment)	Peak Storage Volume for Storm Event	Peak Water Surface Elevation	Emergency Spillway Elevation	Pond Invert Elevation	Maximum Pond Depth	Peak Water Depth	Top of Pond Embankment Elevation	Freeboard to Emergency Spillway Elevation	Freeboard to top of Pond Embankment
		yr / hr a	sq mi a	cfs a	cfs a	ac-ft a	ac-ft b	ac-ft a	ac-ft a	ft b	ft b	ft b	ft	ft b	ft b	ft c	ft c
Pond 1	Proposed	100 / 24	1.7090	372	320	118.6	101.4	44.3	24.9	3840.3	3840.0	3838	4.0	2.3	3842.0	-0.3	1.7
Pond 1	Proposed	50 / 24	1.7090	292	205	90.6	73.4	44.3	24.0	3840.2	3840.0	3838	4.0	2.2	3842.0	-0.2	1.8
Pond 1	Proposed	10 / 24	1.7090	132	46	39.1	22.0	44.3	22.5	3840.1	3840.0	3838	4.0	2.1	3842.0	-0.1	1.9
Pond 1	Proposed	5 / 24	1.7090	87	6	24.5	7.1	44.3	21.8	3840.0	3840.0	3838	4.0	2.0	3842.0	0.0	2.0

(a) Refer to Appendix D for the HEC-HMS model output for the pond routing results. Dead storage was simulated for 2ft. below the principal spillway to account coservatively for heavy sediment loads therefore inflow volume is not equal to outflow volume

(b) See this Appendix for all Elevation - Storage Volume - Discharge Data Tables (Table C6-1)

(c) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

TABLE C7-1

Elevation - Storage Volume - Discharge Data and Computations - Proposed Pond 2

Mesquite Drainage Master Plan

grey box means must input elevation and area data

Contour Elevation NAVD 1988	Depth	Contour Area	Incremental Volume	Incremental Volume	Cumulative Volume	1st Row of Reverse Incline Ports	Principal Spillway Grate Discharge	SUMMATION of reverse incline ports, drains and grate	Principal Spillway 36-in. Outfall Pipe Discharge	Total Principal Spillway / Outfall Pipe Discharge	Emergency Spillway Discharge	Total Discharge Rating Curve	Comment
		Principal Spillway Orifice Diameter (inches)				8.0			36.0				
		Number of Orifices				12.0			1.0				
(ft)		(sq ft)	(cu ft)	(ac-ft)	(ac-ft)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	(cfs)	
(d)		(d)				(a)	(b)		(c)	(e)	(b)		
3832	0.00	0	0	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.0	0	Pond bottom and principal spillway structure invert
3834	2.00	17980	17,980	0.4128	0.4128	0.0	0.0	0.0	4.0	0.1	0.0	4	Highest Invert 1st row of reverse incline ports
3836	4.00	22560	40,540	0.9307	1.3434	28.0	0.0	28.0	16.0	28.0	0.0	16	
3838	6.00	27696	50,256	1.1537	2.4972	39.7	271.5	311.2	32.0	28.0	0.0	32	Emergency Spillway
3840	8.00	33250	60,946	1.3991	3.8963	48.6	768.0	816.6	32.0	28.0	1353.1	1,385	

(a) Ofice equation and coefficient were obtained from Equation 4-10 and Table 4-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1976.

$$Q = Ca\sqrt{2gh}$$ C = 0.590 g=32.2 ft/sec^2, a=area (sq ft) h=head (ft)

$$a = \pi D^2 / 4$$ (full area formula)

(b) Principal spillway box and emergency spillway flows were computed based on the following data used in the Q = CLH^ 1.5 C = discharge coeffient, L = spillway length perp. to flow (ft), H = head (ft)

(b) Emergency Spillway C = 2.6 L = 184 Emer Spill Elev.= 3838.0

(b) Principal Spillway box Grate / Weir C 3.0 L = 32 El. 8 ' x 8' grate = 3836.0

(c) Rating curve computed with the CulvertMaster Program - see Table 506.42 for assumptions and rating curve developed with CulvertMaster

(d) Data Source : 1 ft. accurate topographic design survey

(e) Below the principal spillway grate elevation, the reverse incline ports govern the discharge. After the principal spillway pipe becomes submerged the principal spillway pipe governs the remaining discharge rating curve.

(b) Weir equation and "C" coefficients were obtained from Equation 5-10 and Table 5-3 from "Handbook of Hydraulics" Sixth Edition, by Brater & King, 1982.

TABLE C7-2
Proposed Detention Pond 2 Routing Summary
Mesquite Drainage Master Plan

Detention Pond Name	Existing or Proposed Pond	Storm Return Period / Duration	Drainage Area	Peak Inflow	Peak Outflow	Inflow Runoff Volume	Outflow Runoff Volume	Maximum Design Storage Volume (top of embankment)	Peak Storage Volume for Storm Event	Peak Water Surface Elevation	Emergency Spillway Elevation	Pond Invert Elevation	Maximum Pond Depth	Peak Water Depth	Top of Pond Embankment Elevation	Freeboard to Emergency Spillway Elevation	Freeboard to top of Pond Embankment
		yr / hr a	sq mi a	cfs a	cfs a	ac-ft a	ac-ft b	ac-ft a	ac-ft a	ft b	ft b	ft b	ft	ft b	ft b	ft c	ft c
Pond 2	Proposed	100 / 24	0.0180	11	4	1.1	1.1	3.8	0.4	3833.9	3838.0	3832	8.0	1.8	3840.0	4.2	6.2
Pond 2	Proposed	50 / 24	0.0180	8	3	0.8	0.8	3.8	0.3	3833.4	3838.0	3832	8.0	1.4	3840.0	4.6	6.6
Pond 2	Proposed	10 / 24	0.0180	3	1	0.4	0.4	3.8	0.1	3832.5	3838.0	3832	8.0	0.5	3840.0	5.5	7.5
Pond 2	Proposed	5 / 24	0.0180	2	1	0.2	0.2	3.8	0.1	3832.3	3838.0	3832	8.0	0.3	3840.0	5.7	7.7

(a) Refer to Appendix D for the HEC-HMS model output for the pond routing results. Dead storage was simulated for 2ft. below the principal spillway to account coservatively for heavy sediment loads therefore inflow volume is not equal to outflow volume

(b) See this Appendix for all Elevation - Storage Volume - Discharge Data Tables (Table C7-1)

(c) Negative number indicates the flow depth exceeds referenced elevation - no freeboard available

NOAA Atlas 14, Volume 1, Version 5
Location name: Mesquite, New Mexico, USA*
Latitude: 32.1755°, Longitude: -106.6811°
Elevation: 3848.13 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.219 (0.191-0.249)	0.284 (0.249-0.323)	0.382 (0.335-0.433)	0.458 (0.400-0.519)	0.560 (0.487-0.633)	0.643 (0.555-0.727)	0.729 (0.626-0.823)	0.818 (0.698-0.924)	0.940 (0.795-1.06)	1.04 (0.874-1.18)
10-min	0.333 (0.290-0.379)	0.432 (0.379-0.492)	0.581 (0.509-0.659)	0.697 (0.608-0.790)	0.853 (0.741-0.964)	0.979 (0.845-1.11)	1.11 (0.953-1.25)	1.25 (1.06-1.41)	1.43 (1.21-1.62)	1.58 (1.33-1.79)
15-min	0.413 (0.360-0.470)	0.535 (0.470-0.610)	0.720 (0.631-0.817)	0.864 (0.754-0.979)	1.06 (0.918-1.20)	1.21 (1.05-1.37)	1.38 (1.18-1.55)	1.54 (1.32-1.74)	1.77 (1.50-2.01)	1.96 (1.65-2.23)
30-min	0.556 (0.485-0.633)	0.721 (0.633-0.821)	0.970 (0.850-1.10)	1.16 (1.02-1.32)	1.42 (1.24-1.61)	1.63 (1.41-1.85)	1.85 (1.59-2.09)	2.08 (1.77-2.35)	2.39 (2.02-2.71)	2.65 (2.22-3.00)
60-min	0.688 (0.600-0.783)	0.892 (0.783-1.02)	1.20 (1.05-1.36)	1.44 (1.26-1.63)	1.76 (1.53-1.99)	2.02 (1.75-2.29)	2.29 (1.97-2.59)	2.57 (2.20-2.91)	2.96 (2.50-3.35)	3.27 (2.75-3.71)
2-hr	0.788 (0.694-0.893)	1.02 (0.904-1.16)	1.39 (1.22-1.57)	1.67 (1.46-1.88)	2.05 (1.79-2.31)	2.36 (2.04-2.65)	2.68 (2.30-3.01)	3.02 (2.56-3.39)	3.49 (2.92-3.92)	3.86 (3.20-4.34)
3-hr	0.834 (0.741-0.943)	1.07 (0.954-1.22)	1.44 (1.27-1.62)	1.72 (1.52-1.94)	2.11 (1.85-2.37)	2.42 (2.10-2.71)	2.75 (2.37-3.08)	3.09 (2.64-3.46)	3.56 (3.00-4.00)	3.94 (3.28-4.43)
6-hr	0.949 (0.848-1.06)	1.21 (1.08-1.36)	1.59 (1.42-1.78)	1.88 (1.67-2.10)	2.28 (2.01-2.54)	2.59 (2.27-2.88)	2.91 (2.53-3.24)	3.24 (2.79-3.62)	3.70 (3.15-4.14)	4.06 (3.43-4.56)
12-hr	1.04 (0.931-1.16)	1.32 (1.19-1.48)	1.72 (1.54-1.92)	2.02 (1.80-2.25)	2.42 (2.15-2.69)	2.73 (2.41-3.03)	3.04 (2.67-3.38)	3.36 (2.93-3.75)	3.79 (3.27-4.23)	4.13 (3.54-4.63)
24-hr	1.15 (1.05-1.27)	1.47 (1.33-1.62)	1.92 (1.73-2.12)	2.27 (2.04-2.52)	2.77 (2.45-3.11)	3.18 (2.76-3.62)	3.61 (3.07-4.20)	4.06 (3.39-4.84)	4.72 (3.81-5.85)	5.26 (4.12-6.76)
2-day	1.24 (1.13-1.37)	1.58 (1.44-1.74)	2.06 (1.87-2.27)	2.45 (2.20-2.71)	3.00 (2.65-3.36)	3.45 (3.00-3.92)	3.93 (3.34-4.57)	4.45 (3.69-5.28)	5.18 (4.16-6.37)	5.82 (4.54-7.39)
3-day	1.32 (1.21-1.46)	1.69 (1.54-1.86)	2.21 (2.00-2.43)	2.62 (2.36-2.89)	3.19 (2.83-3.57)	3.65 (3.19-4.13)	4.14 (3.55-4.78)	4.66 (3.91-5.48)	5.41 (4.40-6.57)	6.05 (4.79-7.56)
4-day	1.41 (1.28-1.55)	1.80 (1.64-1.98)	2.35 (2.14-2.59)	2.79 (2.51-3.07)	3.38 (3.01-3.77)	3.85 (3.39-4.35)	4.35 (3.76-4.99)	4.86 (4.12-5.68)	5.63 (4.64-6.77)	6.28 (5.05-7.74)

7-day	**1.59** (1.45-1.75)	**2.04** (1.86-2.24)	**2.67** (2.43-2.93)	**3.17** (2.87-3.49)	**3.86** (3.44-4.29)	**4.41** (3.88-4.96)	**4.99** (4.31-5.70)	**5.59** (4.74-6.50)	**6.44** (5.32-7.70)	**7.12** (5.74-8.72)
10-day	**1.76** (1.60-1.94)	**2.25** (2.05-2.48)	**2.97** (2.70-3.27)	**3.54** (3.19-3.90)	**4.33** (3.85-4.80)	**4.95** (4.34-5.56)	**5.61** (4.83-6.39)	**6.29** (5.32-7.29)	**7.25** (5.96-8.60)	**8.01** (6.45-9.73)
20-day	**2.22** (2.03-2.43)	**2.85** (2.60-3.12)	**3.72** (3.39-4.06)	**4.37** (3.97-4.80)	**5.25** (4.71-5.80)	**5.93** (5.26-6.62)	**6.62** (5.80-7.47)	**7.32** (6.32-8.38)	**8.30** (7.00-9.71)	**9.07** (7.51-10.8)
30-day	**2.64** (2.42-2.89)	**3.38** (3.09-3.69)	**4.36** (3.99-4.77)	**5.10** (4.63-5.59)	**6.08** (5.46-6.71)	**6.82** (6.07-7.60)	**7.56** (6.64-8.53)	**8.31** (7.19-9.51)	**9.30** (7.89-10.9)	**10.1** (8.43-12.1)
45-day	**3.19** (2.92-3.47)	**4.05** (3.72-4.43)	**5.18** (4.75-5.66)	**6.01** (5.49-6.57)	**7.07** (6.40-7.79)	**7.86** (7.05-8.72)	**8.64** (7.67-9.68)	**9.39** (8.25-10.7)	**10.4** (8.96-12.0)	**11.1** (9.46-13.0)
60-day	**3.65** (3.34-3.98)	**4.64** (4.26-5.07)	**5.93** (5.44-6.46)	**6.85** (6.26-7.48)	**8.03** (7.28-8.81)	**8.88** (7.99-9.81)	**9.71** (8.67-10.8)	**10.5** (9.27-11.9)	**11.5** (10.0-13.2)	**12.3** (10.6-14.3)

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

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

Please refer to NOAA Atlas 14 document for more information.

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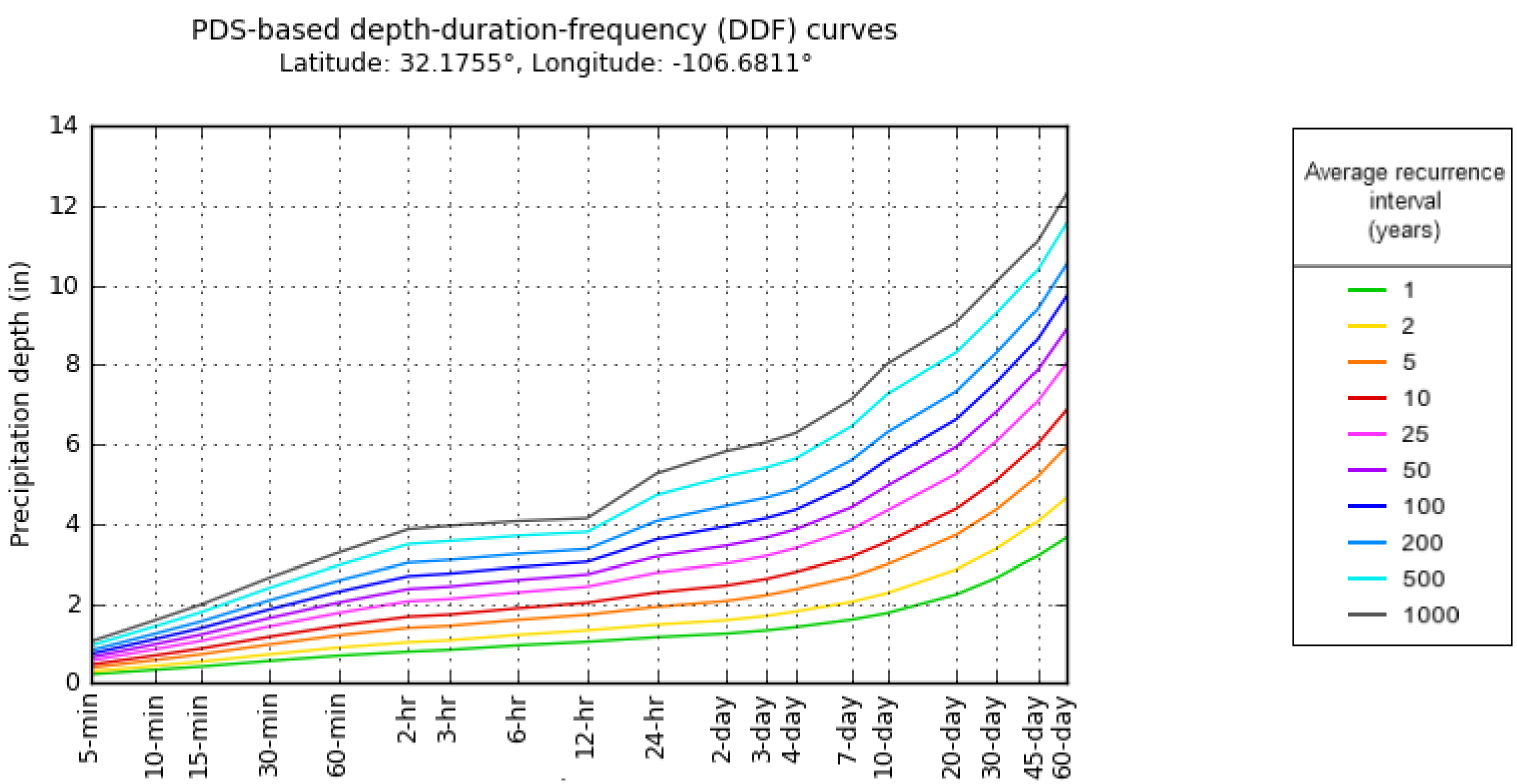
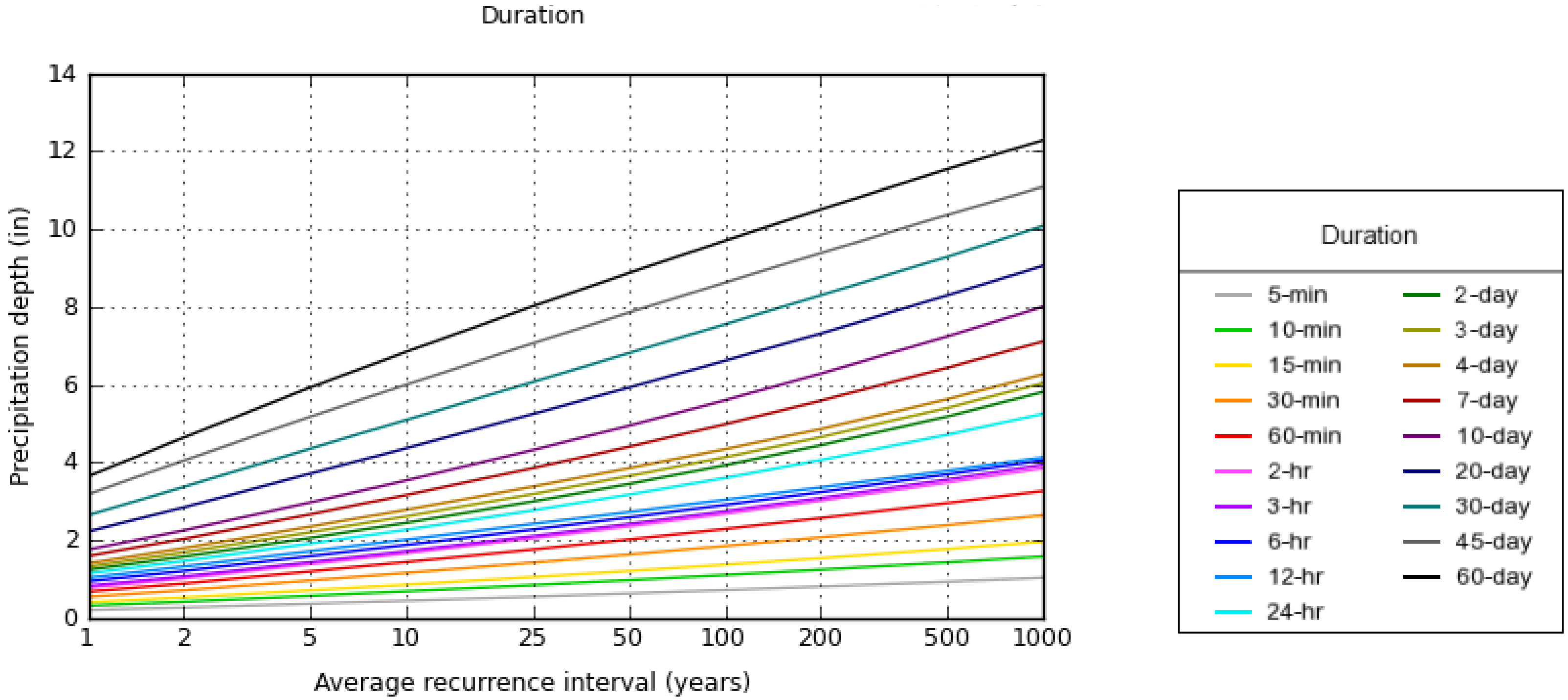
PF graphical





NOAA Atlas 14, Volume 1, Version 5

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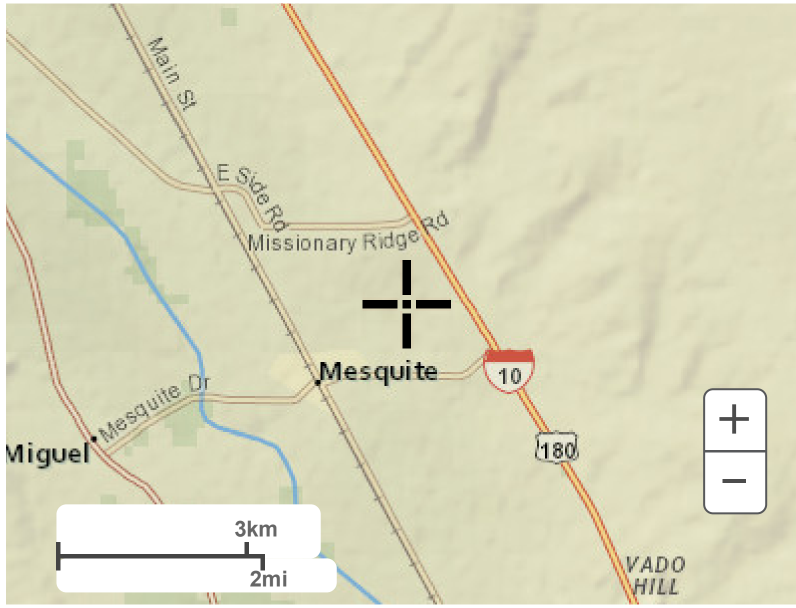
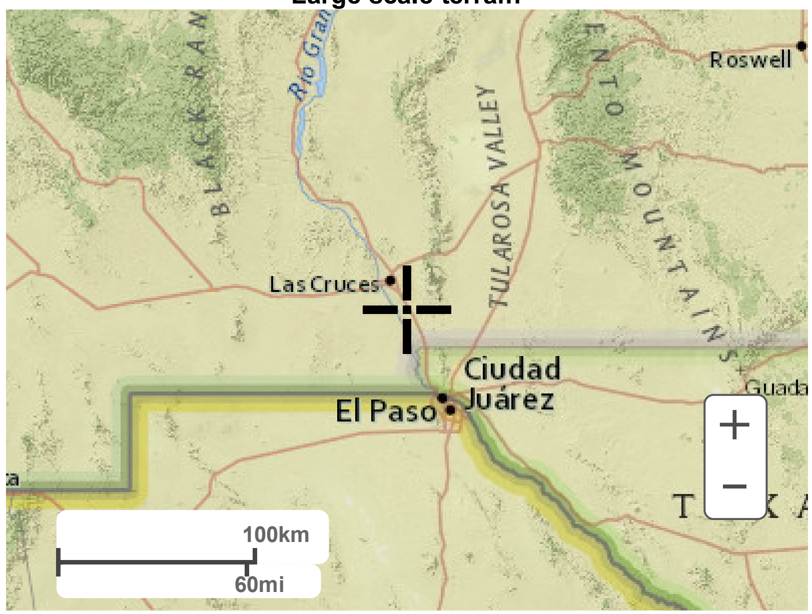
Maps & aerials

Small scale terrain

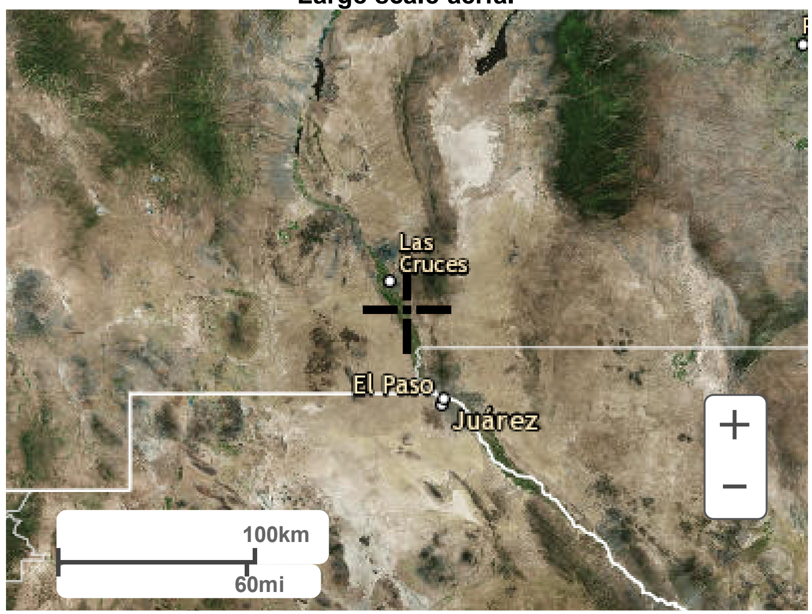


Large scale terrain



Large scale map

Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

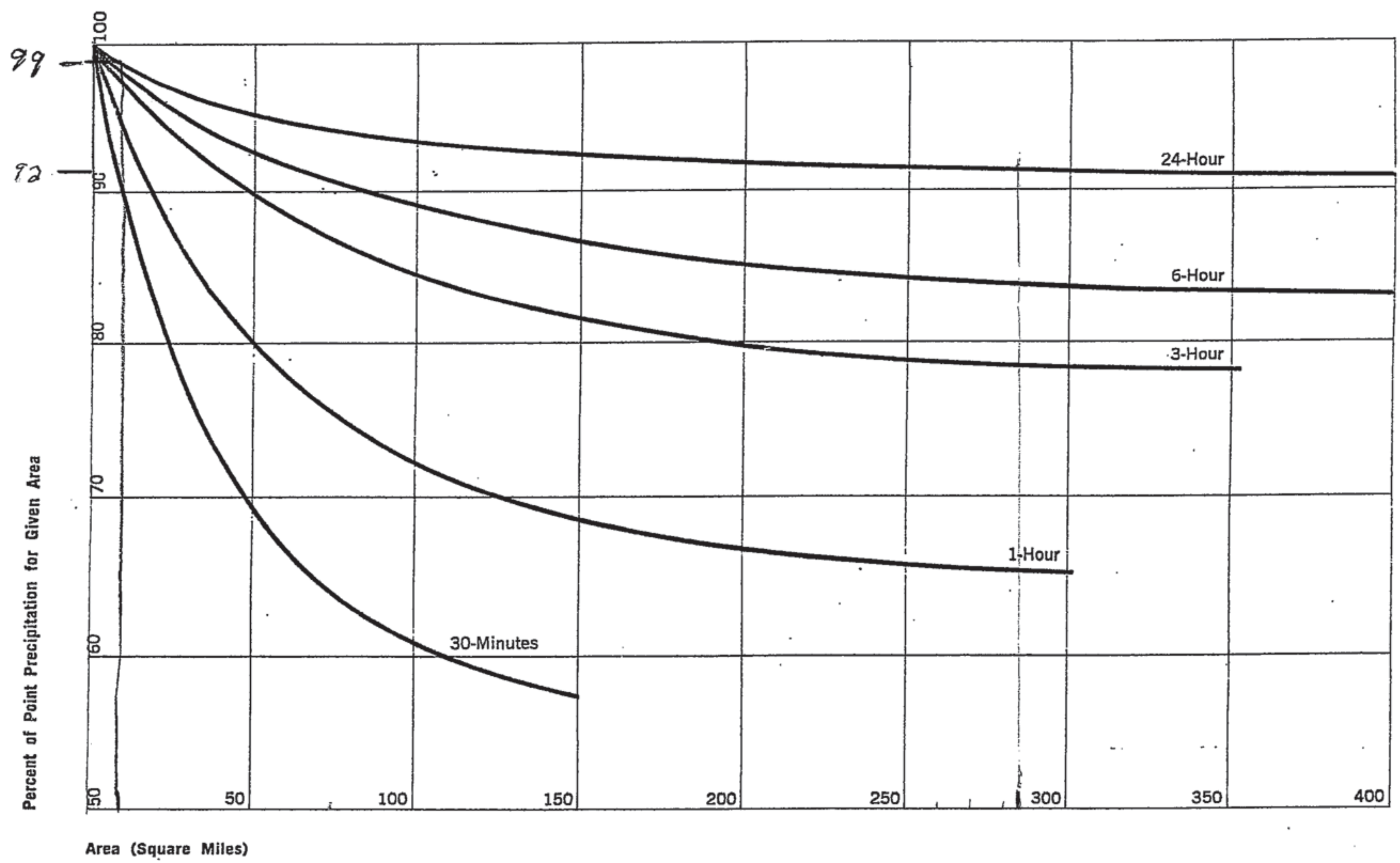


Figure 14. *Depth-Area curves.*

NOAA ATLAS 2 VOL. IV – NEW MEXICO 1973
PRECIPITATION FREQUENCY
ATLAS OF THE WESTERN UNITED STATES

USDA

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Conservation
Engineering
Division

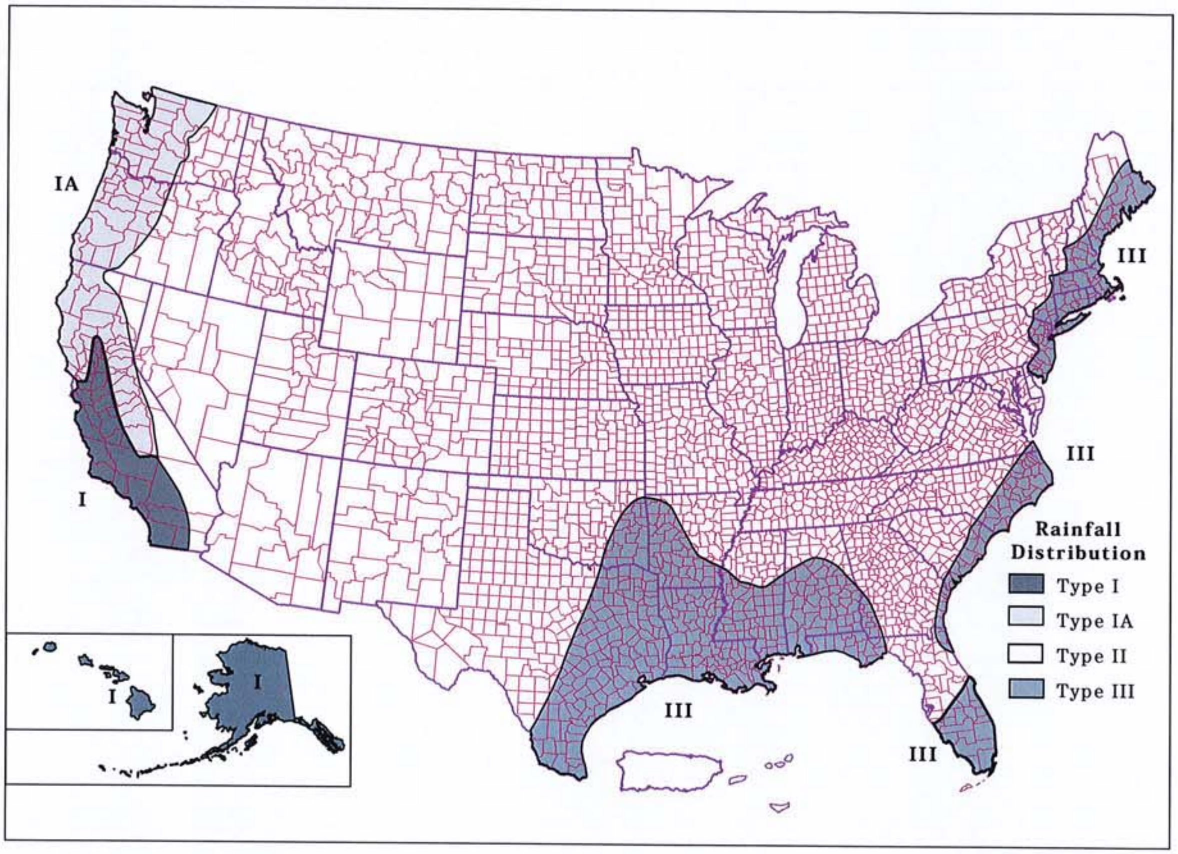
Technical
Release 55

June 1986

Urban Hydrology for Small Watersheds

TR-55

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands 1/

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition 2/	A 3/	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

Chapter 3 Time of Concentration and Travel Time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

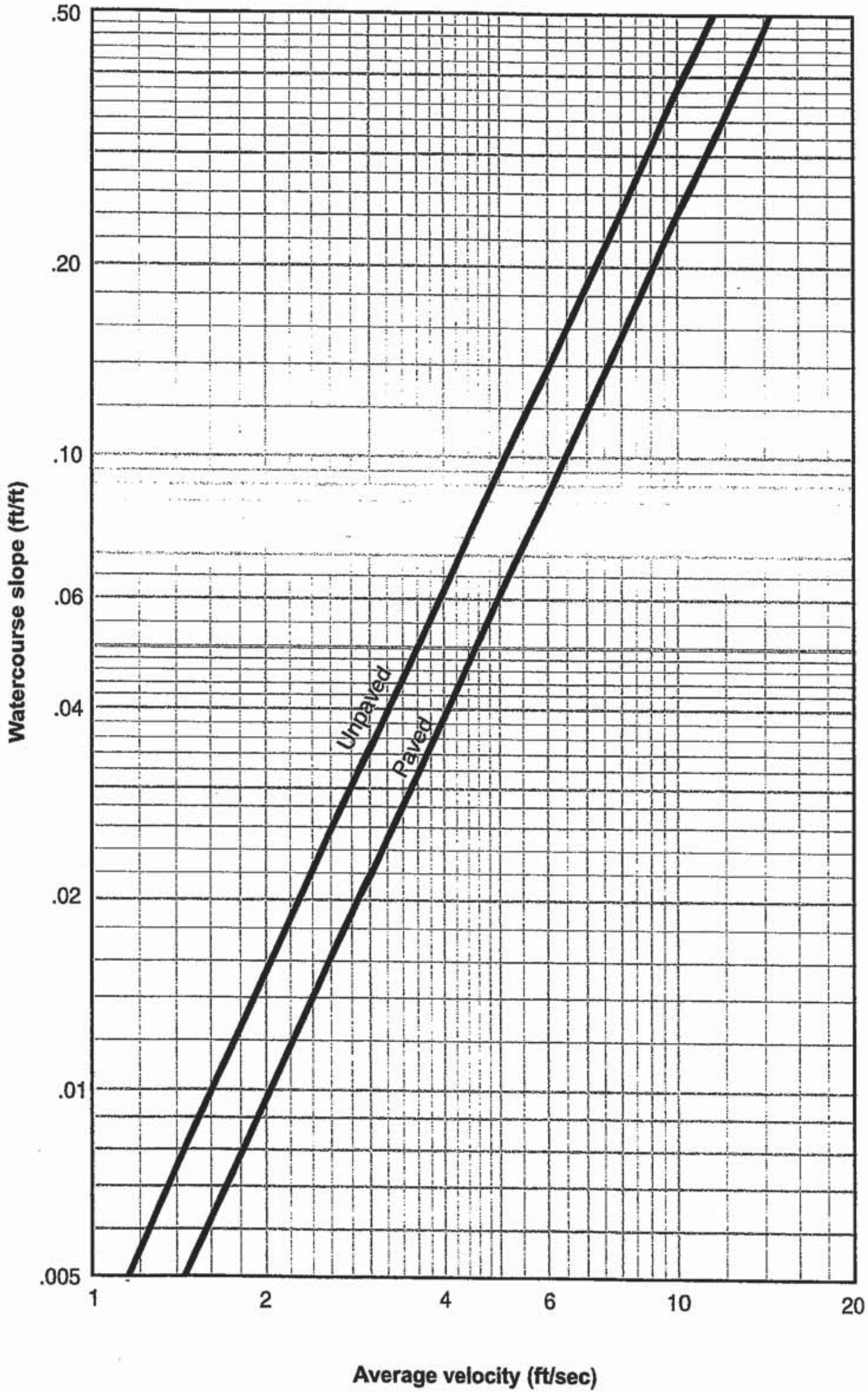
Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



Appendix F Equations for figures and exhibits

This appendix presents the equations used in procedure applications to generate figures and exhibits in TR-55.

Figure 2-1 (runoff equation):

$$Q = \frac{\left[P - .2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where
Q = runoff (in)
P = rainfall (in)
CN = runoff curve number

Figure 2-3 (composite CN with connected impervious area):

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)$$

where
CN_c = composite runoff curve number
CN_p = pervious runoff curve number
P_{imp} = percent imperviousness.

Figure 2-4 (composite CN with unconnected impervious areas and total impervious area less than 30%):

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)(1 - 0.5R)$$

where
R = ratio of unconnected impervious area to total impervious area.

Figure 3-1 (average velocities for estimating travel time for shallow concentrated flow):
Unpaved $V = 16.1345\,(s)^{0.5}$
Paved $V = 20.3282\,(s)^{0.5}$

where

V= average velocity (ft/s)
s = slope of hydraulic grade line (watercourse slope, ft/ft)

These two equations are based on the solution of Manning's equation (eq. 3-4) with different assumptions for n (Manning's roughness coefficient) and r (hydraulic radius, ft). For unpaved areas, n is 0.05 and r is 0.4; for paved areas, n is 0.025 and r is 0.2.

Exhibit 4 (unit peak discharges for SCS tvpe I, IA, II, and III distributions):

$$\log(q_u) = C_o + C_1 \log(T_c) + C_2\left[\log(T_c)\right]^2$$

where
q_u = unit peak discharge (csm/in)
T_c = time of concentration (hr) (minimum, 0.1; maximum, 10.0)
C_0, C_1, C_2 = coefficients from table F-1

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$\frac{V_S}{V_r} = C_o + C_1\left(\frac{q_o}{q_1}\right) + C_2\left(\frac{q_o}{q_1}\right)^2 + C_3\left(\frac{q_o}{q_1}\right)^3$$

where
V_s/V_r = ratio of storage volume (V_s) to runoff volume (V_r)
q_o/q_i = ratio of peak outflow discharge (q_o) to peak inflow discharge (q_i)
C_0, C_1, C_2, C_3 = coefficients from table F-2

Table F-1 Coefficients for the equation used to generate exhibits 4-I through 4-III

Rainfall type	I_a/P	C_0	C_1	C_2
I	0.10	2.30550	-0.51429	-0.11750
	0.20	2.23537	-0.50387	-0.08929
	0.25	2.18219	-0.48488	-0.06589
	0.30	2.10624	-0.45695	-0.02835
	0.35	2.00303	-0.40769	0.01983
	0.40	1.87733	-0.32274	0.05754
	0.45	1.76312	-0.15644	0.00453
	0.50	1.67889	-0.06930	0.0
IA	0.10	2.03250	-0.31583	-0.13748
	0.20	1.91978	-0.28215	-0.07020
	0.25	1.83842	-0.25543	-0.02597
	0.30	1.72657	-0.19826	0.02633
	0.50	1.63417	-0.09100	0.0
II	0.10	2.55323	-0.61512	-0.16403
	0.30	2.46532	-0.62257	-0.11657
	0.35	2.41896	-0.61594	-0.08820
	0.40	2.36409	-0.59857	-0.05621
	0.45	2.29238	-0.57005	-0.02281
	0.50	2.20282	-0.51599	-0.01259
III	0.10	2.47317	-0.51848	-0.17083
	0.30	2.39628	-0.51202	-0.13245
	0.35	2.35477	-0.49735	- 0.11985
	0.40	2.30726	-0.46541	-0.11094
	0.45	2.24876	-0.41314	-0.11508
	0.50	2.17772	- 0.36803	- 0.09525

Table F-2 Coefficients for the equation used to generate figure 6-1

Rainfall distribution (appendix B)	C_0	C_1	C_2	C_3
I, IA	0.660	-1.76	1.96	-0.730
II, III	0.682	-1.43	1.64	-0.804

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \quad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{[eq. 3-4]}$$

where:

V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/p_w
a = cross sectional flow area (ft²)
p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

servoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

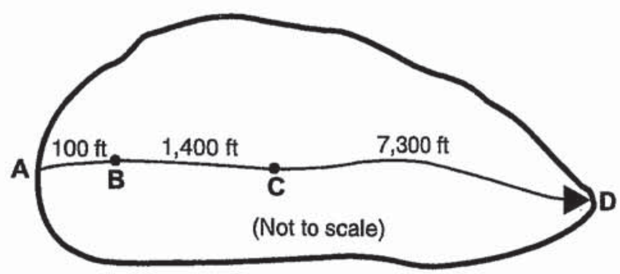
- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- The minimum T_c used in TR-55 is 0.1 hour. = 6 minutes
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB: Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft. Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1,400 ft. Segment CD: Channel flow; Manning's n = .05; flow area (a) = 27 ft²; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7,300 ft.

See figure 3-2 for the computations made on worksheet 3.



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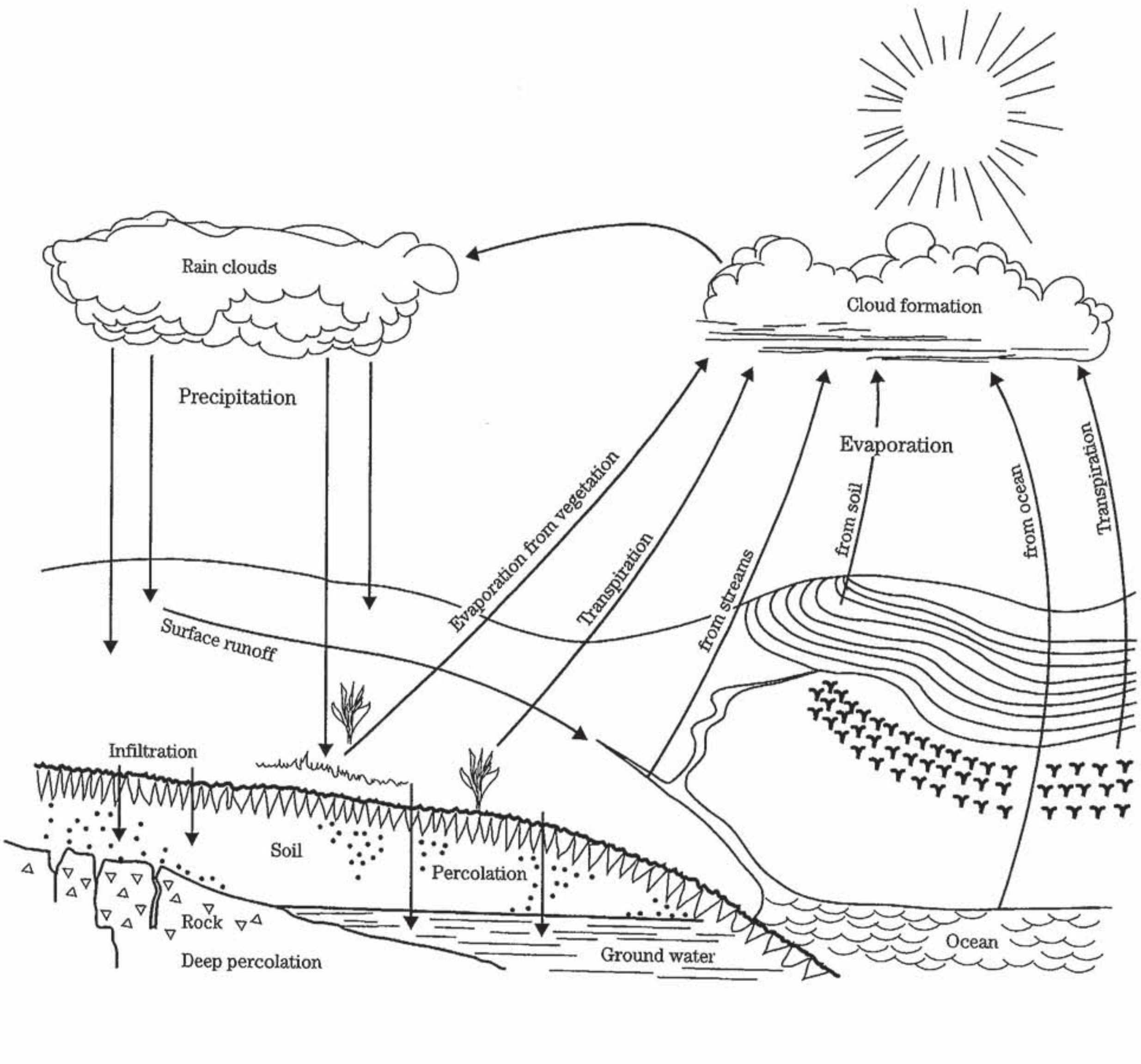
Part 630 Hydrology
National Engineering Handbook

Chapter 15 Time of Concentration



Chapter 15 Time of Concentration

630.1500 Introduction

This chapter contains information on the watershed characteristics called travel time, lag, and time of concentration. These watershed characteristics influence the shape and peak of the runoff hydrograph. The National Engineering Handbook, Part 630, Hydrology, Chapter 16, Hydrographs (NEH630.16) contains information on development of runoff hydrographs. The methods presented in this chapter are suitable for use with any hydrologic model which uses time of concentration or lag as an input parameter. Users of models are cautioned to be mindful of specific model input parameters and limitations, which may not be the same as limitations of a particular time of concentration estimation tool. Limitations of specific models are not described in this chapter.

630.1501 Definitions and basic relations

(a) Types of flow

Rainfall over a watershed that reaches the ground will follow one of four potential paths. Some will be intercepted by vegetation and evaporate into the atmosphere. Some will fall onto the ground surface and evaporate. Some will infiltrate into the soil. Some will run directly off from the ground surface. Depending on total storm rainfall and a variety of other factors, a portion of the water will find its way to the stream system. Of the portion that makes its way to the stream system, there are four types of flow that may occur singly or in combination throughout the watershed. Figure 15–1 illustrates these types of flow.

Surface flow—In figure 15–1, point 1 represents a location where precipitation falls on a watershed. Surface runoff is represented by lines with arrows showing travel along the surface of the watershed from point 1 to point 2. Surface flow takes the form of sheet flow, shallow concentrated flow, and/or channel flow.

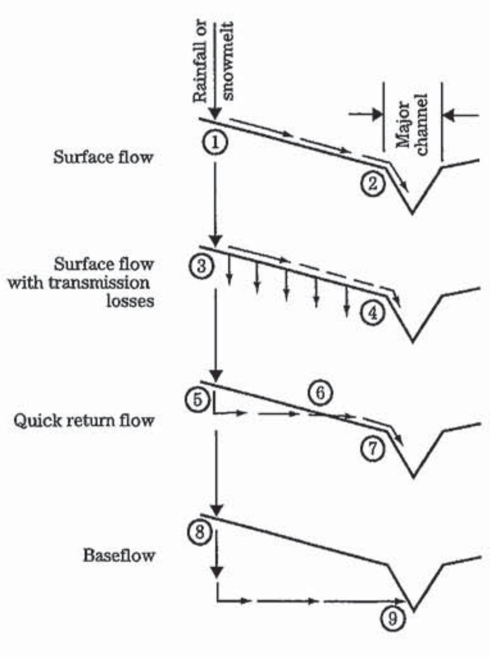
Surface flow with transmission losses—In figure 15–1, point 3 represents a location where precipitation falls on a watershed. Surface flow is represented by the lines with arrows showing travel along the surface of the watershed from point 3 to point 4, while the transmission losses are represented by the lines with arrows indicating water infiltrating into the ground surface. In this type of flow, runoff is largely infiltrated into the ground before reaching the stream channel. This type of flow is common in arid, semiarid and subhumid climates, and in karst areas. The distance from point 3 to point 4 depends on the amount of runoff, moisture characteristics of the soil, topography, and hydraulic features of the flow.

Interflow or quick return flow—In figure 15–1, point 5 represents a location where precipitation falls on a watershed. Water is infiltrated at this point, flows rapidly underground, and eventually returns to the surface at point 6. From point 6, it continues as surface flow until reaching the stream channel at point 7. This flow appears rapidly in comparison to baseflow and is generally much in excess of normal baseflow. It is common in humid climates and in watersheds with soils having high infiltration capacities and moderate to steep slopes.

Baseflow—In figure 15–1, point 8 represents a location where precipitation falls on a watershed, infiltrates directly into the ground, and enters the ground water table. From there, it flows slowly until it eventually reappears, entering a stream channel at point 9. This type of flow has little effect on flood peaks in small watersheds. However, if baseflow is a factor in flood flows, it is usually added to the base of the hydrograph.

In figure 15–1, flows from points 1 to 2, 3 to 4, and 6 to 7 can be measured directly. Flow from points 5 to 6 and 8 to 9 are usually determined indirectly by storm and hydrograph analyses or by field observation of rainfall and runoff. Ground water movement is determined indirectly by analyses of precipitation, soil moisture movements, and evapotranspiration.

Figure 15–1 Types of flow



(b) Travel time

Travel time (T_t) is the time it takes water to travel from one location to another. Travel time between two points is determined using the following relationship:

$$T_t = \frac{\ell}{3{,}600V} \qquad \text{(eq. 15–1)}$$

where:

T_t = travel time, h
ℓ = distance between the two points under consideration, ft
V = average velocity of flow between the two points, ft/s
3,600 = conversion factor, s to h

(c) Lag

Lag is the delay between the time runoff from a rainfall event over a watershed begins until runoff reaches its maximum peak. Conceptually, lag may be thought of as a weighted time of concentration where, if for a given storm, the watershed is divided into bands of area (fig. 15–2), the travel times from the centroids of the areas to the main watershed outlet may be represented by the following relationship:

$$L = \frac{\sum\left(a_x Q_x T_{tx}\right)}{\sum\left(a_x Q_x\right)} \qquad \text{(eq. 15–2a)}$$

$$L = \frac{\sum\left(a_x Q_x T_{tx}\right)}{AQ_a} \qquad \text{(eq. 15–2b)}$$

where:

L = lag, h
a_x = increment of watershed area, mi^2
Q_x = runoff in inches from area a_x, in
T_{tx} = travel time from the centroid of a_x to the point of reference, h
A = total area of the watershed above the point of reference, mi^2
Q_a = total runoff, in

In general hydrologic modeling practice, lag is not computed using equation 15–2a or 15–2b. Instead, time of concentration is estimated using one of the methods in this chapter. In cases where only a peak discharge and/or hydrograph are desired at the watershed outlet and watershed characteristics are fairly homogenous, the watershed may be treated as a single area. A time of concentration for that single area is required. A hydrograph is then developed using the methods described in NEH630.16. However, if land use, hydrologic soil group, slope, or other watershed characteristics are not homogeneous throughout the watershed, the approach is to divide the watershed into a number of smaller subareas, which requires a time of concentration estimation for each subarea. Hydrographs are then developed for each subarea by the methods described in NEH630.16 and routed appropriately to a point of reference using the methods described in NEH630.17, Flood Routing.

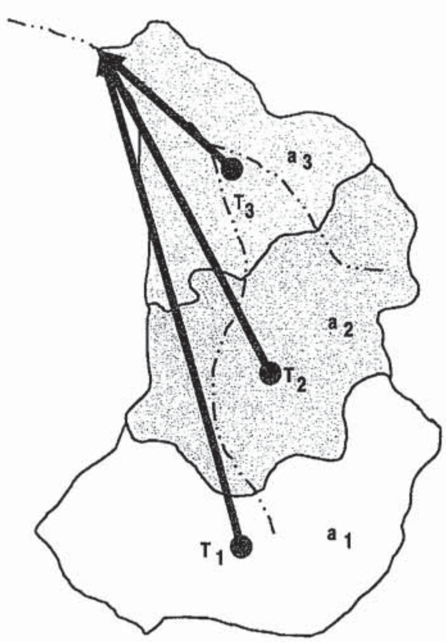
In hydrograph analysis, lag is the time interval between the center of mass of the excess rainfall and the peak runoff rate (fig. 15–3).

(d) Time of concentration

Time of concentration (T_c) is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet. The hydraulically most distant point is the point with the longest travel time to the watershed outlet, and not necessarily the point with the longest flow distance to the outlet. Time of concentration is generally applied only to surface runoff and may be computed using many different methods. Time of concentration will vary depending upon slope and character of the watershed and the flow path.

In hydrograph analysis, time of concentration is the time from the end of excess rainfall to the point on the falling limb of the dimensionless unit hydrograph (point of inflection) where the recession curve begins (fig. 15–3).

Figure 15–2 Conceptual watershed illustrating travel time from the centroid (gray dot) of each band of area to the watershed outlet



(e) Relation between lag and time of concentration

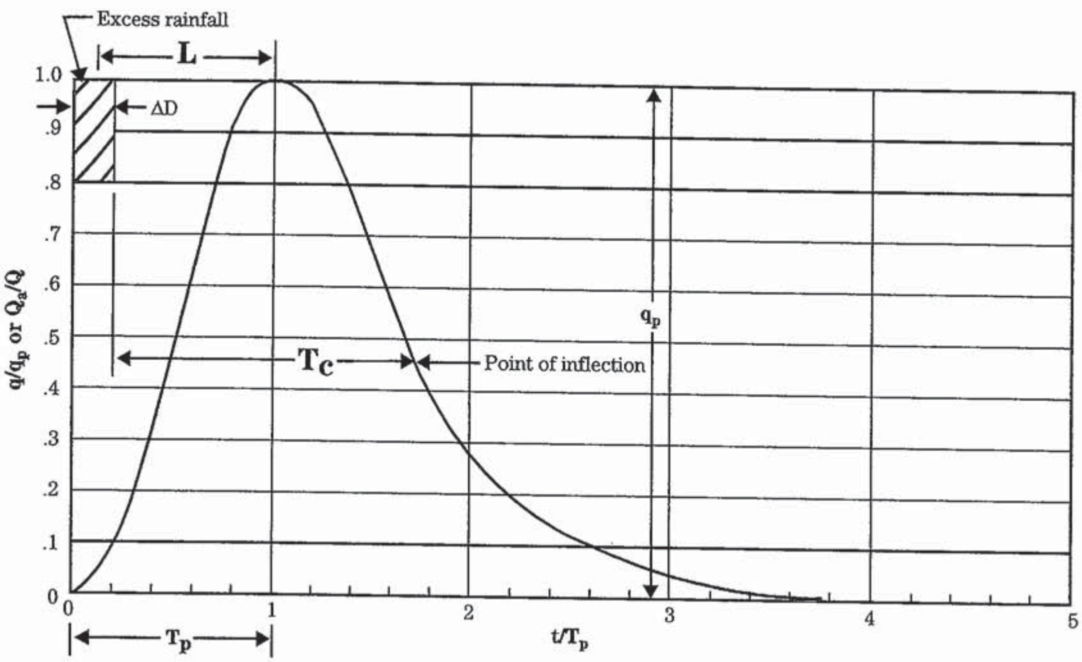
Various researchers (Mockus 1957; Simas 1996) found that for average natural watershed conditions and an approximately uniform distribution of runoff:

$$L = 0.6T_c \qquad \text{(eq. 15–3)}$$

where:
L = lag, h
T_c = time of concentration, h

When runoff is not uniformly distributed, the watershed can be subdivided into areas with nearly uniform flow so that equation 15–3 can be applied to each of the subareas.

Figure 15–3 The relation of time of concentration (T_c) and lag (L) to the dimensionless unit hydrograph



where:

L = Lag, h

T_c = time of concentration, h

T_p = time to peak, h

ΔD = duration of excess rainfall, h

t/T_p = dimensionless ratio of any time to time to peak

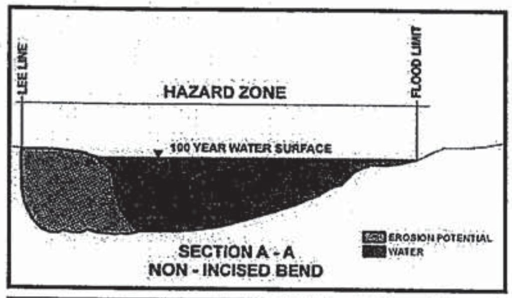
q = discharge rate at time t, ft^3/s

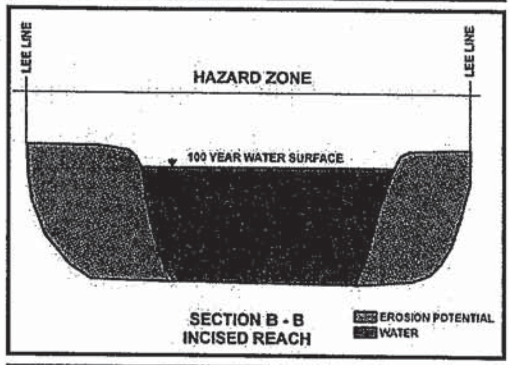
q_p = peak discharge rate at time T_p, ft^3/s

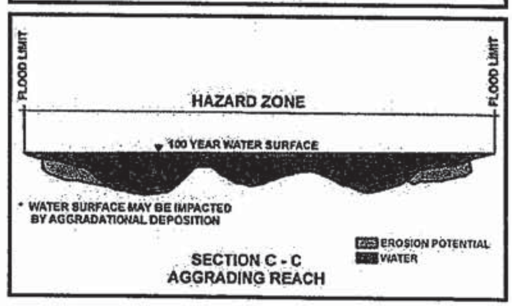
Q_a = runoff volume up to t, in

Q = total runoff volume, in

SEDIMENT AND EROSION DESIGN GUIDE







Prepared for **Southern Sandoval County Arroyo Flood Control Authority**
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relatively low wash-load concentrations. Results from this equation are often in the lower range of realistic values. Because they are simple and have a history of successful use in the greater Albuquerque area, these equations are described in more detail in **Appendix C.**

3.3.6. Bulking Factors for the SSCAFCA Area

Discharges estimated using standard rainfall-runoff procedures typically do not account for the presence of sediment in the flow. At high sediment loads, the total volume of the water/sediment mixture, and thus, the peak design discharges, can be substantially higher than the corresponding clear-water values. The following relation provides a means of adjusting the clear-water discharges for the presence of the transported sediment if the sediment load is known:

$$B_f = \frac{Q + Q_{s\,total}}{Q} = \frac{1}{1 - \dfrac{C_s/10^6}{S_g - \left(C_s/10^6\right)\left(S_g - 1\right)}} \tag{3.24}$$

where B_f = bulking factor,
Q = clear-water discharge,
$Q_{s\,total}$ = **total** sediment load (i.e., combination of bed material and wash load),
C_s = **total** sediment concentration by weight, and
S_g = specific gravity of the sediment.

This relationship indicates that the bulked discharge for a water/sediment mixture at the upper limit of concentrations for water floods (200,000 ppm by volume or 410,000 ppm by weight) would be about 25 percent greater than the clear water discharge (i.e., a bulking factor of 1.25) (**Figure 3.8**).

Because specific knowledge of the sediment load is often not available, conservative estimates of the bulking factor that can be applied to a range of potential design discharges were made by applying the MPM-Woo procedure for a typical, rectangular cross section with width-depth ratio (F_D) at the dominant discharge (Q_D) of 40, assuming critical flow conditions and a range of median (D_{50}) particle sizes. (Dominant discharge is defined, and a method for estimating its magnitude is provided in the text box on the next page.) The assumed width-depth ratio (F) of 40 is based on data from a variety of existing, naturally adjusted arroyos (Leopold and Miller, 1956; Harvey et al., 1985). The assumption of critical flow is based on the observation that average Froude Numbers (F_r) in stable sand-bed streams rarely exceed 0.7 to 1.0 (Richardson, personal communication) at high discharges. It should also be noted that current FEMA procedures for evaluating hydraulic conditions on alluvial fans is based on the assumption of critical flow (F_r = 1). Based on analysis of a wide range of arroyos in the greater Rio Rancho and Albuquerque area, the dominant discharge typically has a recurrence interval in the range of 5 to 10 years under relatively undeveloped conditions, and this decreases to 3 to 5 years under highly developed conditions due, primarily, to the increase in runoff during frequently occurring storms. The peak discharge associated with other recurrence interval flows was estimated using average ratios for conditions in the greater Rio Rancho and Albuquerque area. The 100-year peak discharge, for example, averages about five times the dominant discharge. Bulking factors estimated using the above assumptions for the 100-year peak are shown in **Figure 3.9** for channels with dominant discharge ranging from 50 to 1,000 cfs and median (D_{50}) bed-material sizes ranging from 0.5 to 4 mm. As shown in the figure, the bulking factors range from about 1.01 for small arroyos (W_d< = 50 cfs) with relatively coarse bed material (D_{50} = 4 mm) to a maximum of 1.19 for larger channels (Q_D> = 500 cfs) and relatively fine bed material (D_{50} <= 0.5 mm). Estimated bulking factors for other recurrence interval events for the same range of channel and median bed-material sizes are provided in **Table 3.6**.

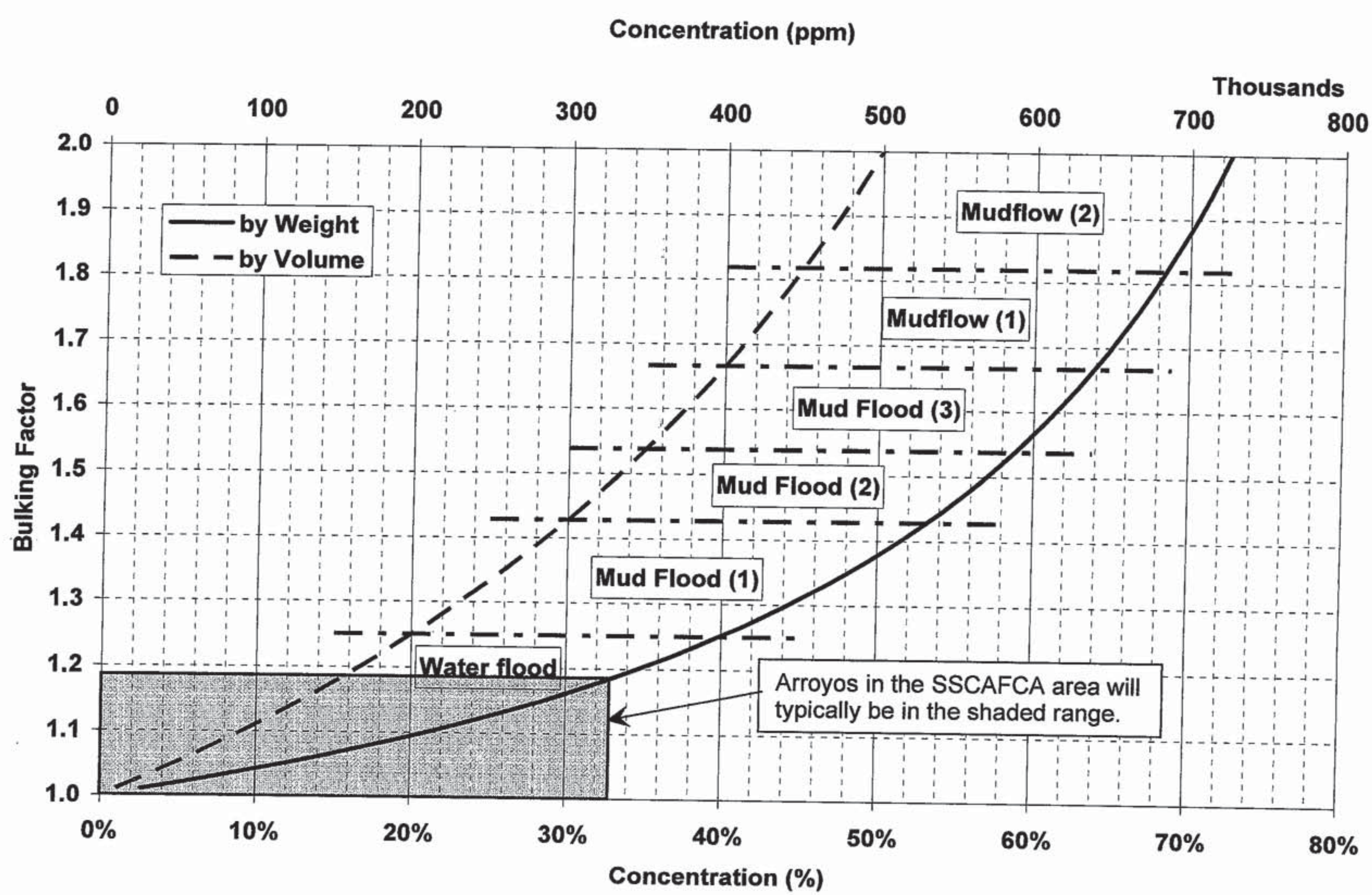

Figure 3.8. Relationship between total sediment concentration and bulking factor.

CHAPTER 4
HYDROLOGY FOR DRAINAGE SYSTEM DESIGN AND ANALYSIS

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Cottonwood, Arizona

4.1 PEAK RUNOFF ESTIMATES

4.1.1 The Rational Formula

The hydraulic sizing of drainage and conveyance structures in urban settings always requires estimation of peak flow rates. Historically, the venerable "*Rational method*" has been the tool of choice for most practicing engineers around the world. Although the method definitely has its place in hydrologic design, it is routinely misapplied and overextended.

The roots of this methodology date as far back as 1851 (Mulvaney, 1851), and certainly as far back as 1889 (Kuichling, 1889). See discussion on chapter 1. The concept is attractive and easy to understand. If rainfall occurs over a basin at a constant intensity for a period of time that is sufficient to produce steady state runoff at the outlet or design point, then the peak outflow rate will be proportional to the product of rainfall intensity and basin area. In the United States, the method is commonly expressed by the equation known as the "*Rational formula*":

$$Q = C \cdot I \cdot A \tag{4.1}$$

where Q = peak runoff rate (cfs)
C = dimensionless runoff coefficient used to adjust for abstractions from rainfall
I = rainfall intensity for a duration that equals time of concentration of the basin (in/hr)
A = basin area (ac)

In English units, it turns out that the dimensions of the product $I \cdot A$ are ac · in/hr, and 1.0 ac · in/hr is very nearly equivalent to 1.0 cfs. In SI units, the equation must be made dimensionally homogeneous (e.g. if A is hectares and I is cm/hr, then the product $C \cdot I \cdot A$ must be multiplied by 0.00278 to make the dimensions on Q equal to cms).

Since its inception, the Rational formula has been discussed extensively in the published literature and in theses. Most of its limitations and shortcomings are well documented, but these constraints are largely ignored by most practicing engineers. For credible engineering

HYDROLOGY FOR DRAINAGE SYSTEM DESIGN AND ANALYSIS

The choice of reporting the SEP as a percentage has the advantage of informing the reader about the approximate scatter about the regression in a direct way. However, where it is reported as a single percentage, it may be somewhat misleading. For instance, in the previous example, the difference between the regression estimate and the lower bound is greater than the difference for the upper bound. The average difference is 47.7% [0.5 · (39100 + 58500)/100000]. Thus, reportage of a singe SEP percentage implies a symmetry about the regression estimate that doesn't exist, but it is still true that as the SEP increases, the reliability of the regression estimate decreases.

In any event, the SEP should be used as a qualitative indicator of the relative reliability of any particular peak flow equation. An informal scan of equations for a few states indicates that the SEP may vary from roughly 20% to 150%, with most being in the range of 30% to 50%. Although there seems to be no published formal guidance, alternative methods of estimating peak flow rates should be considered whenever the SEP is greater than 50%.

4.2 HYDROGRAPH METHODS

When watersheds are large, that is, when they are comprised of two or more smaller watersheds whose streamflow at the confluence with common collector channel can be expected to be displaced in time, where storage influences the time distribution of flow in a stream, or where storage is a part of the design problem, peak flow methods are inappropriate for hydrologic design. In these instances, it is necessary to estimate the entire flow hydrograph. A number of computer programs (models) are available to do the requisite hydrologic and hydraulic computations. Most of these programs have a number of options for each element of the process that begins with rainfall and ends with a hydrograph at some point in the system. Conceptually, the process starts with rainfall over a sub watershed(s) at the periphery of a larger system. The rainfall is transformed into a hydrograph of direct runoff at the outlet of the sub watershed. The hydrograph is then combined with a hydrograph from an adjacent basin and/or is routed through a channel to the next downstream point of interest.

There are two types of computer programs (models) for doing hydrologic and hydraulic computations for a system: continuous simulation models and event-based models. Event-based models are used for nearly all design problems. Discussion in this chapter will be restricted to methods embedded in event-based models. Furthermore, it will be restricted to elements related to hydrograph computations. Flood routing is covered in chapters 7 and 8.

4.2.1 Rainfall Events for Design—Design Hyetographs

The process of computing a hydrograph begins with selection of a design storm, the first step of which is to select a design frequency. In an event-based design using methods of synthetic hydrology, the frequency of the storm event is assumed to equal the frequency of the resulting computed peak flow rate on the hydrograph. This is probably not true for individual events, but it is hoped that it approaches reality over the long term. In any event, there is currently no acceptable alternative.

Often, the local approving authority (city, county, drainage district, etc.) will specify the level of design to be used for any particular type of structure. In the absence of statutory or regulatory specifications, the Table 4.5 (excerpted from Table 13.1.1 in Chow et al., 1988) shows recurrence intervals that are commonly used in the practice.

Next, duration of the rainfall event should be selected so as to be at least as long as the time of concentration of the entire system that is under analysis. Time of concentration has been discussed Section 4.1.1. In published rainfall atlases, depth of rain is directly proportional to duration while average intensity is inversely proportional to duration. Everything

TABLE 4.5 Common Design Frequencies for Hydraulic Structures

Type of structure	Return period (years)
Highway culverts:	
Low traffic	5–10
Intermediate traffic	10–25
High traffic	50–100
Highway bridges	
Secondary system	10–50
Primary system	50–100
Urban drainage	
Storm sewers in small cities	2–25
Storm sewers in large cities	25–50
Airfields	
Low traffic	5–10
Intermediate traffic	10–25
High traffic	50–100

being equal, higher rainfall intensities result in higher runoff rates, while greater rainfall depths result in greater volumes of runoff. It is seldom possible to know in advance whether design of a hydraulic structure will be more sensitive to peak runoff rates or to runoff volumes. Therefore, it is good practice to select several rainfall durations and compute the runoff for each.

Often, regulatory authorities will supply IDF or DDF data. However, peak flows computed by hydrograph methods do not require that rainfall durations equal time of concentration. Therefore, it is usually more efficient to choose durations that equal or exceed the time of concentration, and that are divisible by some convenient fraction of an hour (e.g. 15 minutes, 20 minutes, 30 minutes). As mentioned earlier, it is always best, but seldom practicable, to use rainfall frequency relations that are derived from local rainfall records, provided they have a sufficient period of record and suitable quality. Existing rainfall atlases (e.g. Hershfield, 1961; Miller, et al., 1973; Frederick, et al., 1977; Huff and Angel, 1992) show rainfall for a number of frequencies for a commensurate number of durations such that design values can be taken directly from an appropriate atlas.

The design rainfall must be distributed in time to approximate (in a gross sense) a naturally occurring event comprised of a series of short duration segments whose intensity varies from segment to segment. A histogram (or table) that depicts rainfall intensity versus time is called a *hyetograph*. In design, the sequential increments of rainfall must be of equal duration. A good rule of thumb is to select the time increment to be

$$\frac{t_c}{5} \leq \Delta t \leq \frac{t_c}{3} \tag{4.7}$$

where t_c = time of concentration
Δt = the duration of each time segment of the hyetograph (period of constant intensity)

This guideline ensures that steady state runoff cannot occur during any individual segment of constant intensity (as is the case in nature). At the same time, it gives reasonable detail to the mass arrival characteristics of the rainfall. For convenience of computation, Δt should

HYDROLOGY FOR DRAINAGE SYSTEM DESIGN AND ANALYSIS 4.11

be an integer number of minutes and the total event duration should be an integer multiple of Δt.

A number of procedures have been developed for synthesizing hyetographs. Hereafter, these will be called hyetograph methods. Some (Kiefer and Chu, 1957; Huff, 1967; Pilgrim and Cordery, 1975; Yen and Chow, 1980; Soil Conservation Service, 1986) have developed procedures that derive from an analysis of temporal distributions of naturally occurring rainfall. Pilgrim and Cordery (1975) take a quasi-probabilistic approach that tends to preserve the position in time of the periods of highest intensity. Their procedure usually results in a multimodal distribution, whereas the other methods derived from analysis of naturally occurring rainfall result in unimodal distributions. Other arbitrary methods such as the alternating block method (Chow, Maidment, Mays; 1988) and a similar unnamed approach for creating a Probable Maximum Precipitation hyetograph (U.S. Bureau of Reclamation, 1974) rearrange rainfall segments so that the greatest depth of rainfall occurs prior to the period of peak intensity, and peak intensity is centered in the storm.

Application of the Pilgrim and Cordery method (1975) requires analysis of local or regional rainfall. Because this is a time consuming process, and because applicable rainfall data are not always present, this method has not been widely applied in the U.S. However, it has been adopted as a standard method of hydrologic design in Australia (The Institution of Engineers Australia, 1987) and has been recommended by Greene County, Missouri (Green County Storm-Water Design Standards, 1999).

Kiefer and Chu's procedure (1957) is generally known as the Chicago method. It presupposes an IDF relation of the form

$$i = \frac{a}{t_D^b + c} \tag{4.8}$$

where i = rainfall intensity, in/hr

t_D = total duration of rainfall, hr

a,b,c = shape and location parameters, dimensionless

An equation taken from Modern Sewer Design (1980) proposes an IDF relation (which they attribute to Kiefer and Chu (1957) of the form

$$i = \frac{a}{(t_D + c)^b} \tag{4.9}$$

where the variables and parameters are as defined above. Hyetographs derived from the Modern Sewer Design formulation are very similar to those that are derived from Kiefer and Chu. The peak intensity is slightly smaller and intensities preceding and following the period of peak intensity are slightly larger than those that derive from the Kiefer and Chu procedure. However, the differences are small, and in the application they result in no practical differences in either the computed peak rate or volume of runoff. Furthermore, the Kiefer and Chu Method requires trial and error fitting of periods of peak intensity so as to approximate the continuous curve of intensity versus time that derives from the method. The Modern Sewer Design formulation results in equations that can be integrated to find the proper intensities directly. It also has the advantage that the dimensionless parameters can be determined directly from IDF data.

Figure 4.2 shows a hyetograph for a 25-year, 2-hour rainfall in Rolla, MO as derived from the Modern Sewer Design approach. Rather than a continuously changing rainfall intensity, practical applications demand a discrete representation. By shifting the origin to the time of occurrence of peak intensity, the following equations can be used to find the depth of rainfall under the curve. The following equation can be used to determine the rainfall depth between the peak intensity and any time prior to the peak,

HEC-HMS Computation Time Interval Guidance

The computation interval or time step for modeling within HEC-HMS can be specified for a range of intervals as follows:

Minutes - 1, 2, 3, 4, 5, 6, 10, 15, 20, 30
Hours - 1, 2, 3, 6, 8, 12, 24

Selection of the appropriate computation interval can affect the modeling results with extreme peak discharge differences possible for very large drainage basins. The HEC-HMS (v 4.1) Technical Reference Manual states: "*that for adequate definition of the ordinates on the rising limb of the SCS Unit Hydrograph, a computational interval, Δt, that is less than 29% of* t_{lag}*must be used (USACE 1998)".*

Therefore, if basin Lag=0.6 T_c, then the maximum computational interval for use within HEC-HMS to adequately define the rising limb of the hydrograph (and often to capture the peak) is given by:

$\Delta t = 0.29 \text{ x } 0.60\ T_c = 0.17\ T_c.$ **405-2**

The following is offered as additional guidance for selecting the minimum model computation interval selection:

1. Generally, the computation interval "*Δt*" should relate to the time of concentration of the smallest subbasin in the model and follow equation **405-2.**
2. Unless the computed "*Δt*" is less than 5 minutes, use 5 minutes or greater for all storm durations particularly for 24 hour or greater duration storms, as there are other compelling reasons for doing so (see 3.)
3. It should be noted that the shortest rainfall interval available from NOAA Atlas 14 is 5 minutes, selecting a shorter computation interval will require HEC-HMS to extrapolate to find a smaller than 5 minute rainfall increment.
4. Note that shorter and more numerous computation intervals do not always result in better answers (accuracy verses precision).

HEC-HMS Hydrograph Duration Guidance

1. The model simulation duration (the beginning and ending date and time) should be long enough to <u>*capture the entire storm runoff duration*</u>. Review the terminal basin outfall hydrograph to evaluate if the discharge has ceased at zero discharge. If not extend the model duration and simulate again until reaching zero discharge. Duration greater than 24-hours will generally be required for larger basins (greater than 10 square miles) and for models that contain reservoir routings with long detention times.

OPEN CHANNEL HYDRAULICS

VEN T. CHOW, 1959

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n
(Boldface figures are values generally recommended in design)

Type of channel and description	Minimum	Normal	Maximum
A. CLOSED CONDUITS FLOWING PARTLY FULL			
A-1. Metal			
a. Brass, smooth	0.009	0.010	0.013
b. Steel			
1. Lockbar and welded	0.010	0.012	0.014
2. Riveted and spiral	0.013	0.016	0.017
c. Cast iron			
1. Coated	0.010	0.013	0.014
2. Uncoated	0.011	0.014	0.016
d. Wrought iron			
1. Black	0.012	0.014	0.015
2. Galvanized	0.013	0.016	0.017
e. Corrugated metal			
1. Subdrain	0.017	0.019	0.021
2. Storm drain	0.021	0.024	0.030
A-2. Nonmetal			
a. Lucite	0.008	0.009	0.010
b. Glass	0.009	0.010	0.013
c. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
d. Concrete			
1. Culvert, straight and free of debris	0.010	0.011	0.013
2. Culvert with bends, connections, and some debris	0.011	0.013	0.014
3. Finished	0.011	0.012	0.014
4. Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
5. Unfinished, steel form	0.012	0.013	0.014
6. Unfinished, smooth wood form	0.012	0.014	0.016
7. Unfinished, rough wood form	0.015	0.017	0.020
e. Wood			
1. Stave	0.010	0.012	0.014
2. Laminated, treated	0.015	0.017	0.020
f. Clay			
1. Common drainage tile	0.011	0.013	0.017
2. Vitrified sewer	0.011	0.014	0.017
3. Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
4. Vitrified subdrain with open joint	0.014	0.016	0.018
g. Brickwork			
1. Glazed	0.011	0.013	0.015
2. Lined with cement mortar	0.012	0.015	0.017
h. Sanitary sewers coated with sewage slimes, with bends and connections	0.012	0.013	0.016
i. Paved invert, sewer, smooth bottom	0.016	0.019	0.020
j. Rubble masonry, cemented	0.018	0.025	0.030

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT *n* (*continued*)

Type of channel and description	Minimum	Normal	Maximum
B. LINED OR BUILT-UP CHANNELS			
B-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	**0.012**	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
B-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
d. Concrete bottom float finished with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	.....	0.500

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT *n* (*continued*)

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The *n* value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

United States Department of Agriculture

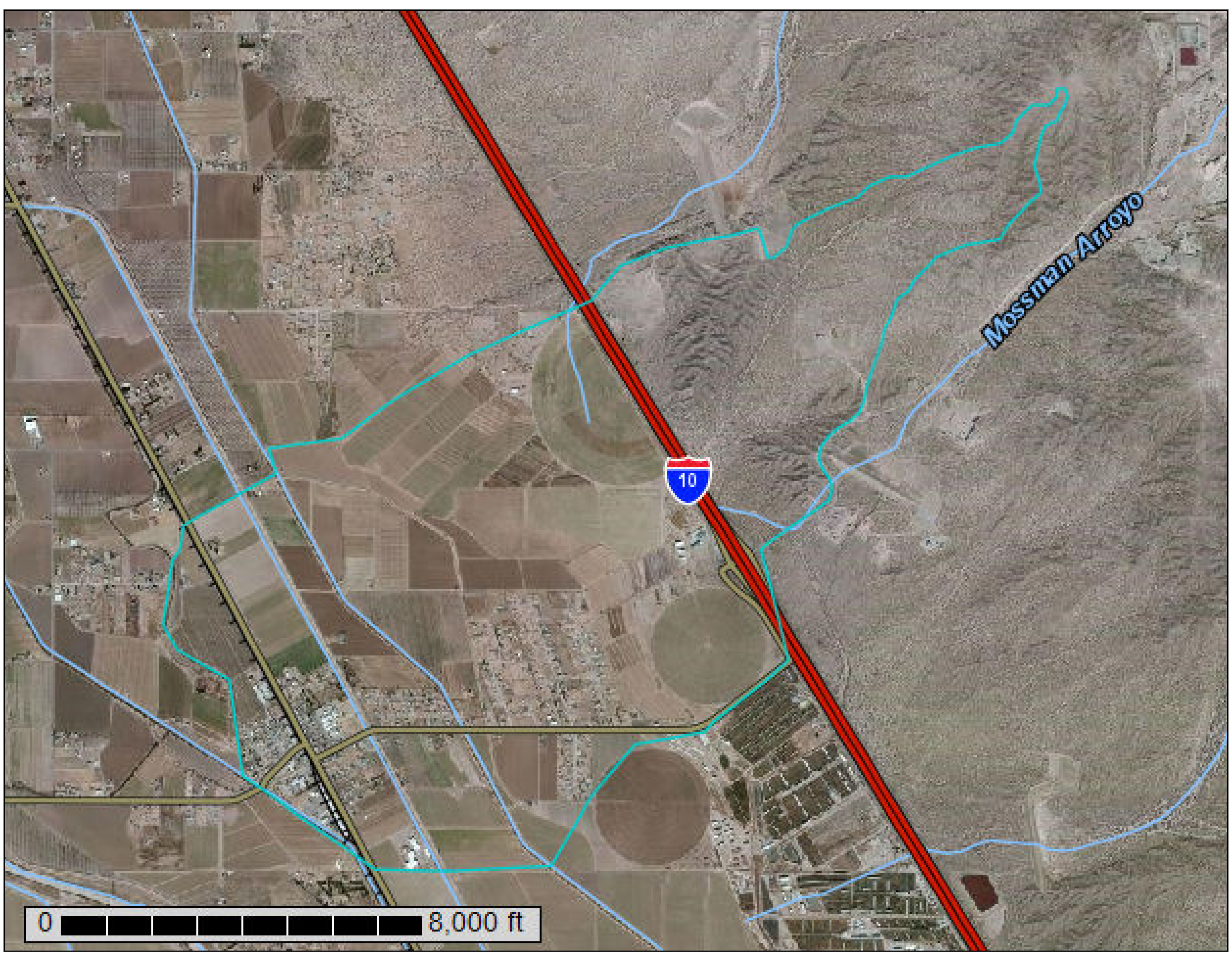
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Dona Ana County Area, New Mexico



March 18, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

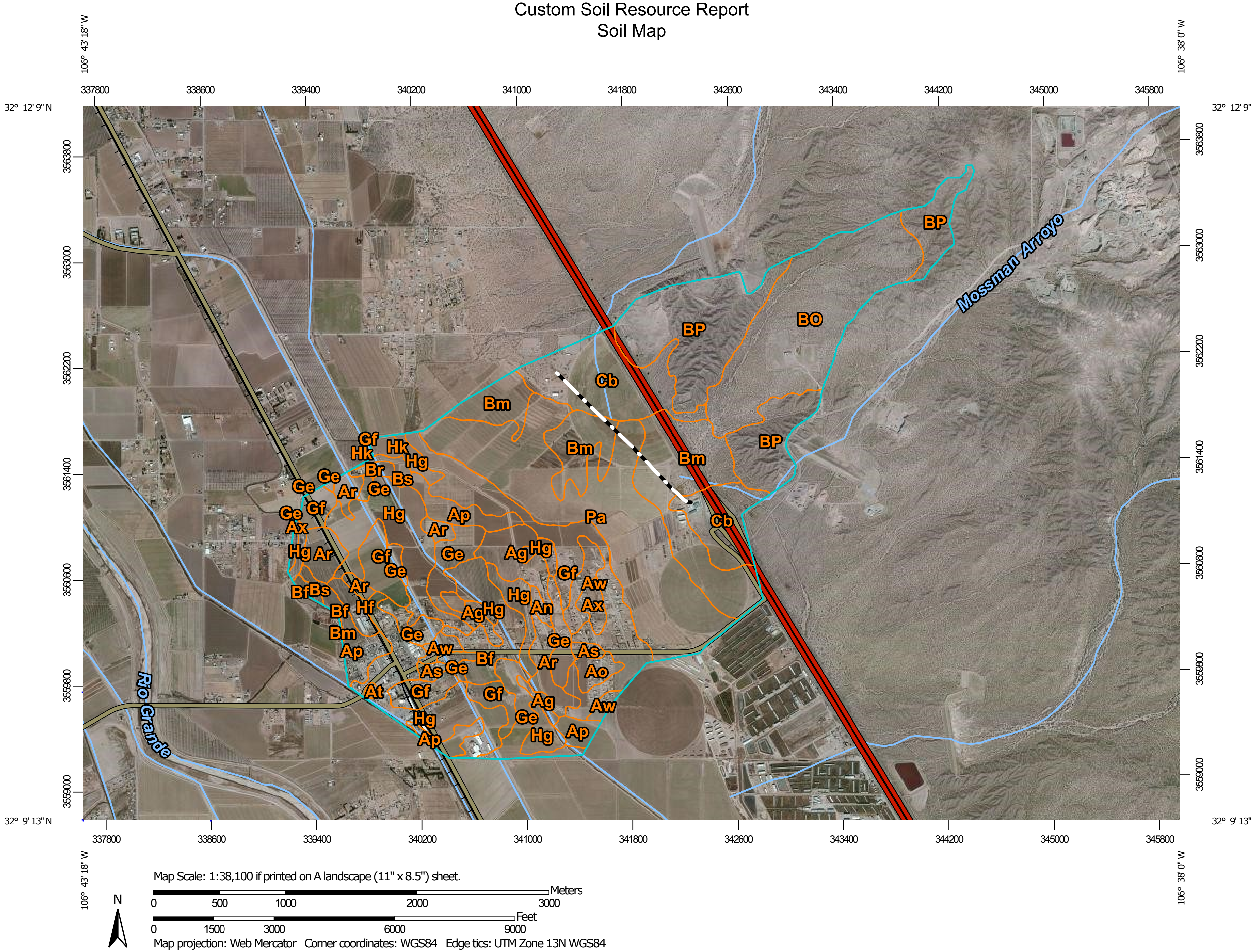
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


106° 43' 18" W
106° 38' 0" W
337800
338600
339400
340200
341000
341800
342600
343400
344200
345000
345800
32° 12' 9" N
32° 9' 13" N
3563800
3563000
3562200
3561400
3560600
3559800
3559000
Mossman Arroyo
Rio Grande
BP
BO
Cb
Bm
Pa
Ge
Gf
Hk
Hg
Br
Bs
Ar
Ax
Ap
Ag
Aw
An
Bf
Hf
As
Ao
At
Map Scale: 1:38,100 if printed on A landscape (11" x 8.5") sheet.
Meters
0
500
1000
2000
3000
Feet
0
1500
3000
6000
9000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Dona Ana County Area, New Mexico
Survey Area Data: Version 12, Sep 26, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 13, 2011—Jan 18, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Dona Ana County Area, New Mexico (NM690)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ag	Agua silt loam, 0 to 2 percent slopes MLRA 42.2	59.8	2.4%
An	Anapra silt loam	6.4	0.3%
Ao	Anapra clay loam	16.4	0.7%
Ap	Anthony-Vinton fine sandy loams	95.5	3.8%
Ar	Anthony-Vinton loams, 0 to 1 percent slopes MLRA 42.2	79.8	3.2%
As	Anthony-Vinton clay loams	15.0	0.6%
At	Armijo loam	2.7	0.1%
Aw	Armijo clay loam	41.4	1.7%
Ax	Armijo clay	15.1	0.6%
Bf	Belen clay loam, 0 to 1 percent slopes MLRA 42.2	69.3	2.8%
Bm	Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42	253.9	10.2%
BO	Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42	283.8	11.4%
BP	Bluepoint-Caliza-Yturbide complex	293.1	11.8%
Br	Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2	7.5	0.3%
Bs	Brazito very fine sandy loam, thick surface	14.7	0.6%
Cb	Canutio and Arizo gravelly sandy loams MLRA 42	199.9	8.0%
Ge	Glendale loam	131.3	5.3%
Gf	Glendale clay loam, 0 to 1 percent slopes MLRA 42.2	242.0	9.7%
Hf	Harkey fine sandy loam	16.0	0.6%
Hg	Harkey loam	281.5	11.3%
Hk	Harkey clay loam	8.1	0.3%
Pa	Pajarito fine sandy loam	352.5	14.2%
Totals for Area of Interest		**2,485.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Dona Ana County Area, New Mexico

Ag—Agua silt loam, 0 to 2 percent slopes MLRA 42.2

Map Unit Setting

National map unit symbol: 2sq27
Elevation: 3,740 to 4,470 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 180 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Agua and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Agua

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium over sandy alluvium

Typical profile

Ap - 0 to 12 inches: silt loam
C1 - 12 to 23 inches: silt loam
2C2 - 23 to 66 inches: fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Moderate (about 6.2 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Bottomland (R042XB018NM)
Hydric soil rating: No

An—Anapra silt loam

Map Unit Setting

National map unit symbol: p98z
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 60 to 64 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Anapra and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Anapra

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified fine-silty alluvium over mixed sandy alluvium

Typical profile

H1 - 0 to 16 inches: silt loam
H2 - 16 to 28 inches: silty clay loam
H3 - 28 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

Ao—Anapra clay loam

Map Unit Setting

National map unit symbol: p990
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 60 to 64 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Anapra and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Anapra

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified fine-silty alluvium over mixed sandy alluvium

Typical profile

H1 - 0 to 16 inches: clay loam
H2 - 16 to 28 inches: clay loam
H3 - 28 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

Ap—Anthony-Vinton fine sandy loams

Map Unit Setting

National map unit symbol: p991
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Anthony and similar soils: 45 percent
Vinton and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Anthony

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified coarse-loamy alluvium

Typical profile

H1 - 0 to 18 inches: fine sandy loam
H2 - 18 to 38 inches: fine sandy loam
H3 - 38 to 60 inches: loamy very fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Sandy (R042XB012NM)
Hydric soil rating: No

Description of Vinton

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed sandy alluvium

Typical profile

H1 - 0 to 13 inches: fine sandy loam
H2 - 13 to 41 inches: loamy fine sand
H3 - 41 to 60 inches: very fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 6.7 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Sandy (R042XB012NM)
Hydric soil rating: No

Ar—Anthony-Vinton loams, 0 to 1 percent slopes MLRA 42.2

Map Unit Setting

National map unit symbol: 2tm52
Elevation: 3,740 to 4,980 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Anthony and similar soils: 50 percent
Vinton and similar soils: 30 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Anthony

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

Ap1 - 0 to 9 inches: loam
Ap2 - 9 to 17 inches: loam
C1 - 17 to 39 inches: fine sandy loam
C2 - 39 to 60 inches: loamy fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 2s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: Bottomland (R042XB018NM)
Hydric soil rating: No

Description of Vinton

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

Ap - 0 to 14 inches: silt loam
C1 - 14 to 22 inches: fine sand
C2 - 22 to 45 inches: loamy fine sand
C3 - 45 to 50 inches: fine sand
C4 - 50 to 60 inches: loamy sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 4 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Moderate (about 6.3 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Bottomland (R042XB018NM)
Hydric soil rating: No

As—Anthony-Vinton clay loams

Map Unit Setting

National map unit symbol: p993
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Anthony and similar soils: 55 percent
Vinton and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Anthony

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified coarse-loamy alluvium

Typical profile

H1 - 0 to 15 inches: clay loam

H2 - 15 to 29 inches: loamy very fine sand
H3 - 29 to 60 inches: stratified loamy sand to silt loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

Description of Vinton

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed sandy alluvium

Typical profile

H1 - 0 to 15 inches: clay loam
H2 - 15 to 50 inches: loamy sand
H3 - 50 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e

Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

At—Armijo loam

Map Unit Setting

National map unit symbol: p994
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Armijo and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Armijo

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium

Typical profile

H1 - 0 to 10 inches: loam
H2 - 10 to 52 inches: clay
H3 - 52 to 60 inches: loamy sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 16.0
Available water storage in profile: Moderate (about 8.0 inches)

Interpretive groups

Land capability classification (irrigated): 4s

Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Loamy (R042XA052NM)
Hydric soil rating: No

Aw—Armijo clay loam

Map Unit Setting

National map unit symbol: p995
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Armijo and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Armijo

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium

Typical profile

H1 - 0 to 15 inches: clay loam
H2 - 15 to 42 inches: clay
H3 - 42 to 60 inches: very fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 16.0
Available water storage in profile: Moderate (about 8.1 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D
Ecological site: Loamy (R042XA052NM)
Hydric soil rating: No

Ax—Armijo clay

Map Unit Setting

National map unit symbol: p996
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Armijo and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Armijo

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium

Typical profile

H1 - 0 to 12 inches: clay
H2 - 12 to 60 inches: clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 16.0
Available water storage in profile: Moderate (about 8.0 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Bottomland (R042XA057NM)

Hydric soil rating: No

Bf—Belen clay loam, 0 to 1 percent slopes MLRA 42.2

Map Unit Setting

National map unit symbol: 2tm5c
Elevation: 3,730 to 4,190 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Belen and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Belen

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed clayey alluvium over mixed loamy alluvium

Typical profile

Ap - 0 to 14 inches: clay loam
C1 - 14 to 22 inches: clay
C2 - 22 to 30 inches: clay loam
2C - 30 to 60 inches: very fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: High (about 9.9 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C

Ecological site: Bottomland (R042XB018NM)
Hydric soil rating: No

Bm—Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42

Map Unit Setting

National map unit symbol: 2sy16
Elevation: 3,720 to 4,420 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 180 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Bluepoint and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluepoint

Setting

Landform: Stream terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Sandy alluvium

Typical profile

A - 0 to 3 inches: loamy sand
C1 - 3 to 15 inches: loamy sand
C2 - 15 to 24 inches: loamy fine sand
C3 - 24 to 31 inches: loamy fine sand
C4 - 31 to 39 inches: loamy fine sand
C5 - 39 to 55 inches: loamy fine sand
C6 - 55 to 79 inches: loamy sand

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 4 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

BO—Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42

Map Unit Setting

National map unit symbol: 2spsg
Elevation: 3,720 to 4,300 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Bluepoint and similar soils: 75 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluepoint

Setting

Landform: Alluvial fans, valley sides
Landform position (three-dimensional): Talf
Down-slope shape: Convex, concave
Across-slope shape: Convex, linear
Parent material: Wind-modified sandy alluvium

Typical profile

H1 - 0 to 17 inches: loamy sand
H2 - 17 to 60 inches: loamy sand

Properties and qualities

Slope: 1 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 13.0
Available water storage in profile: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

BP—Bluepoint-Caliza-Yturbide complex

Map Unit Setting

National map unit symbol: p99k
Elevation: 3,800 to 4,400 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Bluepoint and similar soils: 25 percent
Caliza and similar soils: 25 percent
Yturbide and similar soils: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bluepoint

Setting

Landform: Valley sides, alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Concave, convex
Across-slope shape: Linear, convex
Parent material: Wind-modified sandy alluvium

Typical profile

H1 - 0 to 19 inches: loamy sand
H2 - 19 to 60 inches: loamy sand

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 13.0
Available water storage in profile: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

Description of Caliza

Setting

Landform: Alluvial fans, drainageways
Landform position (three-dimensional): Rise, talf
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Mixed sandy and gravelly alluvium

Typical profile

H1 - 0 to 7 inches: very gravelly sandy loam
H2 - 7 to 12 inches: very gravelly sandy loam
H3 - 12 to 60 inches: very gravelly sand

Properties and qualities

Slope: 15 to 40 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 40 percent
Salinity, maximum in profile: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: Gravelly Sand (R042XB024NM)
Hydric soil rating: No

Description of Yturbide

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Mixed sandy and gravelly alluvium

Typical profile

H1 - 0 to 15 inches: gravelly loamy sand
H2 - 15 to 26 inches: gravelly loamy sand
H3 - 26 to 60 inches: gravelly sand

Properties and qualities

Slope: 1 to 8 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

Br—Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2

Map Unit Setting

National map unit symbol: 2t8vt
Elevation: 3,740 to 4,180 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Brazito and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brazito

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed sandy alluvium

Typical profile

Ap - 0 to 13 inches: loamy fine sand
C - 13 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): 4s
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Deep Sand (R042XB011NM)
Hydric soil rating: No

Bs—Brazito very fine sandy loam, thick surface

Map Unit Setting

National map unit symbol: p99m
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Brazito and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brazito

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed sandy alluvium

Typical profile

H1 - 0 to 15 inches: very fine sandy loam
H2 - 15 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B
Ecological site: Sandy (R042XB012NM)
Hydric soil rating: No

Cb—Canutio and Arizo gravelly sandy loams MLRA 42

Map Unit Setting

National map unit symbol: 2spsh
Elevation: 3,800 to 4,400 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Canutio and similar soils: 40 percent
Arizo and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Canutio

Setting

Landform: Alluvial fans, terraces
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Mixed gravelly loamy alluvium

Typical profile

H1 - 0 to 10 inches: gravelly sandy loam
H2 - 10 to 60 inches: very gravelly sandy loam

Properties and qualities

Slope: 1 to 5 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Gravelly Sand (R042XB024NM)
Hydric soil rating: No

Description of Arizo

Setting

Landform: Valley floors
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed sandy and gravelly alluvium

Typical profile

H1 - 0 to 15 inches: gravelly sandy loam
H2 - 15 to 60 inches: very gravelly sand

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Gravelly Sand (R042XB024NM)
Hydric soil rating: No

Ge—Glendale loam

Map Unit Setting

National map unit symbol: p99t
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Glendale and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Glendale

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified fine-silty alluvium

Typical profile

H1 - 0 to 12 inches: loam
H2 - 12 to 40 inches: clay loam
H3 - 40 to 60 inches: very fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: C
Ecological site: Bottomland (R042XB018NM)
Hydric soil rating: No

Gf—Glendale clay loam, 0 to 1 percent slopes MLRA 42.2

Map Unit Setting

National map unit symbol: 2t8vx
Elevation: 3,730 to 4,460 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Glendale and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Glendale

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-silty alluvium

Typical profile

Ap - 0 to 14 inches: clay loam
AC - 14 to 25 inches: clay loam
C - 25 to 59 inches: silt
2C - 59 to 60 inches: loamy very fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Gypsum, maximum in profile: 2 percent
Salinity, maximum in profile: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C

Ecological site: Bottomland (R042XB018NM)
Hydric soil rating: No

Hf—Harkey fine sandy loam

Map Unit Setting

National map unit symbol: p99z
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Harkey and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harkey

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified coarse-silty alluvium

Typical profile

H1 - 0 to 13 inches: fine sandy loam
H2 - 13 to 56 inches: stratified very fine sandy loam to silt loam
H3 - 56 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

Hg—Harkey loam

Map Unit Setting

National map unit symbol: p9b0
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Harkey and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harkey

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified coarse-silty alluvium

Typical profile

H1 - 0 to 18 inches: loam
H2 - 18 to 38 inches: very fine sandy loam
H3 - 38 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: B
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

Hk—Harkey clay loam

Map Unit Setting

National map unit symbol: p9b2
Elevation: 3,700 to 4,120 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Harkey and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harkey

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed stratified coarse-silty alluvium

Typical profile

H1 - 0 to 12 inches: clay loam
H2 - 12 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 7c
Hydrologic Soil Group: C
Ecological site: Loamy (R042XB014NM)
Hydric soil rating: No

Pa—Pajarito fine sandy loam

Map Unit Setting

National map unit symbol: p9bc
Elevation: 3,750 to 4,200 feet
Mean annual precipitation: 8 to 10 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 180 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Pajarito and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pajarito

Setting

Landform: Alluvial fans
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Mixed coarse-loamy alluvium

Typical profile

H1 - 0 to 12 inches: fine sandy loam
H2 - 12 to 28 inches: fine sandy loam
H3 - 28 to 60 inches: fine sandy loam

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: Sandy (R042XB012NM)
Hydric soil rating: No

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Water Features

This folder contains tabular reports that present soil hydrology information. The reports (tables) include all selected map units and components for each map unit. Water Features include ponding frequency, flooding frequency, and depth to water table.

Hydrologic Soil Group and Surface Runoff

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

Report—Hydrologic Soil Group and Surface Runoff

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Hydrologic Soil Group and Surface Runoff–Dona Ana County Area, New Mexico			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
Ag—Agua silt loam, 0 to 2 percent slopes MLRA 42.2			
Agua	85	Very low	A
An—Anapra silt loam			
Anapra	85	Low	C
Ao—Anapra clay loam			
Anapra	85	Low	C
Ap—Anthony-Vinton fine sandy loams			
Anthony	45	Negligible	A
Vinton	30	Negligible	A
Ar—Anthony-Vinton loams, 0 to 1 percent slopes MLRA 42.2			
Anthony	50	Low	C
Vinton	30	Very low	A
As—Anthony-Vinton clay loams			
Anthony	55	Negligible	B
Vinton	30	Negligible	B
At—Armijo loam			
Armijo	85	High	D
Aw—Armijo clay loam			
Armijo	85	High	D

Hydrologic Soil Group and Surface Runoff–Dona Ana County Area, New Mexico			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
Ax—Armijo clay			
Armijo	85	High	D
Bf—Belen clay loam, 0 to 1 percent slopes MLRA 42.2			
Belen	85	Medium	C
Bm—Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42			
Bluepoint	85	Very low	A
BO—Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42			
Bluepoint	75	Very low	A
BP—Bluepoint-Caliza-Yturbide complex			
Bluepoint	25	Very low	A
Caliza	25	Medium	A
Yturbide	20	Very low	A
Br—Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2			
Brazito	80	Very low	A
Bs—Brazito very fine sandy loam, thick surface			
Brazito	80	Negligible	B
Cb—Canutio and Arizo gravelly sandy loams MLRA 42			
Canutio	40	Very low	A
Arizo	30	Negligible	A
Ge—Glendale loam			
Glendale	85	Low	C
Gf—Glendale clay loam, 0 to 1 percent slopes MLRA 42.2			
Glendale	85	Low	C
Hf—Harkey fine sandy loam			
Harkey	85	Negligible	B
Hg—Harkey loam			
Harkey	85	Negligible	B
Hk—Harkey clay loam			
Harkey	85	Low	C
Pa—Pajarito fine sandy loam			
Pajarito	85	Very low	A

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Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

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Agua	85	Very low	A
An—Anapra silt loam			
Anapra	85	Low	C
Ao—Anapra clay loam			
Anapra	85	Low	C
Ap—Anthony-Vinton fine sandy loams			
Anthony	45	Negligible	A
Vinton	30	Negligible	A

Hydrologic Soil Group and Surface Runoff–Dona Ana County Area, New Mexico			
Map symbol and soil name	Pct. of map unit	Surface Runoff	Hydrologic Soil Group
Ar—Anthony-Vinton loams, 0 to 1 percent slopes MLRA 42.2			
Anthony	50	Low	C
Vinton	30	Very low	A
As—Anthony-Vinton clay loams			
Anthony	55	Negligible	B
Vinton	30	Negligible	B
At—Armijo loam			
Armijo	85	High	D
Aw—Armijo clay loam			
Armijo	85	High	D
Ax—Armijo clay			
Armijo	85	High	D
Bf—Belen clay loam, 0 to 1 percent slopes MLRA 42.2			
Belen	85	Medium	C
Bm—Bluepoint loamy sand, 0 to 5 percent slopes MLRA 42			
Bluepoint	85	Very low	A
BO—Bluepoint loamy sand, 1 to 15 percent slopes MLRA 42			
Bluepoint	75	Very low	A
BP—Bluepoint-Caliza-Yturbide complex			
Bluepoint	25	Very low	A
Caliza	25	Medium	A
Yturbide	20	Very low	A
Br—Brazito loamy fine sand, 0 to 1 percent slopes MLRA 42.2			
Brazito	80	Very low	A
Bs—Brazito very fine sandy loam, thick surface			
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Canutio	40	Very low	A
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Glendale	85	Low	C
Gf—Glendale clay loam, 0 to 1 percent slopes MLRA 42.2			
Glendale	85	Low	C
Hf—Harkey fine sandy loam			
Harkey	85	Negligible	B

Hydrologic Soil Group and Surface Runoff–Dona Ana County Area, New Mexico			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
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Harkey	85	Negligible	B
Hk—Harkey clay loam			
Harkey	85	Low	C
Pa—Pajarito fine sandy loam			
Pajarito	85	Very low	A

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the "National Soil Survey Handbook."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth’s surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0

Coarse sand: 1.0 to 0.5

Medium sand: 0.5 to 0.25

Fine sand: 0.25 to 0.10

Very fine sand: 0.10 to 0.05

Silt: 0.05 to 0.002

Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated
Prismatic: Vertically elongated and having flat tops
Columnar: Vertically elongated and having rounded tops
Angular blocky: Having faces that intersect at sharp angles (planes)
Subangular blocky: Having subrounded and planar faces (no sharp angles)
Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand
Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.

APPENDIX D

EXISTING AND PROPOSED HEC-HMS HYDROLOGIC MODELS (V4.2.1) AND SUMMARY OUTPUT (a)

EXISTING

Table D1	HEC-HMS Existing Conditions Hydrologic Summary – 5yr - 24-hr Storm
Table D2	HEC-HMS Existing Conditions Hydrologic Summary – 10yr - 24-hr Storm
Table D3	HEC-HMS Existing Conditions Hydrologic Summary – 50yr - 24-hr Storm
Table D4	HEC-HMS Existing Conditions Hydrologic Summary – 100yr - 24-hr Storm

PROPOSED

Table D5	HEC-HMS Proposed Conditions Hydrologic Summary – 5yr - 24-hr Storm
Table D6	HEC-HMS Proposed Conditions Hydrologic Summary – 10yr - 24-hr Storm
Table D7	HEC-HMS Proposed Conditions Hydrologic Summary – 50yr - 24-hr Storm
Table D8	HEC-HMS Proposed Conditions Hydrologic Summary – 100yr - 24-hr Storm

(a) Digital HEC-HMS models are included on DVD.

TABLE D1 HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY - 5 YR - 24 HR STORM Mesquite Drainage Master Plan				
Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	53.6	01Mar2017, 07:14	12.71
Sub-1	0.245	18.3	01Mar2017, 07:01	3.72
Junc-1	0.245	18.3	01Mar2017, 07:01	3.72
Reach-1	0.245	18.2	01Mar2017, 07:28	3.73
Sub-2	0.44	44.2	01Mar2017, 06:40	6.68
Junc-2	0.685	44.4	01Mar2017, 06:40	10.41
Sub-7	0.005	5.3	01Mar2017, 06:09	0.25
Sub-8	0.004	4.3	01Mar2017, 06:09	0.20
C-2	0.694	45.8	01Mar2017, 06:40	10.86
Res-1	0.694	33.1	01Mar2017, 07:27	10.86
C2	0.694	33.1	01Mar2017, 07:27	10.86
Sub-4	0.11	19	01Mar2017, 06:15	1.67
Sub-6	0.021	21.4	01Mar2017, 06:10	1.06
Sub-5	0.018	19.2	01Mar2017, 06:09	0.91
C-1	0.149	55.8	01Mar2017, 06:11	3.64
Sub-13	0.009	1.5	01Mar2017, 06:16	0.14
Junc-5	0.158	57	01Mar2017, 06:11	3.78
Res-3	0.158	0	01Mar2017, 00:00	0.00
C1	0.158	0	01Mar2017, 00:00	0.00
Sub-10	0.01	10.6	01Mar2017, 06:09	0.50
Sub-9	0.009	9.6	01Mar2017, 06:09	0.45
C-3	0.019	20.2	01Mar2017, 06:09	0.96
Junc-6	1.709	87.4	01Mar2017, 07:13	24.53
Sub-14	0.326	24.3	01Mar2017, 07:01	4.95
Sub-3B	0.176	21.4	01Mar2017, 06:29	2.68
Junc-4	0.176	21.4	01Mar2017, 06:29	2.68
Sub-12	0.01	10.6	01Mar2017, 06:09	0.50
Sub-11	0.009	9.6	01Mar2017, 06:09	0.45
C-4	0.195	27.1	01Mar2017, 06:26	3.63
Res-2	0.195	13.6	01Mar2017, 06:54	3.63
C4	0.195	13.6	01Mar2017, 06:54	3.63
Sink-1	0.195	13.6	01Mar2017, 06:54	3.63
Sub-21	0.168	62.9	01Mar2017, 06:50	8.88
Sub-20	0.164	40.3	01Mar2017, 06:53	6.17
Sub-35	0.152	56.9	01Mar2017, 06:50	8.03
Sub-25	0.133	42.3	01Mar2017, 06:51	6.15
Sub-19	0.124	42.9	01Mar2017, 06:51	6.14
Sub-42	0.107	24	01Mar2017, 06:53	3.74
Sub-18	0.096	25.5	01Mar2017, 06:27	2.56
Sub-17	0.079	40.7	01Mar2017, 06:25	3.49
Sub-26	0.071	41.6	01Mar2017, 06:24	3.51
Sub-16	0.068	32.2	01Mar2017, 06:25	2.81
Sub-36	0.039	39.3	01Mar2017, 06:22	3.07
Sub-27	0.036	20.2	01Mar2017, 06:24	1.70
Sub-23	0.033	14.3	01Mar2017, 06:25	1.27
Sub-3A	0.03	5.1	01Mar2017, 06:20	0.50
Junc-3	0.03	5.1	01Mar2017, 06:20	0.50
Sub-22	0.02	9.5	01Mar2017, 06:25	0.83
Sub-40	0.018	1.5	01Mar2017, 06:33	0.21
Sub-32	0.017	5	01Mar2017, 06:27	0.49
Sub-33	0.017	8.8	01Mar2017, 06:25	0.75
Sub-34	0.015	4.9	01Mar2017, 06:26	0.47
Sub-31	0.014	13.2	01Mar2017, 06:23	1.04
Sub-28	0.011	6.2	01Mar2017, 06:24	0.52
Sub-39	0.011	1.8	01Mar2017, 06:30	0.21
Sub-37	0.008	7.1	01Mar2017, 06:23	0.56
Sub-38	0.006	5.7	01Mar2017, 06:23	0.44
Sub-29	0.006	3.6	01Mar2017, 06:24	0.30
Sub-41	0.005	0.4	01Mar2017, 06:33	0.06
Sub-24	0.004	1.3	01Mar2017, 06:26	0.12
Sub-30	0.002	2.5	01Mar2017, 06:21	0.20

TABLE D2
HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY -10 YR - 24 HR STORM
Mesquite Drainage Master Plan

Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	95.6	01Mar2017, 07:11	20.28
Sub-1	0.245	32.7	01Mar2017, 06:59	5.94
Junc-1	0.245	32.7	01Mar2017, 06:59	5.94
Reach-1	0.245	32.7	01Mar2017, 07:20	5.95
Sub-2	0.440	80.5	01Mar2017, 06:38	10.67
Junc-2	0.685	80.9	01Mar2017, 06:38	16.61
Sub-7	0.005	7.2	01Mar2017, 06:09	0.33
Sub-8	0.004	5.8	01Mar2017, 06:09	0.27
C-2	0.694	82.9	01Mar2017, 06:37	17.21
Res-1	0.694	36.1	01Mar2017, 07:47	17.20
C2	0.694	36.1	01Mar2017, 07:47	17.20
Sub-4	0.110	36.7	01Mar2017, 06:13	2.67
Sub-6	0.021	29.1	01Mar2017, 06:10	1.40
Sub-5	0.018	26.0	01Mar2017, 06:09	1.20
C-1	0.149	87.9	01Mar2017, 06:11	5.26
Sub-13	0.009	2.9	01Mar2017, 06:14	0.22
Junc-5	0.158	90.5	01Mar2017, 06:11	5.48
Res-3	0.158	1.1	01Mar2017, 20:05	0.38
C1	0.158	1.1	01Mar2017, 20:05	0.38
Sub-10	0.010	14.4	01Mar2017, 06:09	0.66
Sub-9	0.009	13.0	01Mar2017, 06:09	0.60
C-3	0.019	27.4	01Mar2017, 06:09	1.26
Junc-6	1.709	131.9	01Mar2017, 07:10	39.13
Sub-14	0.326	43.6	01Mar2017, 06:58	7.91
Sub-3B	0.176	39.6	01Mar2017, 06:27	4.27
Junc-4	0.176	39.6	01Mar2017, 06:27	4.27
Sub-12	0.010	14.4	01Mar2017, 06:09	0.66
Sub-11	0.009	13.0	01Mar2017, 06:09	0.60
C-4	0.195	48.0	01Mar2017, 06:24	5.53
Res-2	0.195	14.3	01Mar2017, 07:07	5.53
C4	0.195	14.3	01Mar2017, 07:07	5.53
Sink-1	0.195	14.3	01Mar2017, 07:07	5.53
Sub-21	0.168	85.3	01Mar2017, 06:50	11.69
Sub-20	0.164	58.2	01Mar2017, 06:52	8.52
Sub-35	0.152	77.1	01Mar2017, 06:50	10.58
Sub-25	0.133	58.8	01Mar2017, 06:51	8.26
Sub-19	0.124	58.8	01Mar2017, 06:50	8.15
Sub-42	0.107	35.2	01Mar2017, 06:52	5.23
Sub-18	0.096	39.6	01Mar2017, 06:26	3.69
Sub-17	0.079	56.6	01Mar2017, 06:24	4.68
Sub-26	0.071	57.2	01Mar2017, 06:24	4.67
Sub-16	0.068	45.3	01Mar2017, 06:25	3.80
Sub-36	0.039	49.2	01Mar2017, 06:22	3.80
Sub-27	0.036	27.7	01Mar2017, 06:24	2.26
Sub-23	0.033	20.4	01Mar2017, 06:25	1.74
Sub-3A	0.030	9.3	01Mar2017, 06:19	0.79
Junc-3	0.030	9.3	01Mar2017, 06:19	0.79
Sub-22	0.020	13.3	01Mar2017, 06:25	1.12
Sub-40	0.018	2.9	01Mar2017, 06:31	0.35
Sub-32	0.017	7.7	01Mar2017, 06:26	0.70
Sub-33	0.017	12.2	01Mar2017, 06:24	1.01
Sub-34	0.015	7.3	01Mar2017, 06:26	0.66
Sub-31	0.014	16.7	01Mar2017, 06:22	1.29
Sub-28	0.011	8.5	01Mar2017, 06:24	0.69
Sub-39	0.011	3.1	01Mar2017, 06:28	0.32
Sub-37	0.008	9.0	01Mar2017, 06:23	0.70
Sub-38	0.006	7.2	01Mar2017, 06:22	0.55
Sub-29	0.006	4.9	01Mar2017, 06:24	0.40
Sub-41	0.005	0.8	01Mar2017, 06:31	0.10
Sub-24	0.004	2.0	01Mar2017, 06:26	0.18
Sub-30	0.002	3.0	01Mar2017, 06:21	0.24

TABLE D3
HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY - 50 YR - 24 HR STORM
Mesquite Drainage Master Plan

Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	231.0	01Mar2017, 07:07	44.99
Sub-1	0.245	79.3	01Mar2017, 06:55	13.18
Junc-1	0.245	79.3	01Mar2017, 06:55	13.18
Reach-1	0.245	79.3	01Mar2017, 07:11	13.18
Sub-2	0.440	199.0	01Mar2017, 06:35	23.65
Junc-2	0.685	207.3	01Mar2017, 06:39	36.83
Sub-7	0.005	12.1	01Mar2017, 06:09	0.55
Sub-8	0.004	9.7	01Mar2017, 06:09	0.44
C-2	0.694	210.5	01Mar2017, 06:38	37.83
Res-1	0.694	40.5	01Mar2017, 08:12	37.82
C2	0.694	40.5	01Mar2017, 08:12	37.82
Sub-4	0.110	96.3	01Mar2017, 06:12	5.92
Sub-6	0.021	48.6	01Mar2017, 06:10	2.33
Sub-5	0.018	43.5	01Mar2017, 06:09	1.99
C-1	0.149	184.0	01Mar2017, 06:11	10.24
Sub-13	0.009	7.6	01Mar2017, 06:13	0.48
Junc-5	0.158	191.4	01Mar2017, 06:11	10.72
Res-3	0.158	53.4	01Mar2017, 06:34	5.62
C1	0.158	53.4	01Mar2017, 06:34	5.62
Sub-10	0.010	24.2	01Mar2017, 06:09	1.11
Sub-9	0.009	21.7	01Mar2017, 06:09	1.00
C-3	0.019	45.9	01Mar2017, 06:09	2.11
Junc-6	1.709	291.8	01Mar2017, 07:04	90.54
Sub-14	0.326	105.8	01Mar2017, 06:55	17.53
Sub-3B	0.176	99.7	01Mar2017, 06:25	9.47
Junc-4	0.176	99.7	01Mar2017, 06:25	9.47
Sub-12	0.010	24.2	01Mar2017, 06:09	1.11
Sub-11	0.009	21.7	01Mar2017, 06:09	1.00
C-4	0.195	114.9	01Mar2017, 06:23	11.57
Res-2	0.195	15.3	01Mar2017, 07:21	11.57
C4	0.195	15.3	01Mar2017, 07:21	11.57
Sink-1	0.195	15.3	01Mar2017, 07:21	11.57
Sub-21	0.168	143.1	01Mar2017, 06:49	19.50
Sub-20	0.164	107.3	01Mar2017, 06:51	15.32
Sub-35	0.152	129.5	01Mar2017, 06:49	17.64
Sub-25	0.133	102.3	01Mar2017, 06:50	14.18
Sub-19	0.124	100.4	01Mar2017, 06:49	13.80
Sub-42	0.107	66.2	01Mar2017, 06:51	9.55
Sub-18	0.096	80.4	01Mar2017, 06:25	7.10
Sub-17	0.079	98.6	01Mar2017, 06:24	8.04
Sub-26	0.071	97.7	01Mar2017, 06:23	7.90
Sub-16	0.068	80.6	01Mar2017, 06:24	6.63
Sub-36	0.039	73.4	01Mar2017, 06:22	5.73
Sub-27	0.036	47.3	01Mar2017, 06:23	3.82
Sub-23	0.033	37.1	01Mar2017, 06:24	3.08
Sub-3A	0.030	23.1	01Mar2017, 06:17	1.71
Junc-3	0.030	23.1	01Mar2017, 06:17	1.71
Sub-22	0.020	23.7	01Mar2017, 06:24	1.95
Sub-40	0.018	7.9	01Mar2017, 06:28	0.82
Sub-32	0.017	15.2	01Mar2017, 06:25	1.32
Sub-33	0.017	21.2	01Mar2017, 06:24	1.73
Sub-34	0.015	14.2	01Mar2017, 06:25	1.22
Sub-31	0.014	25.3	01Mar2017, 06:22	1.98
Sub-28	0.011	14.5	01Mar2017, 06:23	1.17
Sub-39	0.011	7.1	01Mar2017, 06:26	0.67
Sub-37	0.008	13.9	01Mar2017, 06:22	1.09
Sub-38	0.006	10.9	01Mar2017, 06:22	0.85
Sub-29	0.006	8.3	01Mar2017, 06:23	0.66
Sub-41	0.005	2.2	01Mar2017, 06:28	0.23
Sub-24	0.004	3.8	01Mar2017, 06:25	0.33
Sub-30	0.002	4.2	01Mar2017, 06:21	0.34

TABLE D4 HEC-HMS EXISTING CONDITIONS HYDROLOGIC SUMMARY - 100 YR - 24 HR STORM Mesquite Drainage Master Plan				
Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	304.4	01Mar2017, 07:06	58.54
Sub-1	0.245	104.7	01Mar2017, 06:54	17.14
Junc-1	0.245	104.7	01Mar2017, 06:54	17.14
Reach-1	0.245	104.7	01Mar2017, 07:08	17.15
Sub-2	0.440	264.1	01Mar2017, 06:34	30.77
Junc-2	0.685	280.7	01Mar2017, 06:39	47.92
Sub-7	0.005	14.5	01Mar2017, 06:09	0.66
Sub-8	0.004	11.6	01Mar2017, 06:09	0.53
C-2	0.694	284.4	01Mar2017, 06:38	49.11
Res-1	0.694	42.2	01Mar2017, 08:17	49.11
C2	0.694	42.2	01Mar2017, 08:17	49.11
Sub-4	0.110	129.4	01Mar2017, 06:12	7.70
Sub-6	0.021	58.1	01Mar2017, 06:10	2.79
Sub-5	0.018	52.0	01Mar2017, 06:09	2.39
C-1	0.149	234.9	01Mar2017, 06:11	12.87
Sub-13	0.009	10.2	01Mar2017, 06:12	0.63
Junc-5	0.158	244.8	01Mar2017, 06:11	13.50
Res-3	0.158	108.2	01Mar2017, 06:24	8.40
C1	0.158	108.2	01Mar2017, 06:24	8.40
Sub-10	0.010	28.9	01Mar2017, 06:09	1.33
Sub-9	0.009	26.0	01Mar2017, 06:09	1.19
C-3	0.019	54.9	01Mar2017, 06:09	2.52
Junc-6	1.709	372.0	01Mar2017, 07:03	118.58
Sub-14	0.326	139.7	01Mar2017, 06:54	22.81
Sub-3B	0.176	133.0	01Mar2017, 06:24	12.32
Junc-4	0.176	133.0	01Mar2017, 06:24	12.32
Sub-12	0.010	28.9	01Mar2017, 06:09	1.33
Sub-11	0.009	26.0	01Mar2017, 06:09	1.19
C-4	0.195	151.4	01Mar2017, 06:22	14.84
Res-2	0.195	15.6	01Mar2017, 07:25	14.84
C4	0.195	15.6	01Mar2017, 07:25	14.84
Sink-1	0.195	15.6	01Mar2017, 07:25	14.84
Sub-21	0.168	170.8	01Mar2017, 06:49	23.34
Sub-20	0.164	131.5	01Mar2017, 06:50	18.77
Sub-35	0.152	154.5	01Mar2017, 06:49	21.12
Sub-25	0.133	123.4	01Mar2017, 06:49	17.13
Sub-19	0.124	120.5	01Mar2017, 06:49	16.59
Sub-42	0.107	81.6	01Mar2017, 06:51	11.76
Sub-18	0.096	101.4	01Mar2017, 06:25	8.88
Sub-17	0.079	119.2	01Mar2017, 06:23	9.71
Sub-26	0.071	117.6	01Mar2017, 06:23	9.50
Sub-16	0.068	97.9	01Mar2017, 06:24	8.04
Sub-36	0.039	84.8	01Mar2017, 06:22	6.65
Sub-27	0.036	56.9	01Mar2017, 06:23	4.60
Sub-23	0.033	45.3	01Mar2017, 06:24	3.75
Sub-3A	0.030	30.6	01Mar2017, 06:17	2.21
Junc-3	0.030	30.6	01Mar2017, 06:17	2.21
Sub-22	0.020	28.8	01Mar2017, 06:24	2.37
Sub-40	0.018	10.7	01Mar2017, 06:27	1.09
Sub-32	0.017	19.0	01Mar2017, 06:25	1.64
Sub-33	0.017	25.7	01Mar2017, 06:23	2.09
Sub-34	0.015	17.7	01Mar2017, 06:24	1.51
Sub-31	0.014	29.4	01Mar2017, 06:22	2.31
Sub-28	0.011	17.4	01Mar2017, 06:23	1.41
Sub-39	0.011	9.2	01Mar2017, 06:26	0.85
Sub-37	0.008	16.2	01Mar2017, 06:22	1.27
Sub-38	0.006	12.6	01Mar2017, 06:22	0.99
Sub-29	0.006	9.9	01Mar2017, 06:23	0.80
Sub-41	0.005	3.0	01Mar2017, 06:27	0.30
Sub-24	0.004	4.7	01Mar2017, 06:24	0.40
Sub-30	0.002	4.8	01Mar2017, 06:21	0.39

TABLE D5 HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY - 5 YR - 24 HR STORM Mesquite Drainage Master Plan				
Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	53.6	01Mar2017, 07:14	12.71
Sub-1	0.245	18.3	01Mar2017, 07:01	3.72
Junc-1	0.245	18.3	01Mar2017, 07:01	3.72
Reach-1	0.245	18.2	01Mar2017, 07:28	3.73
Sub-2	0.440	44.2	01Mar2017, 06:40	6.68
Junc-2	0.685	44.4	01Mar2017, 06:40	10.41
Sub-7	0.005	5.3	01Mar2017, 06:09	0.25
Sub-8	0.004	4.3	01Mar2017, 06:09	0.20
C-2	0.694	45.8	01Mar2017, 06:40	10.86
Res-1	0.694	33.1	01Mar2017, 07:27	10.86
C2	0.694	33.1	01Mar2017, 07:27	10.86
Sub-4	0.110	19.0	01Mar2017, 06:15	1.67
Sub-6	0.021	21.4	01Mar2017, 06:10	1.06
Sub-5	0.018	19.2	01Mar2017, 06:09	0.91
C-1	0.149	55.8	01Mar2017, 06:11	3.64
Sub-13	0.009	1.5	01Mar2017, 06:16	0.14
Junc-5	0.158	57.0	01Mar2017, 06:11	3.78
Res-3	0.158	0.0	01Mar2017, 00:00	0.00
C1	0.158	0.0	01Mar2017, 00:00	0.00
Sub-10	0.010	10.6	01Mar2017, 06:09	0.50
Sub-9	0.009	9.6	01Mar2017, 06:09	0.45
C-3	0.019	20.2	01Mar2017, 06:09	0.96
Junc-6	1.709	87.4	01Mar2017, 07:13	24.53
Pond 1	1.709	6.2	01Mar2017, 22:33	7.42
Sink-2	1.709	6.2	01Mar2017, 22:33	7.42
Sub-14	0.326	24.3	01Mar2017, 07:01	4.95
Sub-3B	0.176	21.4	01Mar2017, 06:29	2.68
Junc-4	0.176	21.4	01Mar2017, 06:29	2.68
Sub-12	0.010	10.6	01Mar2017, 06:09	0.50
Sub-11	0.009	9.6	01Mar2017, 06:09	0.45
C-4	0.195	27.1	01Mar2017, 06:26	3.63
Res-2	0.195	13.6	01Mar2017, 06:54	3.63
C4	0.195	13.6	01Mar2017, 06:54	3.63
Sink-1	0.195	13.6	01Mar2017, 06:54	3.63
Sub-21	0.168	62.9	01Mar2017, 06:50	8.88
Sub-20	0.164	40.3	01Mar2017, 06:53	6.17
Sub-35	0.152	56.9	01Mar2017, 06:50	8.03
Sub-25	0.133	42.3	01Mar2017, 06:51	6.15
Sub-19	0.124	42.9	01Mar2017, 06:51	6.14
Sub-42	0.107	24.0	01Mar2017, 06:53	3.74
Sub-18	0.096	25.5	01Mar2017, 06:27	2.56
Sub-17	0.079	40.7	01Mar2017, 06:25	3.49
Sub-26	0.071	41.6	01Mar2017, 06:24	3.51
Sub-16	0.068	32.2	01Mar2017, 06:25	2.81
Sub-36	0.039	39.3	01Mar2017, 06:22	3.07
Sub-27	0.036	20.2	01Mar2017, 06:24	1.70
Sub-23	0.033	14.3	01Mar2017, 06:25	1.27
Sub-3A	0.030	5.1	01Mar2017, 06:20	0.50
Junc-3	0.030	5.1	01Mar2017, 06:20	0.50
Sub-22	0.020	9.5	01Mar2017, 06:25	0.83
Sub-40	0.018	1.5	01Mar2017, 06:33	0.21
Pond 2	0.018	0.6	01Mar2017, 07:14	0.21
Sink-3	0.018	0.6	01Mar2017, 07:14	0.21
Sub-32	0.017	5.0	01Mar2017, 06:27	0.49
Sub-33	0.017	8.8	01Mar2017, 06:25	0.75
Sub-34	0.015	4.9	01Mar2017, 06:26	0.47
Sub-31	0.014	13.2	01Mar2017, 06:23	1.04
Sub-28	0.011	6.2	01Mar2017, 06:24	0.52
Sub-39	0.011	1.8	01Mar2017, 06:30	0.21
Sub-37	0.008	7.1	01Mar2017, 06:23	0.56
Sub-38	0.006	5.7	01Mar2017, 06:23	0.44
Sub-29	0.006	3.6	01Mar2017, 06:24	0.30
Sub-41	0.005	0.4	01Mar2017, 06:33	0.06
Sub-24	0.004	1.3	01Mar2017, 06:26	0.12
Sub-30	0.002	2.5	01Mar2017, 06:21	0.20

TABLE D6 HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY -10 YR - 24 HR STORM Mesquite Drainage Master Plan				
Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	95.6	01Mar2017, 07:11	20.28
Sub-1	0.245	32.7	01Mar2017, 06:59	5.94
Junc-1	0.245	32.7	01Mar2017, 06:59	5.94
Reach-1	0.245	32.7	01Mar2017, 07:20	5.95
Sub-2	0.440	80.5	01Mar2017, 06:38	10.67
Junc-2	0.685	80.9	01Mar2017, 06:38	16.61
Sub-7	0.005	7.2	01Mar2017, 06:09	0.33
Sub-8	0.004	5.8	01Mar2017, 06:09	0.27
C-2	0.694	82.9	01Mar2017, 06:37	17.21
Res-1	0.694	36.1	01Mar2017, 07:47	17.20
C2	0.694	36.1	01Mar2017, 07:47	17.20
Sub-4	0.110	36.7	01Mar2017, 06:13	2.67
Sub-6	0.021	29.1	01Mar2017, 06:10	1.40
Sub-5	0.018	26.0	01Mar2017, 06:09	1.20
C-1	0.149	87.9	01Mar2017, 06:11	5.26
Sub-13	0.009	2.9	01Mar2017, 06:14	0.22
Junc-5	0.158	90.5	01Mar2017, 06:11	5.48
Res-3	0.158	1.1	01Mar2017, 19:59	0.39
C1	0.158	1.1	01Mar2017, 19:59	0.39
Sub-10	0.010	14.4	01Mar2017, 06:09	0.66
Sub-9	0.009	13.0	01Mar2017, 06:09	0.60
C-3	0.019	27.4	01Mar2017, 06:09	1.26
Junc-6	1.709	131.9	01Mar2017, 07:10	39.14
Pond 1	1.709	45.4	01Mar2017, 09:47	22.02
Sink-2	1.709	45.4	01Mar2017, 09:47	22.02
Sub-14	0.326	43.6	01Mar2017, 06:58	7.91
Sub-3B	0.176	39.6	01Mar2017, 06:27	4.27
Junc-4	0.176	39.6	01Mar2017, 06:27	4.27
Sub-12	0.010	14.4	01Mar2017, 06:09	0.66
Sub-11	0.009	13.0	01Mar2017, 06:09	0.60
C-4	0.195	48.0	01Mar2017, 06:24	5.53
Res-2	0.195	14.3	01Mar2017, 07:07	5.53
C4	0.195	14.3	01Mar2017, 07:07	5.53
Sink-1	0.195	14.3	01Mar2017, 07:07	5.53
Sub-21	0.168	85.3	01Mar2017, 06:50	11.69
Sub-20	0.164	58.2	01Mar2017, 06:52	8.52
Sub-35	0.152	77.1	01Mar2017, 06:50	10.58
Sub-25	0.133	58.8	01Mar2017, 06:51	8.26
Sub-19	0.124	58.8	01Mar2017, 06:50	8.15
Sub-42	0.107	35.2	01Mar2017, 06:52	5.23
Sub-18	0.096	39.6	01Mar2017, 06:26	3.69
Sub-17	0.079	56.6	01Mar2017, 06:24	4.68
Sub-26	0.071	57.2	01Mar2017, 06:24	4.67
Sub-16	0.068	45.3	01Mar2017, 06:25	3.80
Sub-36	0.039	49.2	01Mar2017, 06:22	3.80
Sub-27	0.036	27.7	01Mar2017, 06:24	2.26
Sub-23	0.033	20.4	01Mar2017, 06:25	1.74
Sub-3A	0.030	9.3	01Mar2017, 06:19	0.79
Junc-3	0.030	9.3	01Mar2017, 06:19	0.79
Sub-22	0.020	13.3	01Mar2017, 06:25	1.12
Sub-40	0.018	2.9	01Mar2017, 06:31	0.35
Pond 2	0.018	1.1	01Mar2017, 07:09	0.35
Sink-3	0.018	1.1	01Mar2017, 07:09	0.35
Sub-32	0.017	7.7	01Mar2017, 06:26	0.70
Sub-33	0.017	12.2	01Mar2017, 06:24	1.01
Sub-34	0.015	7.3	01Mar2017, 06:26	0.66
Sub-31	0.014	16.7	01Mar2017, 06:22	1.29
Sub-28	0.011	8.5	01Mar2017, 06:24	0.69
Sub-39	0.011	3.1	01Mar2017, 06:28	0.32
Sub-37	0.008	9.0	01Mar2017, 06:23	0.70
Sub-38	0.006	7.2	01Mar2017, 06:22	0.55
Sub-29	0.006	4.9	01Mar2017, 06:24	0.40
Sub-41	0.005	0.8	01Mar2017, 06:31	0.10
Sub-24	0.004	2.0	01Mar2017, 06:26	0.18
Sub-30	0.002	3	01Mar2017, 06:21	0.24

TABLE D7
HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY - 50 YR - 24 HR STORM
Mesquite Drainage Master Plan

Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	231.0	01Mar2017, 07:07	44.99
Sub-1	0.245	79.3	01Mar2017, 06:55	13.18
Junc-1	0.245	79.3	01Mar2017, 06:55	13.18
Reach-1	0.245	79.3	01Mar2017, 07:11	13.18
Sub-2	0.440	199.0	01Mar2017, 06:35	23.65
Junc-2	0.685	207.3	01Mar2017, 06:39	36.83
Sub-7	0.005	12.1	01Mar2017, 06:09	0.55
Sub-8	0.004	9.7	01Mar2017, 06:09	0.44
C-2	0.694	210.5	01Mar2017, 06:38	37.83
Res-1	0.694	40.5	01Mar2017, 08:12	37.82
C2	0.694	40.5	01Mar2017, 08:12	37.82
Sub-4	0.110	96.3	01Mar2017, 06:12	5.92
Sub-6	0.021	48.6	01Mar2017, 06:10	2.33
Sub-5	0.018	43.5	01Mar2017, 06:09	1.99
C-1	0.149	184.0	01Mar2017, 06:11	10.24
Sub-13	0.009	7.6	01Mar2017, 06:13	0.48
Junc-5	0.158	191.4	01Mar2017, 06:11	10.72
Res-3	0.158	53.7	01Mar2017, 06:34	5.63
C1	0.158	53.7	01Mar2017, 06:34	5.63
Sub-10	0.010	24.2	01Mar2017, 06:09	1.11
Sub-9	0.009	21.7	01Mar2017, 06:09	1.00
C-3	0.019	45.9	01Mar2017, 06:09	2.11
Junc-6	1.709	291.8	01Mar2017, 07:04	90.55
Pond 1	1.709	205.2	01Mar2017, 07:38	73.40
Sink-2	1.709	205.2	01Mar2017, 07:38	73.40
Sub-14	0.326	105.8	01Mar2017, 06:55	17.53
Sub-3B	0.176	99.7	01Mar2017, 06:25	9.47
Junc-4	0.176	99.7	01Mar2017, 06:25	9.47
Sub-12	0.010	24.2	01Mar2017, 06:09	1.11
Sub-11	0.009	21.7	01Mar2017, 06:09	1.00
C-4	0.195	114.9	01Mar2017, 06:23	11.57
Res-2	0.195	15.3	01Mar2017, 07:21	11.57
C4	0.195	15.3	01Mar2017, 07:21	11.57
Sink-1	0.195	15.3	01Mar2017, 07:21	11.57
Sub-21	0.168	143.1	01Mar2017, 06:49	19.50
Sub-20	0.164	107.3	01Mar2017, 06:51	15.32
Sub-35	0.152	129.5	01Mar2017, 06:49	17.64
Sub-25	0.133	102.3	01Mar2017, 06:50	14.18
Sub-19	0.124	100.4	01Mar2017, 06:49	13.80
Sub-42	0.107	66.2	01Mar2017, 06:51	9.55
Sub-18	0.096	80.4	01Mar2017, 06:25	7.10
Sub-17	0.079	98.6	01Mar2017, 06:24	8.04
Sub-26	0.071	97.7	01Mar2017, 06:23	7.90
Sub-16	0.068	80.6	01Mar2017, 06:24	6.63
Sub-36	0.039	73.4	01Mar2017, 06:22	5.73
Sub-27	0.036	47.3	01Mar2017, 06:23	3.82
Sub-23	0.033	37.1	01Mar2017, 06:24	3.08
Sub-3A	0.030	23.1	01Mar2017, 06:17	1.71
Junc-3	0.030	23.1	01Mar2017, 06:17	1.71
Sub-22	0.020	23.7	01Mar2017, 06:24	1.95
Sub-40	0.018	7.9	01Mar2017, 06:28	0.82
Pond 2	0.018	2.8	01Mar2017, 07:04	0.82
Sink-3	0.018	2.8	01Mar2017, 07:04	0.82
Sub-32	0.017	15.2	01Mar2017, 06:25	1.32
Sub-33	0.017	21.2	01Mar2017, 06:24	1.73
Sub-34	0.015	14.2	01Mar2017, 06:25	1.22
Sub-31	0.014	25.3	01Mar2017, 06:22	1.98
Sub-28	0.011	14.5	01Mar2017, 06:23	1.17
Sub-39	0.011	7.1	01Mar2017, 06:26	0.67
Sub-37	0.008	13.9	01Mar2017, 06:22	1.09
Sub-38	0.006	10.9	01Mar2017, 06:22	0.85
Sub-29	0.006	8.3	01Mar2017, 06:23	0.66
Sub-41	0.005	2.2	01Mar2017, 06:28	0.23
Sub-24	0.004	3.8	01Mar2017, 06:25	0.33
Sub-30	0.002	4.2	01Mar2017, 06:21	0.34

TABLE D8 HEC-HMS PROPOSED CONDITIONS HYDROLOGIC SUMMARY - 100 YR - 24 HR STORM Mesquite Drainage Master Plan				
Hydrologic Element	Area sq mi	Peak Discharge cfs	Time of Peak	Volume ac-ft
Sub-15	0.838	304.4	01Mar2017, 07:06	58.54
Sub-1	0.245	104.7	01Mar2017, 06:54	17.14
Junc-1	0.245	104.7	01Mar2017, 06:54	17.14
Reach-1	0.245	104.7	01Mar2017, 07:08	17.15
Sub-2	0.440	264.1	01Mar2017, 06:34	30.77
Junc-2	0.685	280.7	01Mar2017, 06:39	47.92
Sub-7	0.005	14.5	01Mar2017, 06:09	0.66
Sub-8	0.004	11.6	01Mar2017, 06:09	0.53
C-2	0.694	284.4	01Mar2017, 06:38	49.11
Res-1	0.694	42.2	01Mar2017, 08:17	49.11
C2	0.694	42.2	01Mar2017, 08:17	49.11
Sub-4	0.110	129.4	01Mar2017, 06:12	7.70
Sub-6	0.021	58.1	01Mar2017, 06:10	2.79
Sub-5	0.018	52.0	01Mar2017, 06:09	2.39
C-1	0.149	234.9	01Mar2017, 06:11	12.87
Sub-13	0.009	10.2	01Mar2017, 06:12	0.63
Junc-5	0.158	244.8	01Mar2017, 06:11	13.50
Res-3	0.158	108.6	01Mar2017, 06:24	8.41
C1	0.158	108.6	01Mar2017, 06:24	8.41
Sub-10	0.010	28.9	01Mar2017, 06:09	1.33
Sub-9	0.009	26.0	01Mar2017, 06:09	1.19
C-3	0.019	54.9	01Mar2017, 06:09	2.52
Junc-6	1.709	372.0	01Mar2017, 07:03	118.59
Pond 1	1.709	319.5	01Mar2017, 07:24	101.43
Sink-2	1.709	319.5	01Mar2017, 07:24	101.43
Sub-14	0.326	139.7	01Mar2017, 06:54	22.81
Sub-3B	0.176	133.0	01Mar2017, 06:24	12.32
Junc-4	0.176	133.0	01Mar2017, 06:24	12.32
Sub-12	0.010	28.9	01Mar2017, 06:09	1.33
Sub-11	0.009	26.0	01Mar2017, 06:09	1.19
C-4	0.195	151.4	01Mar2017, 06:22	14.84
Res-2	0.195	15.6	01Mar2017, 07:25	14.84
C4	0.195	15.6	01Mar2017, 07:25	14.84
Sink-1	0.195	15.6	01Mar2017, 07:25	14.84
Sub-21	0.168	170.8	01Mar2017, 06:49	23.34
Sub-20	0.164	131.5	01Mar2017, 06:50	18.77
Sub-35	0.152	154.5	01Mar2017, 06:49	21.12
Sub-25	0.133	123.4	01Mar2017, 06:49	17.13
Sub-19	0.124	120.5	01Mar2017, 06:49	16.59
Sub-42	0.107	81.6	01Mar2017, 06:51	11.76
Sub-18	0.096	101.4	01Mar2017, 06:25	8.88
Sub-17	0.079	119.2	01Mar2017, 06:23	9.71
Sub-26	0.071	117.6	01Mar2017, 06:23	9.50
Sub-16	0.068	97.9	01Mar2017, 06:24	8.04
Sub-36	0.039	84.8	01Mar2017, 06:22	6.65
Sub-27	0.036	56.9	01Mar2017, 06:23	4.60
Sub-23	0.033	45.3	01Mar2017, 06:24	3.75
Sub-3A	0.030	30.6	01Mar2017, 06:17	2.21
Junc-3	0.030	30.6	01Mar2017, 06:17	2.21
Sub-22	0.020	28.8	01Mar2017, 06:24	2.37
Sub-40	0.018	10.7	01Mar2017, 06:27	1.09
Pond 2	0.018	3.7	01Mar2017, 07:02	1.09
Sink-3	0.018	3.7	01Mar2017, 07:02	1.09
Sub-32	0.017	19.0	01Mar2017, 06:25	1.64
Sub-33	0.017	25.7	01Mar2017, 06:23	2.09
Sub-34	0.015	17.7	01Mar2017, 06:24	1.51
Sub-31	0.014	29.4	01Mar2017, 06:22	2.31
Sub-28	0.011	17.4	01Mar2017, 06:23	1.41
Sub-39	0.011	9.2	01Mar2017, 06:26	0.85
Sub-37	0.008	16.2	01Mar2017, 06:22	1.27
Sub-38	0.006	12.6	01Mar2017, 06:22	0.99
Sub-29	0.006	9.9	01Mar2017, 06:23	0.80
Sub-41	0.005	3.0	01Mar2017, 06:27	0.30
Sub-24	0.004	4.7	01Mar2017, 06:24	0.40
Sub-30	0.002	4.8	01Mar2017, 06:21	0.39

APPENDIX E

CULVERT MASTER AND FLOW MASTER DATA AND OUTPUT FOR EXISTING CULVERTS (a)

Table E1	Existing Culverts Data and Results
	Culvert Master Calculation Reports
	Flow Master Calculation Reports

(a) Digital Culvert Master and Flow Master files are included on DVD.

TABLE E1
EXISTING CULVERT DATA AND RESULTS
Mesquite Draiange Master Plan

	CULVERT DATA FOR CULVERT MASTER									5-yr 24-hr storm				10-yr 24-hr storm				50-yr 24-hr storm				100-yr 24-hr storm			
Culvert Name / Location Description	Existing or Proposed	Comment on Inlet Sediment or Debris	No. of Culverts	Material	Culvert Rise	Culvert Rise	Maximum Cuvlert Capacity assuming 15% Clogging Factor	Discharge Per Culvert	HEC-HMS Analysis Point Name	Peak Discharge	Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity)	Extra Culverts Required Y or N	No. of Extra Cuvlerts to pass flow (same as existing)	Peak Discharge	Spill flow (Max. Capacity minus peak discharge) - positive mens excess capacity	Extra Culverts Required Y or N	No. of Extra Cuvlerts to pass flow (same as existing)	Peak Discharge	Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity)	Extra Culverts Required Y or N	No. of Extra Cuvlerts to pass flow (same as existing)	Peak Discharge	Spill flow (Max. Capacity minus peak discharge) - positive means excess capacity	Extra Culverts Required Y or N	No. of Extra Cuvlerts to pass flow (same as existing)
					inches	feet	cfs	cfs		cfs				cfs				cfs				cfs			
a		d					f		a b	g			h	g			h	g			h	g			h
C1 / I-10	Existing	Fully open	1	CBC	96	8	377	377	C-1 Junction	56	321	N	0.0	88	289	N	0.0	184	193	N	0.0	235	142	N	0.0
C2 / I-10	Existing	Sediment and vegetation	1	RCP	30	2.5	36	36	C-2 Junction	46	-10	Y	0.3	83	-47	Y	1.3	211	-175	Y	4.9	284	-249	Y	7.0
C3 / I-10	Existing	Sediment and vegetation	3	CMP	30	2.5	65	22	C-3 Junction	20	45	N	0.0	27	38	N	0.0	46	19	N	0.0	55	10	N	0.0
C4 / I-10	Existing	Partially Clogged	1	CMP	24	2	12	12	C-4 Junction	27	-15	Y	1.2	48	-36	Y	2.9	115	-103	Y	8.4	151	-139	Y	11.4

a - See Figure 2-Drainage Basin Map for culvert locations
b- See HEC-RAS Model Schematic for HEC-HMS analysis point locations
c - Assume all relative usptream cuvlert invert elevations as elev. 100, compute downstream elevation based on culvert length and an assumed 1 % slope
d - The maximum available headwater depth for the signficant culverts were measured by Smith Engineering engineers
e - Assume tailwater elevation = the downstream invert elevation + 75% of the maximum available headwater depth
f - CulvertMaser output is included in Appendix, assume a 15% clogging factor at inlet due to sediment and debris / vegetation
g - See HEC-HMS Summary output tables included in Appendix D
f - CulvertMaser output is included in this Appendix F, assume a 15% clogging factor at inlet due to sediment and debris / vegetation
h -Compute as spill flow divided by Culvert Capacity

Culvert Calculator Report
C1 - CBC 8' x 8'

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	108.00 ft	Headwater Depth/Height	1.00
Computed Headwater Elevation	108.00 ft	Discharge	443.53 cfs
Inlet Control HW Elev.	107.23 ft	Tailwater Elevation	13.65 ft
Outlet Control HW Elev.	108.00 ft	Control Type	Entrance Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	97.65 ft
Length	235.00 ft	Constructed Slope	0.010000 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	3.44 ft
Slope Type	Steep	Normal Depth	3.28 ft
Flow Regime	Supercritical	Critical Depth	4.57 ft
Velocity Downstream	16.13 ft/s	Critical Slope	0.004099 ft/ft

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.00 ft
Section Size	8 x 8 ft	Rise	8.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	108.00 ft	Upstream Velocity Head	2.29 ft
Ke	0.50	Entrance Loss	1.14 ft

Inlet Control Properties

Inlet Control HW Elev.	107.23 ft	Flow Control	N/A
Inlet Type	45° wingwall flares - offset	Area Full	64.0 ft²
K	0.49700	HDS 5 Chart	13
M	0.66700	HDS 5 Scale	1
C	0.03020	Equation Form	2
Y	0.83500		

Culvert Calculator Report
C2 - RCP @ 30" dia

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	106.00 ft	Headwater Depth/Height	2.40
Computed Headwater Elevation	106.00 ft	Discharge	42.08 cfs
Inlet Control HW Elev.	104.04 ft	Tailwater Elevation	102.05 ft
Outlet Control HW Elev.	106.00 ft	Control Type	Outlet Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	97.55 ft
Length	245.00 ft	Constructed Slope	0.010000 ft/ft

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	4.50 ft
Slope Type	N/A	Normal Depth	2.11 ft
Flow Regime	N/A	Critical Depth	2.17 ft
Velocity Downstream	8.57 ft/s	Critical Slope	0.009618 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	106.00 ft	Upstream Velocity Head	1.14 ft
Ke	0.20	Entrance Loss	0.23 ft

Inlet Control Properties

Inlet Control HW Elev.	104.04 ft	Flow Control	N/A
Inlet Type	Groove end projecting	Area Full	4.9 ft²
K	0.00450	HDS 5 Chart	1
M	2.00000	HDS 5 Scale	3
C	0.03170	Equation Form	1
Y	0.69000		

Culvert Calculator Report
C3 - CMP @ 30" dia

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	106.00 ft	Headwater Depth/Height	2.40
Computed Headwater Elevation	106.00 ft	Discharge	76.59 cfs
Inlet Control HW Elev.	102.77 ft	Tailwater Elevation	102.05 ft
Outlet Control HW Elev.	106.00 ft	Control Type	Outlet Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	97.55 ft
Length	245.00 ft	Constructed Slope	0.010000 ft/ft

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	4.50 ft
Slope Type	N/A	Normal Depth	N/A ft
Flow Regime	N/A	Critical Depth	1.72 ft
Velocity Downstream	5.20 ft/s	Critical Slope	0.019651 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.50 ft
Section Size	30 inch	Rise	2.50 ft
Number Sections	3		

Outlet Control Properties

Outlet Control HW Elev.	106.00 ft	Upstream Velocity Head	0.42 ft
Ke	0.70	Entrance Loss	0.29 ft

Inlet Control Properties

Inlet Control HW Elev.	102.77 ft	Flow Control	N/A
Inlet Type	Mitered to slope	Area Full	14.7 ft²
K	0.02100	HDS 5 Chart	2
M	1.33000	HDS 5 Scale	2
C	0.04630	Equation Form	1
Y	0.75000		

Culvert Calculator Report
C4 - CMP @ 24" dia

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	106.00 ft	Headwater Depth/Height	3.00
Computed Headwater Elevation	106.00 ft	Discharge	14.42 cfs
Inlet Control HW Elev.	102.20 ft	Tailwater Elevation	102.05 ft
Outlet Control HW Elev.	106.00 ft	Control Type	Outlet Control

Grades

Upstream Invert	100.00 ft	Downstream Invert	97.55 ft
Length	245.00 ft	Constructed Slope	0.010000 ft/ft

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	4.50 ft
Slope Type	N/A	Normal Depth	N/A ft
Flow Regime	N/A	Critical Depth	1.37 ft
Velocity Downstream	4.59 ft/s	Critical Slope	0.021004 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	106.00 ft	Upstream Velocity Head	0.33 ft
Ke	0.70	Entrance Loss	0.23 ft

Inlet Control Properties

Inlet Control HW Elev.	102.20 ft	Flow Control	N/A
Inlet Type	Mitered to slope	Area Full	3.1 ft²
K	0.02100	HDS 5 Chart	2
M	1.33000	HDS 5 Scale	2
C	0.04630	Equation Form	1
Y	0.75000		

24" RCP Discharge Calculations Report

Label	Solve For	Friction Method	Roughness Coefficient
24" RCP Pipe	Discharge	Manning Formula	0.013

Channel Slope (ft/ft)	Normal Depth (ft)	Diameter (ft)	Discharge (ft³/s)
0.00100	2.00	2.00	7.15

Flow Area (ft²)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Top Width (ft)
3.14	6.28	0.50	0.00

Critical Depth (ft)	Percent Full (%)	Critical Slope (ft/ft)	Velocity (ft/s)
0.95	100.0	0.00478	2.28

Velocity Head (ft)	Specific Energy (ft)	Froude Number	Maximum Discharge (ft³/s)
0.08	2.08	0.00	7.69

Discharge Full (ft³/s)	Slope Full (ft/ft)	Flow Type	Notes
7.15	0.00100	SubCritical	

Messages

Roadside Pond Discharge Calculations Report

Label	Solve For	Friction Method	Roughness Coefficient
Triangular Roadside Ponding	Discharge	Manning Formula	0.013

Channel Slope (ft/ft)	Normal Depth (ft)	Left Side Slope (ft/ft (H:V))	Right Side Slope (ft/ft (H:V))
0.00100	1.00	4.00	4.00

Discharge (ft^3/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)
8.93	4.00	8.25	0.49

Top Width (ft)	Critical Depth (ft)	Critical Slope (ft/ft)	Velocity (ft/s)
8.00	0.79	0.00349	2.23

Velocity Head (ft)	Specific Energy (ft)	Froude Number	Flow Type
0.08	1.08	0.56	Subcritical

Notes	Messages

APPENDIX F

PROPOSED IMPROVEMENTS/CONCEPTUAL COST ESTIMATES

Facility 1 / Pond 1	
ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN	
Facility No. and Description	Estimated Cost
Facility 1.1 / Pond 1 - Land Acquisition	$37,000.00
Facility 1.2 / Pond 1 - Pond Construction	$1,071,000.00
Facility 1 / Pond 1 Total	$1,108,000.00

Facility 1.1 / Pond 1 - Land Acquisition

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	0.00	$2,500.00	$0.00
2	SEEDING, Complete	ACRES	0.00	$1,650.00	$0.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	0	$10.00	$0.00
4	FINAL GRADING, Complete in Place	SY	0	$2.50	$0.00
5	12" SUBGRADE PREPARATION, Complete in Place	SY	0	$5.00	$0.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$0.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$38.00	$0.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	0	$275.00	$0.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	RIP-RAP CLASS A, Complete in Place	CY	0	$100.00	$0.00
17	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
18	REINFORCED STRUCTURAL CONCRETE, Complete in Place	CY	0	$600.00	$0.00
19	PRINCIPAL SPILLWAY DOUBLE VERTICAL PIPES PORTER RISER - Assume 5 ft tall - (48" and 72" CMPs with 8" PVC reverse incline ports), including concrete slab, Complete in Place	EA	0	$6,408.00	$0.00
20	GABIONS, Complete in Place	CY	0	$275.00	$0.00
21	2" HMA SP III, Complete	SY	0	$15.00	$0.00
22	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
23	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
24	SECURITY SIGNING	LUMP SUM	0	$500.00	$0.00
25	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	0	$2,500.00	$0.00
26	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	0	$15,000.00	$0.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$0.00
27	MOBILIZATION / DEMOBILIZATION	LUMP SUM	0	6.00%	$0.00
28	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	0	2.00%	$0.00
29	MATERIALS TESTING	ALLOW	0	2.00%	$0.00
A	SUBTOTAL OF CONSTRUCTION COST				$0.00
B	CONTINGENCY @ 30%:				$0.00
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$0.00
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$0.00
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$0.00
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	13.5	$2,500.00	$33,750.00
H	SUBTOTAL : (E + F +G)				$33,750.00
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$2,278.13
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$36,028.13

Facility 1.1 / Pond 1 - Land Acquisition

QUANTITY CALCULATIONS

ITEM	green = results, other cells are data			
Pond Clear and Grub Area (from CAD)			Area (SF)	Area (AC)
			0	0
Pond Excavation Volume (from CAD)			Volume (AC-FT)	Volume (CY)
			0	0
Pond Final Grading Area (from CAD)			Area (SF)	Area (SY)
			0	0
Reinforced Concrete Emergency Spillway (assume length perpindicular to flow, width with flow, thickness, compute as concrete channel SY and CY)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Base Course Top of Dam (assume maintenance road for only the downstream emankment length, width)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Trapezoidal Channel Rip-Rap Volume. Assume 1.5' shoulder on each side.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Rip-Rap Thickness (ft)	Area (SF)	Area (SY)	Volume (CY)
	0.00	0	0	0
Trapezoidal Channel Soil Excavation Volume Need to excavate to channel invert, plus volume of channel lining.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
		Excavation to Channel Invert (CY)	Excavation for Channel Lining (CY)	Total Excavation (CY)
		0	0	0
Channel Clear and Grub Area (assume 10' wide disturbed area on each side of channel)	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Total Channel Width (ft)	Disturbed Width (ft)	Area (SF)	Area (AC)
	0.00	0.00	0	0.00
Channel Final Grading and Seeding (for 10' disturbed area on each side of channel)	Length (ft)	Width (ft)	Area (SY)	Area (AC)
	0.0	20.0	0.0	0
Gabions		Length All Baskets(ft)	Width All Baskets (ft)	Depth all Baskets (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0

Facility 1.2 / Pond 1 - Pond Construction

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	12.00	$2,500.00	$30,000.00
2	SEEDING, Complete	ACRES	12.00	$1,650.00	$19,800.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	71,490	$6.00	$428,940.00
4	FINAL GRADING, Complete in Place	SY	56,340	$2.50	$140,850.00
5	12" SUBGRADE PREPARATION, Complete in Place	SY	0	$5.00	$0.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$0.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$38.00	$0.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	0	$275.00	$0.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	RIP-RAP CLASS A, Complete in Place	CY	0	$100.00	$0.00
17	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
18	REINFORCED STRUCTURAL CONCRETE, Complete in Place	CY	0	$600.00	$0.00
19	PRINCIPAL SPILLWAY DOUBLE VERTICAL PIPES PORTER RISER - Assume 5 ft tall - (48" and 72" CMPs with 8" PVC reverse incline ports), including concrete slab, Complete in Place	EA		$6,408.00	$0.00
20	GABIONS, Complete in Place	CY	0	$275.00	$0.00
21	2" HMA SP III, Complete	SY	0	$15.00	$0.00
22	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
23	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
24	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
25	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
26	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$637,590.00
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$38,256.00
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$12,752.00
	MATERIALS TESTING	ALLOW	1	2.00%	$12,752.00
A	SUBTOTAL OF CONSTRUCTION COST				$701,350.00
B	CONTINGENCY @ 30%:				$210,405.00
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$911,755.00
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$91,175.50
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$1,002,930.50
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	0	$2,500.00	$0.00
H	SUBTOTAL : (E + F +G)				$1,002,930.50
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$67,697.81
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$1,070,628.31

Facility 1.2 / Pond 1 - Pond Construction

ASSUMPTIONS

1	Assume entire property to be cleared and grubbed.
4	Final grading area measured from CAD

QUANTITY CALCULATIONS

ITEM	green = results, other cells are data			
Pond Clear and Grub Area (from CAD)			Area (SF)	Area (AC)
			506,998	12
Pond Excavation Volume (from CAD)				Volume (CY)
				71,487
Pond Final Grading Area (from CAD)			Area (SF)	Area (SY)
			506,998	56,333
Reinforced Concrete Emergency Spillway (assume length perpindicular to flow, width with flow, thickness, compute as concrete channel SY and CY)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Base Course Top of Dam (assume maintenance road for only the downstream emankment length, width)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Trapezoidal Channel Rip-Rap Volume. Assume 1.5' shoulder on each side.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Rip-Rap Thickness (ft)	Area (SF)	Area (SY)	Volume (CY)
	0.00	0	0	0
Trapezoidal Channel Soil Excavation Volume Need to excavate to channel invert, plus volume of channel lining.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
		Excavation to Channel Invert (CY)	Excavation for Channel Lining (CY)	Total Excavation (CY)
		0	0	0
Channel Clear and Grub Area (assume 10' wide disturbed area on each side of channel)	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Total Channel Width (ft)	Disturbed Width (ft)	Area (SF)	Area (AC)
	0.00	0.00	0	0.00
Channel 12" Subgrade Preparation (use channel lining area from above)				Area (SY)
				0
Channel Final Grading and Seeding (for 10' disturbed area on each side of channel)	Length (ft)	Width (ft)	Area (SY)	Area (AC)
	0.0	0.0	0.0	0
Gabions		Length All Baskets(ft)	Width All Baskets (ft)	Depth all Baskets (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0

Facility 2 / Pond 2	
ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN	
Facility No. and Description	Estimated Cost
Facility 2.1 / Pond 2 - Land Acquisition	$3,000.00
Facility 2.2 / Pond 2 - Pond Construction	$675,000.00
Facility 2 / Pond 2 Total	$678,000.00

Facility 2.1 / Pond 2 - Land Acquisition

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	0.00	$2,500.00	$0.00
2	SEEDING, Complete	ACRES	0.00	$1,650.00	$0.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	0	$10.00	$0.00
4	FINAL GRADING, Complete in Place	SY	0	$2.50	$0.00
5	12" SUBGRADE PREPARATION, Complete in Place	SY	0	$5.00	$0.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$0.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$38.00	$0.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	0	$275.00	$0.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	RIP-RAP CLASS A, Complete in Place	CY	0	$100.00	$0.00
17	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
18	REINFORCED STRUCTURAL CONCRETE, Complete in Place	CY	0	$600.00	$0.00
19	PRINCIPAL SPILLWAY DOUBLE VERTICAL PIPES PORTER RISER - Assume 5 ft tall - (48" and 72" CMPs with 8" PVC reverse incline ports), including concrete slab, Complete in Place	EA	0	$6,408.00	$0.00
20	GABIONS, Complete in Place	CY	0	$275.00	$0.00
21	2" HMA SP III, Complete	SY	0	$15.00	$0.00
22	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
23	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
24	SECURITY SIGNING	LUMP SUM	0	$500.00	$0.00
25	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	0	$2,500.00	$0.00
26	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	0	$15,000.00	$0.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$0.00
27	MOBILIZATION / DEMOBILIZATION	LUMP SUM	0	6.00%	$0.00
28	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	0	2.00%	$0.00
29	MATERIALS TESTING	ALLOW	0	2.00%	$0.00
A	SUBTOTAL OF CONSTRUCTION COST				$0.00
B	CONTINGENCY @ 30%:				$0.00
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$0.00
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$0.00
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$0.00
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	1.0	$2,500.00	$2,500.00
H	SUBTOTAL : (E + F +G)				$2,500.00
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$168.75
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$2,668.75

Facility 2.1 / Pond 2 - Land Acquisition

QUANTITY CALCULATIONS

ITEM	green = results, other cells are data			
Pond Clear and Grub Area (from CAD)			Area (SF)	Area (AC)
			0	0
Pond Excavation Volume (from CAD)			Volume (AC-FT)	Volume (CY)
			0	0
Pond Final Grading Area (from CAD)			Area (SF)	Area (SY)
			0	0
Reinforced Concrete Emergency Spillway (assume length perpindicular to flow, width with flow, thickness, compute as concrete channel SY and CY)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Base Course Top of Dam (assume maintenance road for only the downstream emankment length, width)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Trapezoidal Channel Rip-Rap Volume. Assume 1.5' shoulder on each side.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Rip-Rap Thickness (ft)	Area (SF)	Area (SY)	Volume (CY)
	0.00	0	0	0
Trapezoidal Channel Soil Excavation Volume Need to excavate to channel invert, plus volume of channel lining.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
		Excavation to Channel Invert (CY)	Excavation for Channel Lining (CY)	Total Excavation (CY)
		0	0	0
Channel Clear and Grub Area (assume 10' wide disturbed area on each side of channel)	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Total Channel Width (ft)	Disturbed Width (ft)	Area (SF)	Area (AC)
	0.00	0.00	0	0.00
Channel Final Grading and Seeding (for 10' disturbed area on each side of channel)	Length (ft)	Width (ft)	Area (SY)	Area (AC)
	0.0	0.0	0.0	0
Gabions		Length All Baskets(ft)	Width All Baskets (ft)	Depth all Baskets (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0

Facility 2.2 / Pond 2 - Pond Construction

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	1.00	$2,500.00	$2,500.00
2	SEEDING, Complete	ACRES	1.00	$1,650.00	$1,650.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	6,295	$6.00	$37,770.00
4	FINAL GRADING, Complete in Place	SY	3,695	$2.50	$9,237.50
5	12" SUBGRADE PREPARATION, Complete in Place	SY	0	$5.00	$0.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$50,000.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	2,000	$30.00	$60,000.00
8	24" DIAMETER PIPE, RCP, Place in Open Trench, Complete	LF	2,000	$46.00	$92,000.00
9	DROP INLET, Complete in Place	EA	18	$4,000.00	$72,000.00
2	4' DIAMETER CONCRETE STORM DRAINAGE MANHOLE, including frame and cover, footing, excavation, and backfil	EA	10	$5,000.00	$50,000.00
3	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$38.00	$0.00
4	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
5	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
6	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
7	24" DIAMETER CMP, END SECTION, Complete	EA	0	$275.00	$0.00
8	36" DIAMETER CMP, END SECTION, Complete	EA	0	$400.00	$0.00
9	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
10	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
11	RIP-RAP CLASS A, Complete in Place	CY	0	$100.00	$0.00
12	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
13	REINFORCED STRUCTURAL CONCRETE, Complete in Place	CY	0	$600.00	$0.00
14	PRINCIPAL SPILLWAY DOUBLE VERTICAL PIPES PORTER RISER - Assume 5 ft tall - (48" and 72" CMPs with 8" PVC reverse incline ports), including concrete slab, Complete in Place	EA		$6,408.00	$0.00
15	GABIONS, Complete in Place	CY	0	$275.00	$0.00
16	2" HMA SP III, Complete	SY	0	$15.00	$0.00
17	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
18	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	1,200	$7.00	$8,400.00
19	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
20	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
21	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$401,557.50
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$24,094.00
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$8,032.00
	MATERIALS TESTING	ALLOW	1	2.00%	$8,032.00
A	SUBTOTAL OF CONSTRUCTION COST				$441,715.50
B	CONTINGENCY @ 30%:				$132,514.65
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$574,230.15
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$57,423.02
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$631,653.17
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	0	$2,500.00	$0.00
H	SUBTOTAL : (E + F +G)				$631,653.17
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$42,636.59
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$674,289.75

Facility 2.2 / Pond 2 - Pond Construction

ASSUMPTIONS

1	Assume entire property to be cleared and grubbed.
4	Final grading area measured from CAD

QUANTITY CALCULATIONS

ITEM	green = results, other cells are data			
Pond Clear and Grub Area (from CAD)			Area (SF)	Area (AC)
			33,250	1
Pond Excavation Volume (from CAD)				Volume (CY)
				6,292
Pond Final Grading Area (from CAD)			Area (SF)	Area (SY)
			33,250	3,694
Reinforced Concrete Emergency Spillway (assume length perpindicular to flow, width with flow, thickness, compute as concrete channel SY and CY)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Base Course Top of Dam (assume maintenance road for only the downstream emankment length, width)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Trapezoidal Channel Rip-Rap Volume. Assume 1.5' shoulder on each side.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Rip-Rap Thickness (ft)	Area (SF)	Area (SY)	Volume (CY)
	0.00	0	0	0
Trapezoidal Channel Soil Excavation Volume Need to excavate to channel invert, plus volume of channel lining.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
		Excavation to Channel Invert (CY)	Excavation for Channel Lining (CY)	Total Excavation (CY)
		0	0	0
Channel Clear and Grub Area (assume 10' wide disturbed area on each side of channel)	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Total Channel Width (ft)	Disturbed Width (ft)	Area (SF)	Area (AC)
	0.00	0.00	0	0.00
Channel 12" Subgrade Preparation (use channel lining area from above)				Area (SY)
				0
Channel Final Grading and Seeding (for 10' disturbed area on each side of channel)	Length (ft)	Width (ft)	Area (SY)	Area (AC)
	0.0	0.0	0.0	0
Gabions		Length All Baskets(ft)	Width All Baskets (ft)	Depth all Baskets (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0

Facility 3 / Roadside Ponding Construction	
ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN	
Facility No. and Description	Estimated Cost
Facility 3 / Roadside Ponding Construction	$119,000.00
Facility 3 / Roadside Ponding Construction Total	$119,000.00

Facility 3 / Roadside Ponding Construction

ENGINEER'S OPINION OF PROBABLE COST (EOPC) FOR CONCEPTUAL DESIGN

ITEM NO.	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	ITEM COST
1	CLEARING AND GRUBBING, Complete in Place	ACRES	2	$2,500.00	$5,000.00
2	SEEDING, Complete	ACRES	2	$1,650.00	$3,300.00
3	SOIL BULK EXCAVATION FOR POND EMBANKMENT, CHANNELS / ROADWAY and FILL CONSTRUCTION FOR EMBANKMENTS, (incl. excavation, haul, disposal, fill placement and compaction), Complete in Place	CY	4,020	$6.00	$24,120.00
4	FINAL GRADING, Complete in Place	SY	7,975	$2.50	$19,937.50
5	12" SUBGRADE PREPARATION, Complete in Place	SY	0	$5.00	$0.00
6	TRENCHING, BACKFILL, & COMPACTION FOR 18" TO 36" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$25.00	$0.00
7	TRENCHING, BACKFILL, & COMPACTION FOR 42" TO 60" PIPE, UP TO 8' IN DEPTH, Complete	LF	0	$30.00	$0.00
8	24" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$38.00	$0.00
9	36" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$58.00	$0.00
10	48" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$76.00	$0.00
11	60" DIAMETER PIPE, CMP, Place in Open Trench, Complete	LF	0	$110.00	$0.00
12	24" DIAMETER CMP, END SECTION, Complete	EA	0	$275.00	$0.00
13	36" DIAMETER CMP, END SECTION, Complete	EA	1	$400.00	$400.00
14	48" DIAMETER CMP, END SECTION, Complete	EA	0	$800.00	$0.00
15	60" DIAMETER CMP, END SECTION, Complete	EA	0	$1,400.00	$0.00
16	RIP-RAP CLASS A, Complete in Place	CY	0	$100.00	$0.00
17	REINFORCED CONCRETE CHANNEL 6", Complete in Place	SF	0	$9.28	$0.00
18	REINFORCED STRUCTURAL CONCRETE, Complete in Place	CY	0	$600.00	$0.00
19	PRINCIPAL SPILLWAY DOUBLE VERTICAL PIPES PORTER RISER - Assume 5 ft tall - (48" and 72" CMPs with 8" PVC reverse incline ports), including concrete slab, Complete in Place	EA		$6,408.00	$0.00
20	GABIONS, Complete in Place	CY	0	$275.00	$0.00
21	2" HMA SP III, Complete	SY	0	$15.00	$0.00
22	BASE COURSE 6", Complete	SY	0	$8.00	$0.00
23	SAWCUT, REMOVE AND DISPOSE OF EXISTING ASPHALT PAVEMENT, up to 4" thick, Complete	SY	0	$7.00	$0.00
24	SECURITY SIGNING	LUMP SUM	1	$500.00	$500.00
25	CONSTRUCTION TRAFFIC CONTROL	LUMP SUM	1	$2,500.00	$2,500.00
26	NPDES PERMITTING AND SWPPP PREPARATION AND IMPLEMENTATION	LUMP SUM	1	$15,000.00	$15,000.00
	SUBTOTAL OF CONSTRUCTION LINE ITEMS				$70,757.50
	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1	6.00%	$4,246.00
	CONSTRUCTION STAKING (incl. LAYOUT, QUANTITY VERIFICATION, AS-BUILT INFORMATION), Complete	LUMP SUM	1	2.00%	$1,416.00
	MATERIALS TESTING	ALLOW	1	2.00%	$1,416.00
A	SUBTOTAL OF CONSTRUCTION COST				$77,835.50
B	CONTINGENCY @ 30%:				$23,350.65
C	SUBTOTAL OF CONSTRUCTION COST PLUS CONTINGENCY:				$101,186.15
D	PRE-CONSTRUCTION COSTS: (DESIGN, SURVEY, GEOTECHNICAL, & SUE = 10% of C)				$10,118.62
E	SUBTOTAL , CONTINGENCY, AND PRE-CONSTRUCTION COSTS: (C + D)				$111,304.77
	ALLOWANCES				
F	ASSUMED UTILITY RELOCATION (IF APPLICABLE)				$0.00
G	LAND ACQUISITION (ASSUMED VALUE OF $2,500/AC)	ACRE	0	$2,500.00	$0.00
H	SUBTOTAL : (E + F +G)				$111,304.77
I	NEW MEXICO GROSS RECEIPTS TAX (Dona Ana County) (NMGRT - JANUARY 2017) - 6.7500%				$7,513.07
J	TOTAL EOPC w/ TAX (NMGRT 2017): (H + I)				$118,817.84

Facility 3 / Roadside Ponding Construction

ASSUMPTIONS

1	Assume entire property to be cleared and grubbed.
4	Final grading area measured from CAD

QUANTITY CALCULATIONS

ITEM	green = results, other cells are data			
Pond Clear and Grub Area (from CAD)			Area (SF)	Area (AC)
			71,752	2
Pond Excavation Volume (from CAD)				Volume (CY)
				4,017
Pond Final Grading Area (from CAD)			Area (SF)	Area (SY)
			71,752	7,972
Reinforced Concrete Emergency Spillway (assume length perpindicular to flow, width with flow, thickness, compute as concrete channel SY and CY)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Base Course Top of Dam (assume maintenance road for only the downstream emankment length, width)		Length (ft)	Width (ft)	Thickness (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0
Trapezoidal Channel Rip-Rap Volume. Assume 1.5' shoulder on each side.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Rip-Rap Thickness (ft)	Area (SF)	Area (SY)	Volume (CY)
	0.00	0	0	0
Trapezoidal Channel Soil Excavation Volume Need to excavate to channel invert, plus volume of channel lining.	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
		Excavation to Channel Invert (CY)	Excavation for Channel Lining (CY)	Total Excavation (CY)
		0	0	0
Channel Clear and Grub Area (assume 10' wide disturbed area on each side of channel)	Length (ft)	Bottom Width (ft)	Depth (ft)	Side Slope (H:V)
	0.0	0.0	0.0	0.0
	Total Channel Width (ft)	Disturbed Width (ft)	Area (SF)	Area (AC)
	0.00	0.00	0	0.00
Channel 12" Subgrade Preparation (use channel lining area from above)				Area (SY)
				0
Channel Final Grading and Seeding (for 10' disturbed area on each side of channel)	Length (ft)	Width (ft)	Area (SY)	Area (AC)
	0.0	0.0	0.0	0
Gabions		Length All Baskets(ft)	Width All Baskets (ft)	Depth all Baskets (ft)
		0.0	0.0	0.0
			Area (SY)	Volume (CY)
			0.0	0.0