APPENDIX B
SOIL STUDY

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 Andrews County, Texas, and Lea County, New Mexico

WCS

December 22, 2015

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 (http://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.

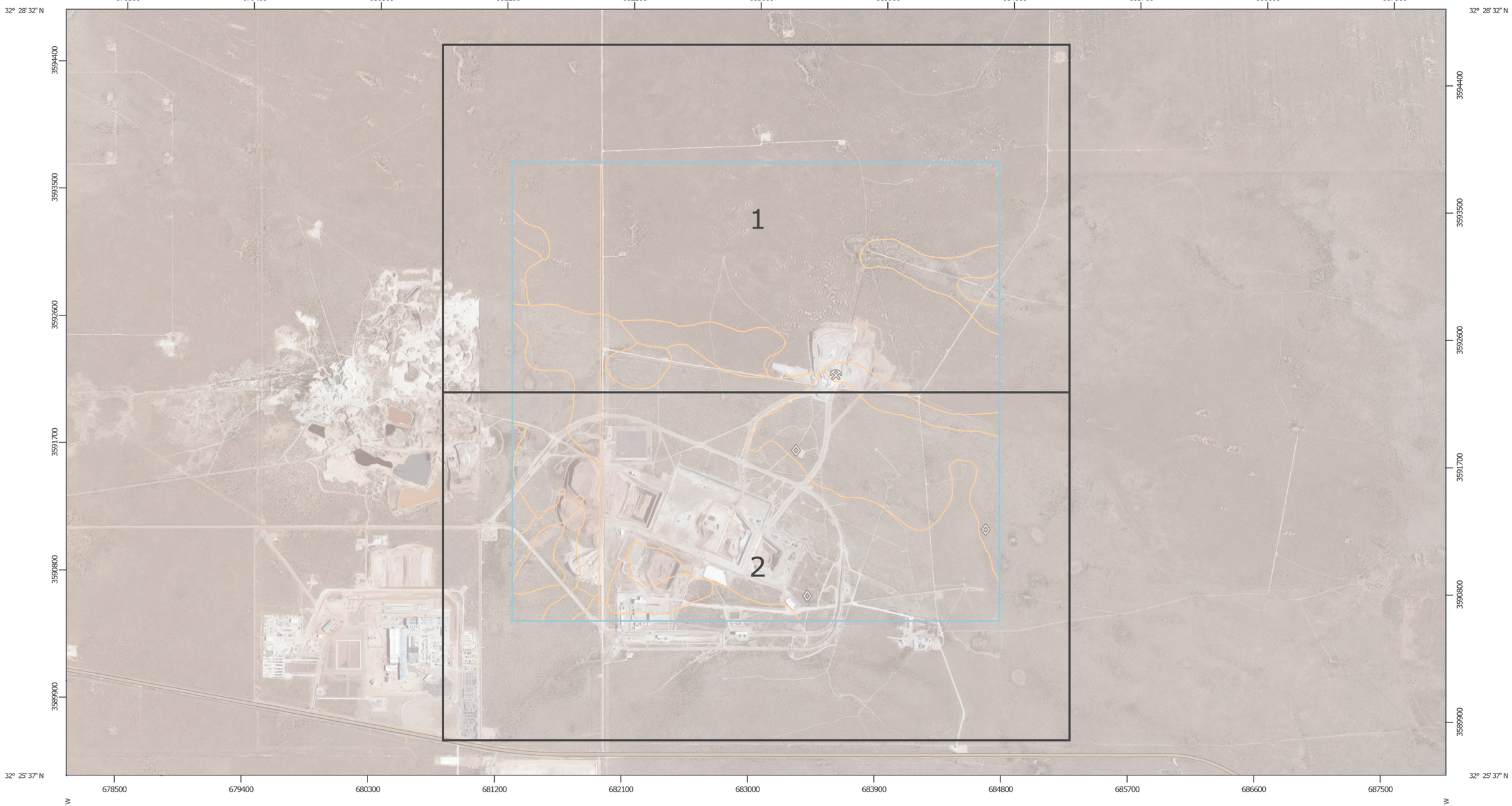
While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the 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.



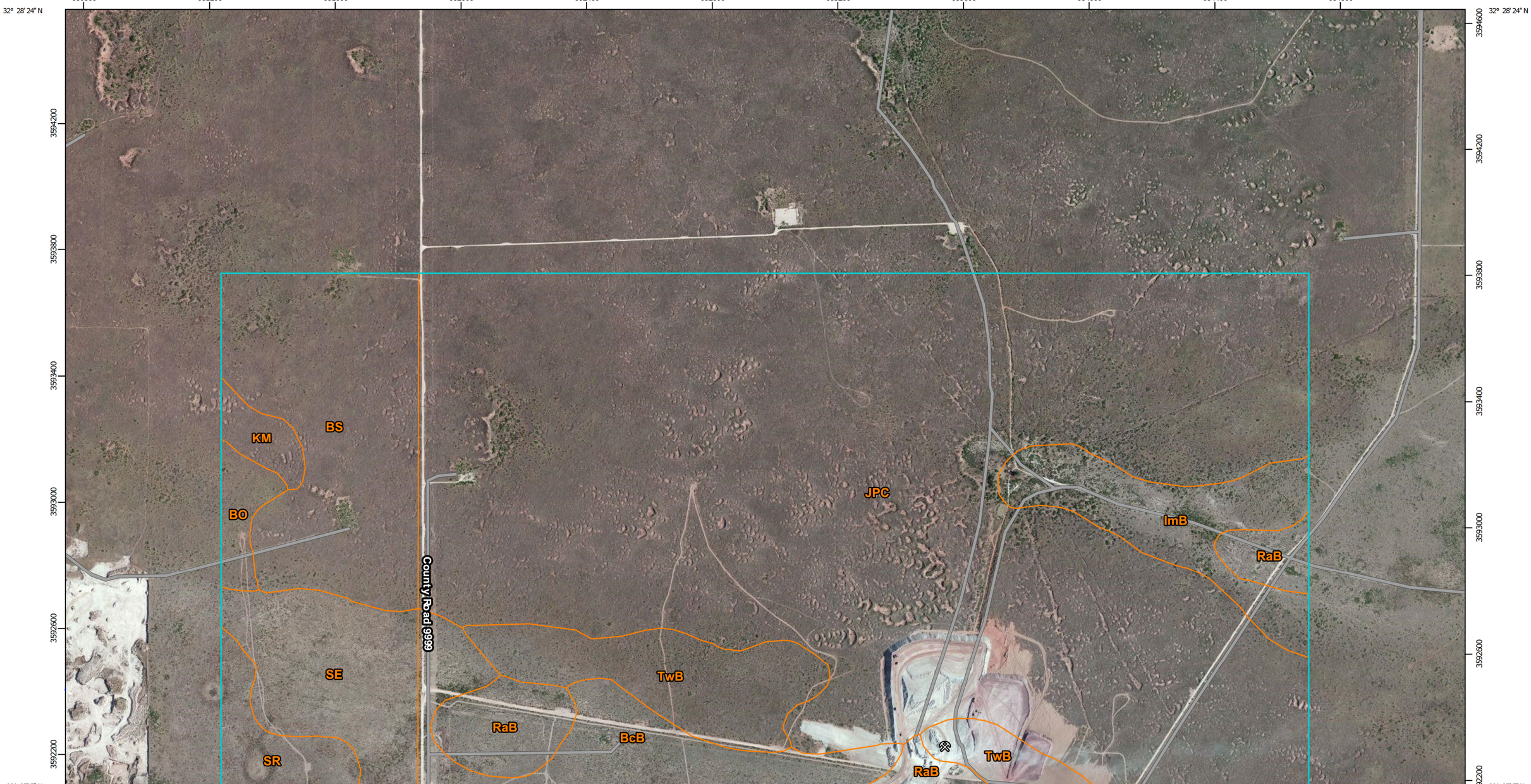
Map Scale: 1:26,400 if printed on B landscape (17" x 11") sheet.

N

Meters
0 350 700 1400 2100

Feet
0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84



Joins sheet 2

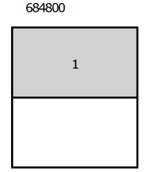
Map Scale: 1:12,000 if printed on B landscape (17" x 11") sheet.

N

Meters
0 150 300 600 900

Feet
0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84



Map Sheet Location

Custom Soil Resource Report
Soil Map
Map sheet 2 of 2

Joins sheet 1

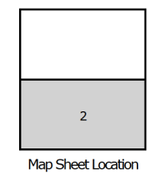
Map Scale: 1:12,000 if printed on B landscape (17" x 11") sheet.

N

Meters
0 150 300 600 900

Feet
0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84



Map Sheet Location

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 scales ranging from 1:20,000 to 1:31,700.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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: Andrews County, Texas
Survey Area Data: Version 13, Sep 18, 2015

Soil Survey Area: Lea County, New Mexico
Survey Area Data: Version 12, Sep 29, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Data not available.

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

Andrews County, Texas (TX003)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
BcB	Blakeney and Conger soils, gently undulating	795.1	28.6%
FdB	Faskin and Douro soils, gently undulating	40.8	1.5%
ImB	Ima loamy fine sand, 0 to 3 percent slopes	61.8	2.2%
JPC	Jalmar-Penwell association, undulating	907.7	32.6%
KmB	Kimbrough soils, gently undulating	21.2	0.8%
RaB	Ratliff soils, gently undulating	342.7	12.3%
TwB	Triomas and Wickett soils, gently undulating	109.6	3.9%
Subtotals for Soil Survey Area		**2,278.8**	**82.0%**
Totals for Area of Interest		**2,780.3**	**100.0%**

Lea County, New Mexico (NM025)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
AB	Amarillo-Arvana loamy fine sands association	12.5	0.5%
BO	Brownfield-Springer association	47.5	1.7%
BS	Brownfield-Springer association, hummocky	134.3	4.8%
KM	Kermit soils and dune land, 0 to 12 percent slopes	11.5	0.4%
MU	Mixed alluvial land	19.4	0.7%
PG	Portales and gomez fine sandy loams	17.9	0.6%
SE	Simona fine sandy loam, 0 to 3 percent slopes	117.0	4.2%
SR	Simona-Upton association	141.3	5.1%
Subtotals for Soil Survey Area		**501.5**	**18.0%**
Totals for Area of Interest		**2,780.3**	**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.

Andrews County, Texas

BcB—Blakeney and Conger soils, gently undulating

Map Unit Setting

National map unit symbol: d53f
Elevation: 1,500 to 3,600 feet
Mean annual precipitation: 10 to 17 inches
Mean annual air temperature: 63 to 68 degrees F
Frost-free period: 210 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Blakeney and similar soils: 49 percent
Conger and similar soils: 47 percent
Minor components: 4 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blakeney

Setting

Landform: Ridges, divides
Landform position (two-dimensional): Summit
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Loamy eolian deposits in the blackwater draw formation of pleistocene age overlying calcareous loamy alluvium in the ogallala formation of miocene-pliocene age

Typical profile

H1 - 0 to 18 inches: fine sandy loam
H2 - 18 to 32 inches: cemented material
H3 - 32 to 68 inches: gravelly loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 7 to 20 inches to petrocalcic
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 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: 70 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 2.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: Shallow 12-17" PZ (R077DY048TX)

Description of Conger

Setting

Landform: Ridges, divides
Landform position (two-dimensional): Summit
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Loamy eolian deposits in the blackwater draw formation of pleistocene age overlying calcareous loamy alluvium in the ogallala formation of miocene-pliocene age

Typical profile

H1 - 0 to 17 inches: loam
H2 - 17 to 39 inches: cemented material
H3 - 39 to 75 inches: gravelly loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 8 to 20 inches to petrocalcic
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 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: 70 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: Shallow 12-17" PZ (R077DY048TX)

Minor Components

Unnamed

Percent of map unit: 4 percent

FdB—Faskin and Douro soils, gently undulating

Map Unit Setting

National map unit symbol: d53h
Elevation: 2,750 to 3,400 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 57 to 70 degrees F
Frost-free period: 210 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Faskin and similar soils: 63 percent
Douro and similar soils: 21 percent
Minor components: 16 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Faskin

Setting

Landform: Plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loamy eolian deposits from the blackwater draw formation of pleistocene age

Typical profile

H1 - 0 to 8 inches: fine sandy loam
H2 - 8 to 42 inches: sandy clay loam
H3 - 42 to 80 inches: sandy clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
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: 50 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy Loam 12-17" PZ (R077DY047TX)

Description of Douro

Setting

Landform: Plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loamy eolian deposits in the blackwater draw formation of pleistocene age overlying calcareous loamy alluvium in the ogallala formation of miocene-pliocene age

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 30 inches: sandy clay loam
H3 - 30 to 51 inches: cemented material
H4 - 51 to 75 inches: gravelly loam

Properties and qualities

Slope: 0 to 3 percent

Depth to restrictive feature: 20 to 40 inches to petrocalcic
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 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: 80 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Sandy Loam 12-17" PZ (R077DY047TX)

Minor Components

Unnamed

Percent of map unit: 16 percent

ImB—Ima loamy fine sand, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: d53j
Elevation: 4,000 to 4,600 feet
Mean annual precipitation: 12 to 17 inches
Mean annual air temperature: 57 to 63 degrees F
Frost-free period: 180 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Ima and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ima

Setting

Landform: Plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Sandy alluvium and eolian deposits derived from calcareous sandstone of triassic and/or permian age

Typical profile

H1 - 0 to 14 inches: loamy fine sand
H2 - 14 to 55 inches: fine sandy loam
H3 - 55 to 80 inches: very fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
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: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 4.0
Available water storage in profile: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: Sandy 12-17" PZ (R077DY046TX)

JPC—Jalmar-Penwell association, undulating

Map Unit Setting

National map unit symbol: d53k
Elevation: 2,400 to 3,500 feet
Mean annual precipitation: 10 to 17 inches
Mean annual air temperature: 61 to 70 degrees F
Frost-free period: 210 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Jalmar and similar soils: 56 percent
Penwell and similar soils: 40 percent
Minor components: 4 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Jalmar

Setting

Landform: Sand sheets
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits of holocene age over loamy eolian deposits from the blackwater draw formation of pleistocene age

Typical profile

H1 - 0 to 14 inches: fine sand
H2 - 14 to 26 inches: fine sand
H3 - 26 to 80 inches: sandy clay loam

Properties and qualities

Slope: 0 to 8 percent

Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
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: 25 percent
Available water storage in profile: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Description of Penwell

Setting

Landform: Sand sheets
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits of holocene age

Typical profile

H1 - 0 to 13 inches: fine sand
H2 - 13 to 80 inches: fine sand

Properties and qualities

Slope: 1 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
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
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: Sand Hills 12-17" PZ (R077DY045TX)

Minor Components

Unnamed

Percent of map unit: 4 percent

KmB—Kimbrough soils, gently undulating

Map Unit Setting

National map unit symbol: d53l
Elevation: 2,000 to 5,000 feet
Mean annual precipitation: 10 to 17 inches
Mean annual air temperature: 57 to 75 degrees F
Frost-free period: 175 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Kimbrough and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kimbrough

Setting

Landform: Plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Calcareous, loamy alluvium in the ogallala formation of miocene-pliocene age

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 31 inches: cemented material

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 4 to 20 inches to petrocalcic
Natural drainage class: Well drained
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: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 1.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Shallow 12-17" PZ (R077DY048TX)

RaB—Ratliff soils, gently undulating

Map Unit Setting

National map unit symbol: d53s
Elevation: 2,500 to 3,400 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 63 to 70 degrees F
Frost-free period: 210 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Ratliff and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ratliff

Setting

Landform: Plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Calcareous, loamy eolian deposits from the blackwater draw formation of pleistocene age

Typical profile

H1 - 0 to 10 inches: loam
H2 - 10 to 25 inches: clay loam
H3 - 25 to 80 inches: clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
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: 50 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Limy Upland 12-17" PZ (R077DY042TX)

TwB—Triomas and Wickett soils, gently undulating

Map Unit Setting

National map unit symbol: d53w
Elevation: 2,300 to 3,500 feet
Mean annual precipitation: 10 to 17 inches
Mean annual air temperature: 63 to 68 degrees F
Frost-free period: 210 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Triomas and similar soils: 78 percent
Wickett and similar soils: 16 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Triomas

Setting

Landform: Plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits from the blackwater draw formation of pleistocene age

Typical profile

H1 - 0 to 16 inches: fine sand
H2 - 16 to 68 inches: sandy clay loam
H3 - 68 to 80 inches: sandy clay loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
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: 30 percent
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Description of Wickett

Setting

Landform: Plains

Landform position (three-dimensional): Talf
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Sandy eolian deposits overlying calcareous, loamy alluvium in the ogallala formation of miocene-pliocene age

Typical profile

H1 - 0 to 16 inches: loamy fine sand
H2 - 16 to 33 inches: fine sandy loam
H3 - 33 to 53 inches: cemented material
H4 - 53 to 67 inches: gravelly loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 40 inches to petrocalcic
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 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: 85 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 3.5 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Minor Components

Unnamed

Percent of map unit: 6 percent

Lea County, New Mexico

AB—Amarillo-Arvana loamy fine sands association

Map Unit Setting

National map unit symbol: dmnr
Elevation: 3,500 to 4,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 58 to 60 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Amarillo and similar soils: 50 percent
Arvana and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Amarillo

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous alluvium and/or calcareous eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 8 inches: loamy fine sand
Bt - 8 to 36 inches: sandy clay loam
Bk - 36 to 60 inches: marly loam

Properties and qualities

Slope: 0 to 3 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 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: 50 percent
Gypsum, maximum in profile: 1 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 8.7 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy Plains (R077CY056NM)

Description of Arvana

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous alluvium and/or calcareous eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 6 inches: loamy fine sand
Bt - 6 to 28 inches: sandy clay loam
Bkm - 28 to 38 inches: cemented material
BCk - 38 to 60 inches: sandy clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 40 inches to petrocalcic
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 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: 50 percent
Gypsum, maximum in profile: 1 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 3.8 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: Sandy Plains (R077CY056NM)

Minor Components

Portales

Percent of map unit: 2 percent
Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Brownfield

Percent of map unit: 2 percent
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Patricia

Percent of map unit: 2 percent
Ecological site: Sandy Plains (R077CY056NM)

Gomez

Percent of map unit: 2 percent
Ecological site: Sandy Plains (R077CY056NM)

Mansker

Percent of map unit: 1 percent

Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Tivoli

Percent of map unit: 1 percent
Ecological site: Sandy 12-17" PZ (R077DY046TX)

BO—Brownfield-Springer association

Map Unit Setting

National map unit symbol: dmpj
Elevation: 3,500 to 4,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 58 to 60 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Brownfield and similar soils: 60 percent
Springer and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brownfield

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 22 inches: fine sand
Bt - 22 to 60 inches: sandy clay loam

Properties and qualities

Slope: 0 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): 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
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 7.0 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Description of Springer

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 14 inches: loamy fine sand
Bt - 14 to 60 inches: fine sandy loam
Bk - 60 to 79 inches: fine sandy loam

Properties and qualities

Slope: 0 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): Moderately high to high (0.60 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: 20 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 7.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Minor Components

Patricia

Percent of map unit: 4 percent
Ecological site: Sandy Plains (R077CY056NM)

Amarillo

Percent of map unit: 4 percent
Ecological site: Sandy 16-21" PZ (R077CY035TX)

Tivoli

Percent of map unit: 1 percent
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Gomez

Percent of map unit: 1 percent
Ecological site: Sandy Plains (R077CY056NM)

BS—Brownfield-Springer association, hummocky

Map Unit Setting

National map unit symbol: dmpk
Elevation: 3,500 to 4,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 58 to 60 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Brownfield and similar soils: 65 percent
Springer and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brownfield

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 22 inches: fine sand
Bt - 22 to 60 inches: sandy clay loam

Properties and qualities

Slope: 0 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): 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
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 7.0 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Description of Springer

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 7 inches: loamy fine sand
Bt - 7 to 60 inches: fine sandy loam
Bk - 60 to 79 inches: fine sandy loam

Properties and qualities

Slope: 0 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): Moderately high to high (0.60 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: 20 percent
Gypsum, maximum in profile: 1 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 7.4 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Minor Components

Amarillo

Percent of map unit: 4 percent
Ecological site: Sandy 16-21" PZ (R077CY035TX)

Arvana

Percent of map unit: 3 percent
Ecological site: Sandy 16-21" PZ (R077CY035TX)

Tivoli

Percent of map unit: 2 percent
Ecological site: Sandy 12-17" PZ (R077DY046TX)

Dune land

Percent of map unit: 1 percent

KM—Kermit soils and dune land, 0 to 12 percent slopes

Map Unit Setting

National map unit symbol: dmpx
Elevation: 3,000 to 4,400 feet
Mean annual precipitation: 10 to 15 inches
Mean annual air temperature: 60 to 62 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Dune land: 45 percent
Kermit and similar soils: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kermit

Setting

Landform: Dunes
Landform position (two-dimensional): Shoulder, backslope, footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex
Parent material: Calcareous sandy eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 8 inches: fine sand
C - 8 to 60 inches: fine sand

Properties and qualities

Slope: 5 to 12 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): Very high (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: 3 percent
Gypsum, maximum in profile: 1 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 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A

Ecological site: Sandhills (R042XC022NM)

Description of Dune Land

Setting

Landform: Dunes
Landform position (two-dimensional): Shoulder, backslope, footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex

Typical profile

A - 0 to 6 inches: fine sand
C - 6 to 60 inches: fine sand

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8e
Hydrologic Soil Group: A

Minor Components

Palomas

Percent of map unit: 3 percent
Ecological site: Loamy Sand (R042XC003NM)

Pyote

Percent of map unit: 3 percent
Ecological site: Loamy Sand (R042XC003NM)

Maljamar

Percent of map unit: 2 percent
Ecological site: Loamy Sand (R042XC003NM)

Wink

Percent of map unit: 2 percent
Ecological site: Loamy Sand (R042XC003NM)

MU—Mixed alluvial land

Map Unit Setting

National map unit symbol: dmqg
Elevation: 3,600 to 4,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Ustifluvents and similar soils: 85 percent
Minor components: 15 percent

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

Description of Ustifluvents

Setting

Landform: Drainageways
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Mixed alluvium derived from sedimentary rock

Typical profile

C - 0 to 60 inches: stratified sand to loamy fine sand to loam to sandy clay loam to clay loam to clay

Properties and qualities

Slope: 0 to 7 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 low to very high (0.06 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum in profile: 20 percent
Gypsum, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: Bottomland (R042XC017NM)

Minor Components

Amarillo

Percent of map unit: 7 percent
Ecological site: Sandy Plains (R077CY056NM)

Portales

Percent of map unit: 7 percent
Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Playas

Percent of map unit: 1 percent
Landform: Flood-plain playas
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave

PG—Portales and gomez fine sandy loams

Map Unit Setting

National map unit symbol: dmqm
Elevation: 3,600 to 4,400 feet
Mean annual precipitation: 12 to 16 inches
Mean annual air temperature: 58 to 60 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Portales and similar soils: 45 percent
Gomez and similar soils: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gomez

Setting

Landform: Plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous alluvium and/or calcareous lacustrine deposits derived from sedimentary rock

Typical profile

A - 0 to 6 inches: fine sandy loam
Bk1 - 6 to 22 inches: fine sandy loam
Bk2 - 22 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 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: 50 percent
Gypsum, maximum in profile: 1 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): 3e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: A

Ecological site: Sandy 16-21" PZ (R077CY035TX)

Description of Portales

Setting

Landform: Plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous alluvium and/or calcareous eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 8 inches: fine sandy loam
Bk - 8 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 3 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 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: 50 percent
Gypsum, maximum in profile: 1 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: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Sandy 16-21" PZ (R077CY035TX)

Minor Components

Lea

Percent of map unit: 4 percent
Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Arvana

Percent of map unit: 3 percent
Ecological site: Sandy 16-21" PZ (R077CY035TX)

Amarillo

Percent of map unit: 2 percent
Ecological site: Sandy Plains (R077CY056NM)

Playas

Percent of map unit: 1 percent
Landform: Playa floors
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Concave

Across-slope shape: Concave

SE—Simona fine sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: dmr2
Elevation: 3,000 to 4,400 feet
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Simona and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Simona

Setting

Landform: Plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 8 inches: fine sandy loam
Bk - 8 to 16 inches: gravelly fine sandy loam
Bkm - 16 to 26 inches: cemented material

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 7 to 20 inches to petrocalcic
Natural drainage class: Well drained
Runoff class: Very 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: 35 percent
Gypsum, maximum in profile: 1 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: Very low (about 2.0 inches)

Interpretive groups

Land capability classification (irrigated): 6s
Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D
Ecological site: Shallow Sandy (R042XC002NM)

Minor Components

Kimbrough
Percent of map unit: 7 percent
Ecological site: Very Shallow 16-21" PZ (R077CY037TX)

Lea
Percent of map unit: 7 percent
Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Playas
Percent of map unit: 1 percent
Landform: Playa floors
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave

SR—Simona-Upton association

Map Unit Setting
National map unit symbol: dmr3
Elevation: 3,000 to 4,400 feet
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 58 to 62 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition
Simona and similar soils: 50 percent
Upton and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Simona

Setting
Landform: Ridges
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Calcareous eolian deposits derived from sedimentary rock

Typical profile
A - 0 to 8 inches: gravelly fine sandy loam
Bk - 8 to 16 inches: fine sandy loam
Bkm - 16 to 26 inches: cemented material

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 7 to 20 inches to petrocalcic
Natural drainage class: Well drained
Runoff class: Very low
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: 50 percent
Gypsum, maximum in profile: 1 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: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Shallow Sandy (R042XC002NM)

Description of Upton

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Calcareous eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 8 inches: gravelly loam
Bkm - 8 to 18 inches: cemented material
BCk - 18 to 60 inches: very gravelly loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 7 to 20 inches to petrocalcic
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 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: 75 percent
Gypsum, maximum in profile: 1 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: Very low (about 0.9 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D
Ecological site: Shallow (R042XC025NM)

Minor Components

Stegall
Percent of map unit: 5 percent
Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Kimbrough
Percent of map unit: 5 percent
Ecological site: Very Shallow 16-21" PZ (R077CY037TX)

Slaughter
Percent of map unit: 4 percent
Ecological site: Limy Upland 16-21" PZ (R077CY028TX)

Playas
Percent of map unit: 1 percent
Landform: Playa floors
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave

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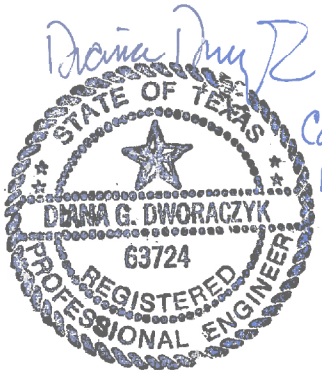
APPENDIX C
CALCULATIONS



Calculations
14 Pages
12/12/16

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT CURVE NUMBER CALCULATIONS

	DES		CHK	
WCS	DD	9/6/2016	DD	3/8/2016
File: 15052 - CN				
Revised 12/08/2016	DD			

CURVE NUMBER

Reference: 1. drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P CN.dwg

2. Soil information taken from US Department Of Agriculture, Natural Resources Conservation Service Custom Soil Resource Report For Andrews County, Texas, And Lea County, New Mexico, dated December 22, 2015

3. Texas Engineering Technical Note, No. 210-18-TX5, *Estimating Runoff for Conservation Practices,* 1990

Drainage Area - P DA 1 A= **100.86** Acres **0.158** sq mi

Cover Type & Hydrologic Condition	Soil Type	Hyd. Soil Group	Area	CN*	Area x CN	ARC I Adjustment** (60 Min.)	ARC III Adjustment** (60 Min.)
Desert Shrub Poor	JPC	B/A***	55.08	77	4241.2		
		Imp. Cover	0.00	98	0.0		
Desert Shrub Poor	TwB	B	12.79	77	984.8		
		Imp. Cover	0.00	98	0.0		
Desert Shrub Poor	BCB	D	13.19	88	1160.7		
		Imp. Cover	0.00	98	0.0		
Desert Shrub Poor	RaB	B	17.80	77	1370.6		
		Imp. Cover	2.00	98	196.0		
Total			100.9		7953.3		
COMPOSITE CN			**79**			62	91

Drainage Area - P DA 2 A= **46.1** Acres **0.072** sq mi

Cover Type & Hydrologic Condition	Soil Type	Hyd. Soil Group	Area	CN*	Area x CN	ARC I Adjustment** (60 Min.)	ARC III Adjustment** (60 Min.)
Desert Shrub Poor	BcB	D	34.88	88	3069.8		
		Imp. Cover	0.00	98	0.0		
Desert Shrub Poor	SE	D	7.88	88	693.0		
		Imp. Cover	0.00	0	0.0		
Desert Shrub Poor	SR	D	0.84	88	73.7		
		Imp. Cover	0.00	0	0.0		
Desert Shrub Poor	RaB	B	2.50	77	192.2		
		Imp. Cover	0.00	98	0.0		
Total			46.1		4028.7		
COMPOSITE CN			**87**			73	95

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT CURVE NUMBER CALCULATIONS

Drainage Area - P DA 3	A=		**42.8** Acres		**0.067** sq mi	ARC I Adjustment**	ARC III Adjustment**
Cover Type & Hydrologic Condition	Soil Type	Hyd. Soil Group	Area	CN*	Area x CN	(60 Min.)	(60 Min.)
Desert Shrub Poor	RaB	B	2.95	77	227.1		
		Imp. Cover	0.00	0	0.0		
Desert Shrub Poor	BcB	D	34.20	88	3009.6		
		Imp. Cover	5.65	98	553.8		
Total			42.8		3790.5		
COMPOSITE CN			**89**			76	96

Drainage Area - P DA 4	A=		**679.34** Acres		**1.061** sq mi	ARC I Adjustment**	ARC III Adjustment**
Cover Type & Hydrologic Condition	Soil Type	Hyd. Soil Group	Area	CN*	Area x CN	(60 Min.)	(60 Min.)
Stockpile (Bare soil)		D	60.67	94	5703.3		
Desert Shrub Poor	JPC	B/A***	150.67	77	11601.5		
		Imp. Cover	21.88	98	2143.9		
Desert Shrub Poor	RaB	B	215.19	77	16569.4		
		Imp. Cover	4.48	98	439.3		
Desert Shrub Poor	BcB	D	98.43	88	8662.1		
		Imp. Cover	54.29	98	5320.2		
Desert Shrub Poor	TwB	B	25.88	77	1992.8		
		Imp. Cover	47.81	98	4685.8		
Total			679.3		57118.4		
COMPOSITE CN			**84**			68	93

*Taken from Table 2c of Texas Engineering Technical Note, Hydrology, No. 210-18-TX5, Estimating Runoff for Conservation Practices

**Taken from Table 3 of Texas Engineering Technical Note, Hydrology, No. 210-18-TX5, Estimating Runoff for Conservation Practices

***USDA Soil Survey indicates 46% A and 50% B. CN is conservatively calculated to be 100% B

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT DRAINAGE AREA TIME OF CONCENTRATION

	DES		CHK	
WCS	DD	9/6/2016	DD	3/8/2016
Revised 12/08/16	DD			

Reference: 1. United States Department of Agriculture, Urban Hydrology for Small Watersheds TR-55, 1986
2. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs PMP.dwg

Drainage Area		P DA 1			P DA 2			P DA 3			P DA 4	
	A	**100.86**	(acres)	A	**46.1**	(acres)	A	**42.8**	(acres)	A	**679.3**	(acres)
		0.158	(sqmi)		0.072	(sqmi)		0.067	(sqmi)		1.061	(sqmi)
Sheet Flow												
Manning's roughness coef.[1]	n	0.15	n/a	n	0.011	n/a	n	0.011	n/a	n	0.15	n/a
Flow Length	L	300	feet	L	300	feet	L	300	feet	L	300	feet
2-year, 24-hour rainfall	P2	2.5	inches	P2	2.5	inches	P2	2.5	inches	P2	2.5	inches
Slope	s	0.015	ft/ft	s	0.003	ft/ft	s	0.003	ft/ft	s	0.01400	ft/ft
Travel time[2]	Tt	**0.50**	hours	Tt	**0.11**	hours	Tt	**0.11**	hours	Tt	**0.51**	hours
		30.0	min.		6.8	min.		6.8	min.		30.8	min.
Shallow Concentrated Flow												
Flow Length	L	1540	feet	L	1656	feet	L	1681	feet	L	3545	feet
Slope	s	0.01650	ft/ft	s	0.00477	ft/ft	s	0.00476	ft/ft	s	0.00555	ft/ft
Surface (1=paved or 2=unpaved)		2	n/a		2	n/a		2	n/a		2	n/a
Velocity[3]	V	2.07	ft/sec	V	1.11	ft/sec	V	1.11	ft/sec	V	1.20	ft/sec
Travel time	Tt	**0.21**	hours	Tt	**0.41**	hours	Tt	**0.42**	hours	Tt	**0.82**	hours
		12.38	min.		24.77	min.		25.17	min.		49.15	min.
Manning's Equation												
Flow Length	L	1605	feet	L	1196	feet	L	0	feet	L	0	feet
Slope	S	0.00460	ft/ft	S	0.01589	ft/ft	S	0.00000	ft/ft	S	0.00000	ft/ft
roughness[4]	n	0.028	n/a	n	0.028	n/a	n	0.028	n/a	n	0.028	n/a
Open Channel												
Bottom Width	BW	150	feet	BW	3.5	feet	BW	0	feet	BW	0	feet
Side Slopes (ft/ft, H:V) Rt.	H:V	125	feet	H:V	5.5	feet	H:V	0	feet	H:V	0	feet
Side Slopes (ft/ft, H:V) Lt.	H:V	125	feet	H:V	2.66	feet	H:V	0	feet	H:V	0	feet
Depth	d	0.5	feet	d	1.5	feet	d	0	feet	d	0	feet
Flow Rate	Q	203	cfs	Q	90	cfs	Q	0	cfs	Q	0	cfs
Velocity	V	1.91	ft/sec	V	6.23	ft/sec	V	1	ft/sec	V	1	ft/sec
Travel time	Tt	**0.23**	hours	Tt	**0.05**	hours	Tt	**0.00**	hours	Tt	**0.00**	hours
		14.01	min.		3.20	min.		0.00	min.		0.00	min.
Total Travel Time	T	**0.94**	hours	T	**0.58**	hours	T	**0.53**	hours	T	**1.33**	hours
	T	56.34	min.	T	34.73	min.	T	31.93	min.	T	79.94	min.
Lag Time (Tc*0.6)	Tlag	**0.56**	hours	Tlag	**0.35**	hours	Tlag	**0.32**	hours	Tlag	**0.80**	hours
	Tlag	33.80	min.	Tlag	20.84	min.	Tlag	19.16	min.	Tlag	47.97	min.

Notes:
1. Manning's roughness coefficient taken from 'Table 3-1 Roughness coefficients (Manning's n) for sheet flow' - United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
2. Equation 3-3, United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
3. Figure 3-1, United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
4. Reference Manning's 'n' calculations in APPDX C: POST-DEVELOPMENT HYDRAULIC CALCULATIONS
S:\Projects\W - Z\WCS (Waste Control Specialists)\draft\15052 Floodplain Analysis CISF\Engineering\15052 - Tc.xls

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT HYDRAULIC CALCULATIONS

	DES		CHK	
WCS	AVV	3/8/2016	DD	3/8/2016

Reference: 1. Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains, The U.S. Department of Transportation, 1984

Manning's Roughness Coefficient

Eq. 3 $n = (n_0 + n_1 + n_2 + n_3 + n_4)m$

Where:

n_0= a base value of n for straight, uniform, smooth channel in natural materials

n_1= a value added to correct for the effect of surface irregularities

n_2= a value for variations in shape and size of the channel cross section

n_3= a value for obstructions

n_4= a value for vegetation and flow conditions

m= a correction factor for meandering of the channel

Channel Roughness

n_0=	0.020	earth	Table1
n_1=	0.000	smooth	Table 2
n_2=	0.000	gradual	Table 2
n_3=	0.000	neglible	Table 2
n_4=	0.008	low	Table 2
m=	1.0	minor	Table 2

$n = (0.02 + 000 + 000 + 000 + 0.008)1.0$

$= 0.028$

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT HYDRAULIC CALCULATIONS

	DES		CHK	
WCS	AVV	3/8/2016	DD	3/8/2016
Revised 12/09/2016		DD		

Reference: 1. Topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014. 10220 Forest Lane, Dallas, Texas 214-349-2190, 800-862-2190, Fax 214-349-2193.
2. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs PMP.dwg

Manning's Formula

$$Q = vA = (1.49/n)AR^{2/3}s^{1/2}$$

Where:

Q=	Flow Rate (cfs)
v=	velocity, (ft/s)
A=	Flow Area, (ft^2)
n=	Manning's Roughness Coefficient
R=	Hydraulic Radius, (ft)
s=	Channel Slope, (ft/ft)

AP-1 Stateline Road

Road Elevation at P AP 1: 3486.5 ft

AMC I

100 YR

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	118.3	1.58	0.38

500 YR

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	245.4	1.99	0.56

PMP

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	410.7	2.33	0.73

AMC II

100 YR

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	223.4	1.95	0.53

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT HYDRAULIC CALCULATIONS

500 YR

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	373.1	2.24	0.7

PMP

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	421.5	2.35	0.74

AMC III

100 YR

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	292	2.12	0.61

500 YR

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	440.6	2.37	0.76

PMP

Roughness Coef n^2	Channel Slope (ft/ft)	Left Side Slope (ft/ft) (H:V)	Right Side Slope (ft/ft) (H:V)	Bottom Width (ft)	Peak Discharge (CFS)	Peak Velocity (ft/s)	Peak Depth (ft)
0.028	0.0046	125	125	150	424.2	2.36	0.74

Notes:

1. Channel geometry sources from aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014.
2. See Manning's Roughness Coefficient calculation. Manning's n from Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains, The U.S. Department of Transportation, 1984
3. Peak velocity and depth calculated using AutoCAD Civil 3D Hydraflow Express 2014.

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT ELEVATION-STORAGE TABLES

	DES		CHK	
WCS	AVV	2/1/2016	DD	2/4/2016

Elevation-Storage-Discharge

Reference: 1. 2008 URS As-Built Rail Drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600
2. Topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014. 10220 Forest Lane, Dallas,
3. WCS CISF Rail Plans, 1/22/16
4. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - Elevation-Storage Calcs.dwg.dwg

P DA 2

Elevation[1] ft	Storage cu yd	Storage ac-ft
3465	0	0.0000
3468	77	0.0474
3470	295	0.1829
3472	966	0.5987
3474	2112	1.3090
3476	4106	2.5450
3478	7221	4.4756
3480	11613	7.1979
3482	17893	11.0903
3484	27141	16.8228
3486	42007	26.0373
3488	69708	43.2069
3490	124344	77.0723

Notes:
1. Topographic elevations reference aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014.

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT ELEVATION-STORAGE TABLES

	DES		CHK	
WCS	AVV	2/1/2016	DD	2/4/2016

Elevation-Storage-Discharge

Reference:
1. 2008 URS As-Built Rail Drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600
2. Topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014. 10220 Forest Lane, Dallas,
3. WCS CISF Rail Plans, 1/22/16
4. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - Elevation-Storage Calcs.dwg.dwg

P DA 3

Elevation[1] ft	Storage cu yd	Storage ac-ft
3484	0	0.0000
3486	12111	7.5068
3488	43926	27.2267
3490	103970	64.4437

Notes:
1. Topographic elevations reference aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014.

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT ELEVATION-STORAGE TABLES

	DES		CHK	
WCS	AVV	2/1/2016	DD	2/4/2016
Revised 12/08/16	DD			

Elevation-Storage-Discharge

Reference: 1. 2008 URS As-Built Rail Drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600

2. Topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014. 10220 Forest Lane, Dallas,

3. WCS CISF Rail Plans, 1/22/16

4. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Design\Surfaces\15052 - EX TOPO & PROP.dwg

Playa

Elevation[1]	Storage	Storage
ft	cu yd	ac-ft
3476.65	0	0
3478	3559	2.2060
3480	34133	21.1567
3482	84014	52.0744
3484	172618	106.9938
3486	476370	295.2684
3487	762062	472.3489
3488	1104022	684.3060
3489	1514069	938.4654
3490	1963987	1217.3381

Notes:

1. Topographic elevations reference aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014.

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT NON-LEVEL DAM TOP CROSS SECTIONS

	DES		CHK	
WCS	AVV	3/8/2016	DD	3/8/2016

Cross Sections

Reference: 1. WCS CISF Rail Plans, 1/22/16
2. 2008 URS As-Built Rail Drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600

Non-Level Dam - P DA 2

	Rail Station	XS Station	Station Elevation	Slope Ahead
p-rail[1]	1863.4	0.00	3489.35	0.37%
p-rail[1]	1463.4	400.00	3487.87	1.50%
p-rail[1]	700.0	1163.36	3476.42	1.63%
p-rail[1]	0.0	1863.36	3465.02	0.19%
ex-rail[2]	3000.0	2243.36	3470.72	1.50%
ex-rail[2]	3600.0	2843.36	3479.72	0.98%
ex-rail[2]	4400.0	3643.36	3487.52	0.30%
ex-rail[2]	4800.0	4043.36	3488.72	-

NOTES:

1. Proposed rail stations reference the proposed WCS CISF Rail Plans, 1/22/16

2. Existing rail stations reference 2008 URS rail as-built drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600 and are approximate

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT NON-LEVEL DAM TOP CROSS SECTIONS

	DES		CHK	
WCS	AVV	3/8/2016	DD	3/8/2016

Cross Sections

Reference: 1. WCS CISF Rail Plans, 1/22/16

Non-Level Dam - P DA 3

	Rail XS Station[1]	Station Elevation	Slope Ahead
p-rail	5477.49	3489.00	-0.16%
p-rail	5489.81	3488.98	-0.13%
p-rail	5689.81	3488.72	-0.13%
p-rail	5889.81	3488.46	-0.13%
p-rail	6089.81	3488.20	-0.12%
p-rail	6262.89	3488.00	0.22%
p-rail	6632.18	3488.80	0.06%
p-rail	7407.91	3489.23	-

NOTES:

1. Proposed rail stations reference the proposed WCS CISF Rail Plans, 1/22/16

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT NON-LEVEL DAM TOP CROSS SECTIONS

	DES		CHK	
WCS	AVV	3/8/2016	DD	3/8/2016

Cross Sections

Reference: 1. 2008 URS As-Built Rail Drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600

2. Topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014. 10220 Forest Lane, Dallas, Texas 214-349-2190, 800-862-2190, Fax 214-349-2193.

3. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs PMP.dwg

Non-Level Dam - P DA 4

	Rail Station	XS Station	Station Elevation	Slope Ahead
ex-rail[1]	8500.00	8500.00	3489.96	-0.12%
ex-rail[1]	9900.00	9900.00	3488.28	-0.15%
ex-rail[1]	10017.67	10017.67	3488.10	-0.20%
ex-rail[1]	10387.00	10387.00	3487.36	-8.00%
topo[2]	-	10404.00	3486.00	5.58%
topo[2]	-	10439.87	3488.00	0.00%
topo[2]	-	10742.10	3488.00	0.65%
topo[2]	-	11051.85	3490.00	-

NOTES:

1. Existing rail stations reference 2008 URS rail as-built drawings - R/T Infrastructure Improvements Facilities G.E. Hudson River Project Andrews County, Texas Project No. 29600 and are approximate

2. Topographic elevations come from the topographic aerial survey provided by Dallas Aerial Surveys, Inc., flown 5-29-2014.

APPENDIX C
WCS - CISF FLOOD ANALYSIS
POST-DEVELOPMENT PAD OVERLAND DEPTH OF FLOW

	DES		CHK	
WCS	AVV	3/8/2016	DD	3/8/2016
Revised 11/11/16	Clarifications		DD	

Reference: 1. Reference Drawing: Figure 1.1.2-1
2. Fundamentals of Hydraluic Engineering Systems, Ned H.C. Hwang, 1982

Manning Equation

$$v = 1.49/n * R_h^{2/3} * s^{1/2}$$

Where,

v= velocity (ft/s)
n= Manning's n
R_h= hydraulic radius
s= slope (ft/ft)

And

$$q = v * y$$

Where,

q= unit discharge (ft^2/s)
y= depth

For sheet flow and a wide rectangular channel:

$R_h \cong y$ Reference 2, page 182

Therefore

$$q = (1.49/n * y^{2/3} * s^{1/2})(y)$$
$$= 1.49/n * y^{5/3} * s^{1/2}$$

And

$$y = (q/(1.49/n * s^{1/2}))^{3/5}$$
$$v = q/y$$

Where,

q= unit discharge (ft^2/s)
v= velocity (ft/s)
n= Manning's n
y= depth
s= slope (ft/ft)

Max flow

$$q_{Max} = I * L$$

Where,

q_{Max}= maximum unit discharge (ft^2/s)
I= maximum rainfaill Intensity
L= Length of Pad

Max depth

$$y_{max} = (q_{max}/(1.49/n*s^{1/2}))^{3/5}$$

Where,

y_{max}= Maximum depth of flow (ft)

q_{Max}= Maximum unit discharge

n= Manning's n

s= slope (ft/ft)

Max velocity

$$v_{max} = q_{max}/y_{max}$$

Where,

q_{Max}= maximum unit discharge (ft^2/s)

y_{max}= Maximum depth of flow (ft)

Inputs

s=	0.0075	ft/ft	phase slope
L=	515	ft	length of phase
I=	0.210	in/min	Max 500 yr-24hr rainfall intensity (HEC-HMS 500 yr SCS Storm)
	2.92E-04	ft/s	
n=	0.015		manning's n for concrete

Calculation

q_{Max}= I*L

q_{Max}= 1.50E-01 ft^2/s

y_{max} =	**0.088154**	**ft**
=	**1.1**	**in**

v_{max}=	**1.7**	**ft/s**

APPENDIX D
HEC-HMS OUTPUT

Project: 15052-CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC I
End of Run: 02Jan2016, 12:00 Meteorologic Model: 100 yr
Compute Time: 09Dec2016, 10:04:16 Control Specifications: Control 24 HR Storr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	118.3	01Jan2016, 12:29	2.09

Project: 15052-CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC I
End of Run: 02Jan2016, 12:00 Meteorologic Model: 500 yr
Compute Time: 09Dec2016, 10:25:57 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	245.4	01Jan2016, 12:27	4.11

Project: 15052-CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC I
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 09Dec2016, 10:38:57 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	410.7	03Jan2016, 06:00	33.97

Project: 15052-CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC II
End of Run: 02Jan2016, 12:00 Meteorologic Model: 100 yr
Compute Time: 09Dec2016, 10:08:25 Control Specifications: Control 24 HR Storr

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	223.4	01Jan2016, 12:26	3.68

Project: 15052-CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC II
End of Run: 02Jan2016, 12:00 Meteorologic Model: 500 yr
Compute Time: 09Dec2016, 10:34:17 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	373.1	01Jan2016, 12:26	6.17

Project: 15052-CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC II
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 09Dec2016, 10:40:20 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	421.5	03Jan2016, 06:00	37.48

Project: 15052-CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC III
End of Run: 02Jan2016, 12:00 Meteorologic Model: 100 yr
Compute Time: 09Dec2016, 10:11:24 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	292.0	01Jan2016, 12:25	4.96

Project: 15052-CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC III
End of Run: 02Jan2016, 12:00 Meteorologic Model: 500 yr
Compute Time: 09Dec2016, 11:10:06 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	440.6	01Jan2016, 12:25	7.63

Project: 15052-CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 1 AMC III
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 09Dec2016, 10:41:24 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 1	0.158	424.2	03Jan2016, 06:00	39.34

Project: 15052 - CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 08Mar2016, 14:18:56

Basin Model: P AP 2 AMC I
Meteorologic Model: 100 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	118.1	01Jan2016, 12:14	3.09
P DA 2 STORAGE	0.072	118.6	01Jan2016, 12:14	3.08

Project: 15052 - CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 08Mar2016, 14:21:22

Basin Model: P AP 2 AMC I
Meteorologic Model: 500 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	209.2	01Jan2016, 12:13	5.44
P DA 2 STORAGE	0.072	209.9	01Jan2016, 12:13	5.42

Project: 15052 - CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00
End of Run: 05Jan2016, 00:00
Compute Time: 08Mar2016, 14:21:46

Basin Model: P AP 2 AMC I
Meteorologic Model: PMP Distribution A
Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	191.1	03Jan2016, 06:00	36.38
P DA 2 STORAGE	0.072	191.1	03Jan2016, 06:00	36.37

Project: 15052 - CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 08Mar2016, 14:22:36

Basin Model: P AP 2 AMC II
Meteorologic Model: 100 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	170.8	01Jan2016, 12:13	4.52
P DA 2 STORAGE	0.072	170.9	01Jan2016, 12:13	4.50

Project: 15052 - CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 08Mar2016, 14:23:04

Basin Model: P AP 2 AMC II
Meteorologic Model: 500 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	264.8	01Jan2016, 12:13	7.14
P DA 2 STORAGE	0.072	265.3	01Jan2016, 12:13	7.11

Project: 15052 - CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00
End of Run: 05Jan2016, 00:00
Compute Time: 08Mar2016, 14:23:26

Basin Model: P AP 2 AMC II
Meteorologic Model: PMP Distribution A
Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	193.1	03Jan2016, 06:00	38.76
P DA 2 STORAGE	0.072	193.1	03Jan2016, 06:00	38.75

Project: 15052 - CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 08Mar2016, 14:24:13

Basin Model: P AP 2 AMC III
Meteorologic Model: 100 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	193.2	01Jan2016, 12:12	5.41
P DA 2 STORAGE	0.072	194.1	01Jan2016, 12:12	5.40

Project: 15052 - CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 08Mar2016, 14:24:59

Basin Model: P AP 2 AMC III
Meteorologic Model: 500 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	284.4	01Jan2016, 12:12	8.11
P DA 2 STORAGE	0.072	284.6	01Jan2016, 12:13	8.08

Project: 15052 - CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 2 AMC III
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 08Mar2016, 14:25:18 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 2	0.072	193.5	03Jan2016, 06:00	39.88
P DA 2 STORAGE	0.072	193.5	03Jan2016, 05:59	39.86

Project: 15052-CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP3 AMC I
End of Run: 02Jan2016, 12:00 Meteorologic Model: 100 yr
Compute Time: 09Dec2016, 10:44:51 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	127.5	01Jan2016, 12:12	3.38
P DA 4	1.061	803.6	01Jan2016, 12:43	2.62
P DA 3 STORAGE	0.067	0.0	01Jan2016, 00:00	0.00
PLAYA	1.128	0.0	01Jan2016, 00:00	0.00

Project: 15052-CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP3 AMC I
End of Run: 02Jan2016, 12:00 Meteorologic Model: 500 yr
Compute Time: 09Dec2016, 11:27:08 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	218.2	01Jan2016, 12:11	5.81
P DA 4	1.061	1523.1	01Jan2016, 12:42	4.84
P DA 3 STORAGE	0.067	0.0	01Jan2016, 00:00	0.00
PLAYA	1.128	0.0	01Jan2016, 00:00	0.00

Project: 15052-CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP3 AMC I
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 09Dec2016, 11:35:24 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	178.4	03Jan2016, 06:00	36.94
P DA 4	1.061	2786.9	03Jan2016, 06:01	35.35
P DA 3 STORAGE	0.067	178.3	03Jan2016, 06:01	29.18
PLAYA	1.128	2874.6	03Jan2016, 06:19	26.75

Project: 15052-CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP3 AMC II
End of Run: 02Jan2016, 12:00 Meteorologic Model: 100 yr
Compute Time: 09Dec2016, 10:48:24 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	173.8	01Jan2016, 12:11	4.74
P DA 4	1.061	1324.0	01Jan2016, 12:41	4.20
P DA 3 STORAGE	0.067	0.0	01Jan2016, 00:00	0.00
PLAYA	1.128	0.0	01Jan2016, 00:00	0.00

Project: 15052-CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP3 AMC II
End of Run: 02Jan2016, 12:00 Meteorologic Model: 500 yr
Compute Time: 09Dec2016, 11:30:31 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	265.4	01Jan2016, 12:11	7.38
P DA 4	1.061	2113.8	01Jan2016, 12:40	6.78
P DA 3 STORAGE	0.067	0.0	01Jan2016, 00:00	0.00
PLAYA	1.128	4.6	02Jan2016, 01:53	0.09

Project: 15052-CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP3 AMC II
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 09Dec2016, 11:41:03 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	179.8	03Jan2016, 06:00	39.05
P DA 4	1.061	2839.4	03Jan2016, 06:00	38.30
P DA 3 STORAGE	0.067	179.8	03Jan2016, 06:00	31.29
PLAYA	1.128	2980.6	03Jan2016, 06:13	29.65

Project: 15052-CISF Simulation Run: 100 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 3 AMC III
End of Run: 02Jan2016, 12:00 Meteorologic Model: 100 yr
Compute Time: 09Dec2016, 11:21:27 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	191.1	01Jan2016, 12:11	5.53
P DA 4	1.061	1574.7	01Jan2016, 12:40	5.18
P DA 3 STORAGE	0.067	0.0	01Jan2016, 00:00	0.00
PLAYA	1.128	0.0	01Jan2016, 00:00	0.00

Project: 15052-CISF Simulation Run: 500 YR 24 HR

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 3 AMC III
End of Run: 02Jan2016, 12:00 Meteorologic Model: 500 yr
Compute Time: 09Dec2016, 11:32:30 Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	279.9	01Jan2016, 12:11	8.23
P DA 4	1.061	2346.9	01Jan2016, 12:40	7.87
P DA 3 STORAGE	0.067	2.7	02Jan2016, 00:18	0.41
PLAYA	1.128	16.0	02Jan2016, 01:22	0.35

Project: 15052-CISF Simulation Run: PMP Dist A

Start of Run: 01Jan2016, 00:00 Basin Model: P AP 3 AMC III
End of Run: 05Jan2016, 00:00 Meteorologic Model: PMP Distribution A
Compute Time: 09Dec2016, 11:37:50 Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
P DA 3	0.067	180.1	03Jan2016, 06:00	40.00
P DA 4	1.061	2849.7	03Jan2016, 06:00	39.61
P DA 3 STORAGE	0.067	180.0	03Jan2016, 05:58	32.24
PLAYA	1.128	3004.8	03Jan2016, 06:11	30.94

Project: 15052-CISF Simulation Run: 100 YR 24 HR
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP3 AMC I
End of Run:	02Jan2016, 12:00	Meteorologic Model:	100 yr
Compute Time:	09Dec2016, 11:16:19	Control Specifications:	Control 24 HR Storms

Volume Units: IN

Computed Results

Peak Inflow:	803.6 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:43
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	2.47 (IN)	Peak Storage:	148.30 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	3484.4 (FT)

Project: 15052-CISF Simulation Run: 500 YR 24 HR
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP3 AMC I
End of Run:	02Jan2016, 12:00	Meteorologic Model:	500 yr
Compute Time:	09Dec2016, 11:27:08	Control Specifications:	Control 24 HR Storms

Volume Units: IN

Computed Results

Peak Inflow:	1523.1 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:42
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	4.55 (IN)	Peak Storage:	273.77 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	3485.8 (FT)

Project: 15052-CISF Simulation Run: PMP Dist A
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP3 AMC I
End of Run:	05Jan2016, 00:00	Meteorologic Model:	PMP Distribution A
Compute Time:	09Dec2016, 11:35:24	Control Specifications:	Control PMP

Volume Units: IN

Computed Results

Peak Inflow:	2965.2 (CFS)	Date/Time of Peak Inflow:	03Jan2016, 06:01
Peak Discharge:	2874.6 (CFS)	Date/Time of Peak Discharge:	03Jan2016, 06:19
Inflow Volume:	34.99 (IN)	Peak Storage:	894.74 (AC-FT)
Discharge Volume:	26.75 (IN)	Peak Elevation:	3488.8 (FT)

Project: 15052-CISF Simulation Run: 100 YR 24 HR
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP3 AMC II
End of Run:	02Jan2016, 12:00	Meteorologic Model:	100 yr
Compute Time:	09Dec2016, 11:19:04	Control Specifications:	Control 24 HR Storms

Volume Units: IN

Computed Results

Peak Inflow:	1324.0 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:41
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	3.95 (IN)	Peak Storage:	237.47 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	3485.4 (FT)

Project: 15052-CISF Simulation Run: 500 YR 24 HR
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP3 AMC II
End of Run:	02Jan2016, 12:00	Meteorologic Model:	500 yr
Compute Time:	09Dec2016, 11:30:31	Control Specifications:	Control 24 HR Storms

Volume Units: IN

Computed Results

Peak Inflow:	2113.8 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:40
Peak Discharge:	4.6 (CFS)	Date/Time of Peak Discharge:	02Jan2016, 01:53
Inflow Volume:	6.38 (IN)	Peak Storage:	381.51 (AC-FT)
Discharge Volume:	0.09 (IN)	Peak Elevation:	3486.5 (FT)

Project: 15052-CISF Simulation Run: PMP Dist A
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP3 AMC II
End of Run:	05Jan2016, 00:00	Meteorologic Model:	PMP Distribution A
Compute Time:	09Dec2016, 11:41:03	Control Specifications:	Control PMP

Volume Units: IN

Computed Results

Peak Inflow:	3019.2 (CFS)	Date/Time of Peak Inflow:	03Jan2016, 06:00
Peak Discharge:	2980.6 (CFS)	Date/Time of Peak Discharge:	03Jan2016, 06:13
Inflow Volume:	37.88 (IN)	Peak Storage:	900.69 (AC-FT)
Discharge Volume:	29.65 (IN)	Peak Elevation:	3488.9 (FT)

Project: 15052-CISF Simulation Run: 100 YR 24 HR
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP 3 AMC III
End of Run:	02Jan2016, 12:00	Meteorologic Model:	100 yr
Compute Time:	09Dec2016, 11:21:27	Control Specifications:	Control 24 HR Storms

Volume Units: IN

Computed Results

Peak Inflow:	1574.7 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:40
Peak Discharge:	0.0 (CFS)	Date/Time of Peak Discharge:	01Jan2016, 00:00
Inflow Volume:	4.87 (IN)	Peak Storage:	293.26 (AC-FT)
Discharge Volume:	0.00 (IN)	Peak Elevation:	3486.0 (FT)

Project: 15052-CISF Simulation Run: 500 YR 24 HR
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP 3 AMC III
End of Run:	02Jan2016, 12:00	Meteorologic Model:	500 yr
Compute Time:	09Dec2016, 11:32:30	Control Specifications:	Control 24 HR Storms

Volume Units: IN

Computed Results

Peak Inflow:	2346.9 (CFS)	Date/Time of Peak Inflow:	01Jan2016, 12:40
Peak Discharge:	16.0 (CFS)	Date/Time of Peak Discharge:	02Jan2016, 01:22
Inflow Volume:	7.42 (IN)	Peak Storage:	436.95 (AC-FT)
Discharge Volume:	0.35 (IN)	Peak Elevation:	3486.8 (FT)

Project: 15052-CISF Simulation Run: PMP Dist A
Reservoir: PLAYA

Start of Run:	01Jan2016, 00:00	Basin Model:	P AP 3 AMC III
End of Run:	05Jan2016, 00:00	Meteorologic Model:	PMP Distribution A
Compute Time:	09Dec2016, 11:37:50	Control Specifications:	Control PMP

Volume Units: IN

Computed Results

Peak Inflow:	3029.7 (CFS)	Date/Time of Peak Inflow:	03Jan2016, 06:00
Peak Discharge:	3004.8 (CFS)	Date/Time of Peak Discharge:	03Jan2016, 06:11
Inflow Volume:	39.17 (IN)	Peak Storage:	902.03 (AC-FT)
Discharge Volume:	30.94 (IN)	Peak Elevation:	3488.9 (FT)

APPENDIX E
HEC-HMS INPUT (CD)

ADDENDUM A
BERM BREACH ANALYSIS

COOK-JOYCE INC.
ENGINEERING AND CONSULTING
812 WEST ELEVENTH 512-474-9097
AUSTIN, TEXAS 78701

ADDENDUM A
BERM BREACH ANALYSIS

FEBRUARY 2019

Prepared for:

Waste Control Specialists LLC
P.O. Box 1129
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Prepared by:

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812 West 11th Street, Suite 205
Austin, Texas 78701

This report is issued for permitting or licensing purposes. It is not intended for bidding or construction purposes.

Diana Dworaczyk P.E. No. 63724
06 February 2019

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A-1	DEVELOPED DRAINAGE AREA DITCHES

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APPENDIX B	HEC-HMS OUTPUT

1.0 INTRODUCTION

This addendum presents the results of a hydrologic and hydraulic analysis for an unlikely berm breach of the proposed berm and ditch located just north of the protected area fence for the Centralized Interim Storage Facility (CISF). The same analysis methods, strategies and references that are found in the main part of the flood report are used in this analysis.

The diversion berms and collection ditches, A and B as shown on Figure A-1, will divert surface water runoff from the area north and upgradient of the CISF. Collection ditches A and B drainage areas that will contribute runoff to the ditches and berms are delineated on Figure A-1. Collection Ditch A drainage area is 4.3 acres and Collection Ditch B drainage area is 62.2 acres. Collection Ditch B has the largest drainage area contributing surface water runoff to it by a substantial amount and will carry the largest flow. Therefore, only a berm breach in Collection Ditch B is analyzed since it will yield the greatest potential surface water flow to the storage pads.

2.0 WATERSHED DESCRIPTION AND MODEL

Drainage Area Ditch B DA contains 62.2 acres and drains southeast toward the collection ditch and berm. Collection Ditch B drains to the east and ends several hundred feet past the northeast corner of the protected area fence. The soils in the area draining to Ditch B DA are the Jalmar-Pehnwell series and are classified as hydrologic group A/B as shown on Figure 2.2.1-1, Soils Boundary Map. Curve number (CN) and time of concentration parameters are found in Addendum A, Appendix A, Calculations.

The Ditch B DA parameters are input into the HEC-HMS model to determine peak runoff rates for Collection Ditch B. The 100-year, 500-year and PMP peak discharges for Collection Ditch B are 60 cubic feet per second (CFS), 129 CFS and 251 CFS, respectively. HEC-HMS model setup and inputs are found on the CD in Appendix E of the main part of the report. Results of the HEC-HMS modeling for Collection Ditch B are found in Addendum A, Appendix B, HEC-HMS Output.

3.0 BERM BREACH

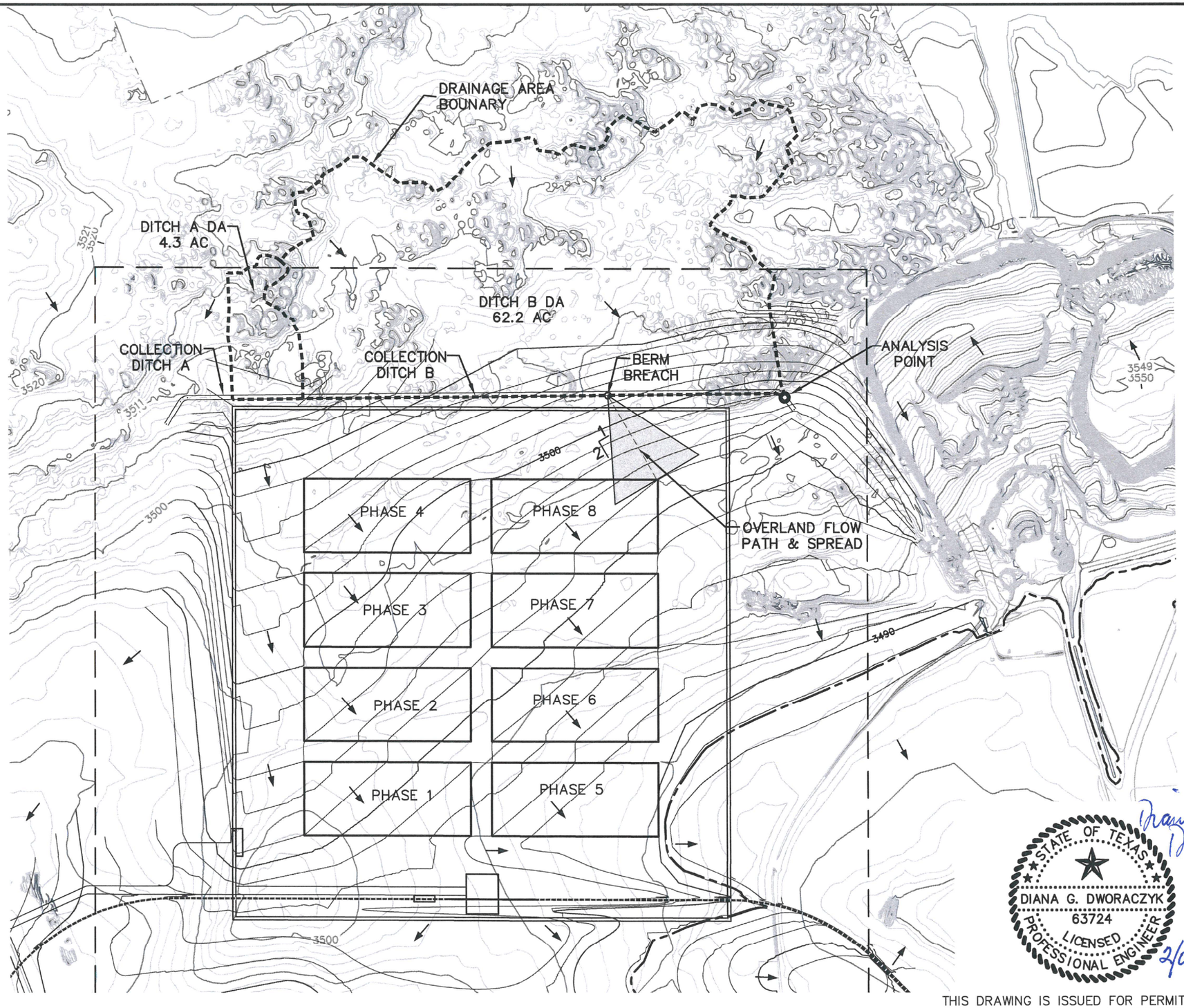
Onsite surface water runoff will be mainly sheet flow off the sloped storage pads and the sloped areas in between the pads. The Collection Ditch B berm is 2.6 feet high and approximately 470 feet from the nearest storage pad at the northern side of the CISF as surface water flows, which is the Phase 8 storage pad. The worst-case for a berm breach will be when Collection Ditch B

has the greatest amount of surface water flowing in it and will be at the location where breach flow can still reach a storage pad. The peak flow, 251 CFS, in Collection Ditch B is calculated by HEC-HMS at the analysis point depicted on Figure A-1. The analyzed berm breach location is approximately 800 feet upstream from the analysis point, yet the peak flow is conservatively assumed to flow in Collection Ditch B at that location. The berm breach location is depicted on Figure A-1.

Assumptions for the overland depth of flow adjacent to the Phase 8 storage pad from a berm breach include the following: the berm breach is large enough to release the entire PMP flow, even though Ditch B will still be flowing to the southeast; all of the breach flow will reach the storage pad, even though the pads sit above the surrounding area; and the berm breach flow will spread out from the breach at approximately 2:1 angles from the breach area as it returns to overland flow over the approximately 470 feet to the nearest pad.

The estimated depth of flow adjacent to the pad is approximately 3 inches. Overland depth of flow calculations are found in Addendum A, Appendix A, Calculations.

FIGURE



500 0 500

(SCALE IN FEET)

LEGEND

- DRAINAGE AREA BOUNDARY
- LIMITS OF TOPOGRAPHIC SURVEY BY DALLAS AERIAL SURVEY 5-29-2014
- ANALYSIS POINT
- DIRECTION OF FLOW
- APPROXIMATE PLAYA PMP WSE FLOODPLAIN LIMIT
- CISF OWNER CONTROLLED AREA FENCE
- EXISTING MINOR CONTOUR
- —3490— EXISTING MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- —3490— PROPOSED MAJOR CONTOUR

NOTES:

1. EXISTING TOPOGRAPHIC INFORMATION WITHIN LIMITS SHOWN PROVIDED BY DALLAS AERIAL SURVEYS, INC., FLOWN 5-29-2014. 10220 FOREST LANE, DALLAS, TEXAS 214-349-2190, 800-862-2190, FAX 214-349-2193.
2. EXISTING TOPOGRAPHIC INFORMATION OUTSIDE OF THE LIMITS SHOWN IS BASED ON A DIGITAL ELEVATION MODEL (DEM) PROVIDED BY THE TEXAS NATURAL RESOURCE INFORMATION SYSTEM (TNRIS).

REV.	DATE	DESCRIPTION	DR BY	APP BY

WCS
THE TEXAS SOLUTION

COOK-JOYCE INC.
ENGINEERING AND CONSULTING
812 WEST ELEVENTH 512-474-9097
AUSTIN, TEXAS 78701
HUB & WBE CERTIFIED
TEXAS REGISTERED ENGINEERING FIRM F-883

PROJECT:
CENTRAL INTERIM STORAGE FACILITY
ANDREWS COUNTY, TEXAS

SHEET TITLE:
DEVELOPED DRAINAGE AREA DITCHES

DES BY	DD		SCALE: SEE BAR SCALE	
DR BY	DD		PROJECT NO. 15052.01	
CHK BY	DD		CJI NO. 15052016	
APP BY	DD		SHEET 1 OF 1 SHEETS	
DATE ISSUED: 02-06-2019			FIGURE NO.	A-1

STATE OF TEXAS
DIANA G. DWORACZYK
63724
LICENSED
PROFESSIONAL ENGINEER
2/06/19

THIS DRAWING IS ISSUED FOR PERMITTING OR LICENSING PURPOSES. IT IS NOT INTENDED FOR BIDDING OR CONSTRUCTION PURPOSES.
DIANA DWORACZYK P.E. No. 63724

S:\CAD\WCS\15052 CISF Floodplain\15052016 Fig A-1 Developed Drainage Area Ditches.dwg, 2/6/2019 1:22:35 PM, 1:1

APPENDICES

APPENDIX A
CALCULATIONS

ADDENDUM A
WCS - CISF DITCH B
POST-DEVELOPMENT DRAINAGE AREA TIME OF CONCENTRATION

	DES		CHK	
WCS	DD	1/31/2019	SC	2/5/2019

Reference: 1. United States Department of Agriculture, Urban Hydrology for Small Watersheds TR-55, 1986
2. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs DD.dwg

		DITCH B	
Drainage Area	A	**62.2**	(acres)
		0.097	(sqmi)
Sheet Flow			
Manning's roughness coef.[1]	n	0.15	n/a
Flow Length	L	408	feet
2-year, 24-hour rainfall	P2	2.5	inches
Slope	s	0.0098	ft/ft
Travel time[2]	Tt	**0.76**	hours
		45.4	min.
Shallow Concentrated Flow			
Flow Length	L	1060	feet
Slope	s	0.00710	ft/ft
Surface (1=paved or 2=unpaved)		2	n/a
Velocity[3]	V	1.36	ft/sec
Travel time	Tt	**0.22**	hours
		12.99	min.
Manning's Equation			
Flow Length	L	1383	feet
Slope	S	0.00500	ft/ft
roughness[4]	n	0.028	n/a
Open Channel			
Bottom Width	BW	4	feet
Side Slopes (ft/ft, H:V) Rt.	H:V	3	feet
Side Slopes (ft/ft, H:V) Lt.	H:V	3	feet
Depth	d	2	feet
Flow Rate	Q	111	cfs
Velocity	V	4.2	ft/sec
Travel time	Tt	**0.09**	hours
		5.49	min.
Total Travel Time	T	**1.06**	hours
	T	63.90	min.
Lag Time (Tc*0.6)	Tlag	**0.64**	hours
	Tlag	38.34	min.

Notes:
1. Manning's roughness coefficient taken from 'Table 3-1 Roughness coefficients (Manning's n) for sheet flow' - United States Department of Agriculture, Urban Hydrology for Small Watersheds TR-55, 1986
2. Equation 3-3, United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
3. Figure 3-1, United States Department of Agriculture, *Urban Hydrology for Small Watersheds TR-55*, 1986
4. Reference Manning's 'n' calculations in APPDX C: POST-DEVELOPMENT HYDRAULIC CALCULATIONS

S:\Projects\W - Z\WCS (Waste Control Specialists)\draft\18059 ISP - NRC Responses\Engineering Checks\Ditch B HEC\R190204_TC.xls

Diana Dworaczyk

STATE OF TEXAS
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REGISTERED
PROFESSIONAL ENGINEER

02/06/19
Calculations
4 Pages

ADDENDUM A
WCS - CISF DITCH B
POST-DEVELOPMENT CURVE NUMBER CALCULATIONS

	DES		CHK	
WCS Job No. 18059	DD	2/4/2019	SC	2/5/2019
File: R190204_CURVE NO				

CURVE NUMBER

Reference: 1. CISF Drainage Evaluation and Floodplain Analysis Fig. No. 2.2.1-1, Soils Boundary Map
2. Soil information taken from US Department Of Agriculture, Natural Resources Conservation Service Custom Soil Resource Report For Andrews County, Texas, And Lea County, New Mexico, dated December 22, 2015
3. Texas Engineering Technical Note, No. 210-18-TX5, *Estimating Runoff for Conservation Practices,* 1990

Drainage Area - Ditch B	A=	**62.2** Acres	**0.097** sq mi	ARC I Adjustment**	ARC III Adjustment**
Cover Type & Hydrologic Condition	Soil Type	Hyd. Soil Group	CN*	(60 Min.)	(60 Min.)
Desert Shrub Poor	JPC	B/A***	77	60	89

*Taken from Table 2c of Texas Engineering Technical Note, Hydrology, No. 210-18-TX5, Estimating Runoff for Conservation Practices
**Taken from Table 3 of Texas Engineering Technical Note, Hydrology, No. 210-18-TX5, Estimating Runoff for Conservation Practices
***USDA Soil Survey indicates 46% A and 50% B. CN is conservatively calculated to be 100% B

ADDENDUM A
WCS - CISF BERM BREACH
POST-DEVELOPMENT BERM BREACH OVERLAND DEPTH OF FLOW

	DES		CHK	
WCS	DD	1/16/2019	SC	2/5/2019

Reference:

1. Reference Drawing: S:\CAD\WCS\15052 CISF Floodplain\Engineering\15052 - P Hydraulic Calcs PMP.dwg

Dich B carries the largest flow.
Use the PMP peak flow in Ditch B to calculate the pad depth of flow.

Manning Equation

$$v = 1.49/n * R_h^{2/3} * s^{1/2}$$

Where,

v= velocity (ft/s)
n= Manning's n
R_h= hydraulic radius
s= slope (ft/ft)

Manning Equation for Sheet Flow

$$q = v*y = 1.49/n * y^{5/3} * s^{1/2}$$

Therefore

$$y = (q/(1.49/n * s^{1/2}))^{3/5}$$
$$v = q/y$$

Where,

q= unit discharge (ft^2/s)
v= velocity (ft/s)
n= Manning's n
y= depth
s= slope (ft/ft)

Max flow

$$q_{Max} = I * L$$

Where,

q_{Max}= maximum unit discharge (ft^2/s)
I= Rainfaill Intensity
L= Length of flow

Max depth at edge of pad

$$y_{max} = (q_{max}/(1.49/n * s^{1/2}))^{3/5}$$

Where,

y_{max}= Maximum depth of flow (ft)
q_{Max}= Maximum unit discharge
n= Manning's n
s= slope (ft/ft)

Max velocity

$v_{max} = q_{max}/y_{max}$

Where,

q_{Max} = maximum unit discharge (ft^2/s)

y_{max} = Maximum depth of flow (ft)

Inputs

Q_{max} = 251 cfs From HEC-HMS Ditch B

Assumptions: Berm breach is large enough to release Ditch B PMP peak flow
The flow spreads out at approx. 1:2 on each side from center of berm breach,
Length of flow from berm breach to phase 8 pad = 470 ft., See Fig. A-1
Width of flow at phase 8 pad = 470 ft
The peak flow reaches a pad and flows onto a pad.

q_{Max} = 0.534043 ft^2/s

$I = q_{max}/L$

s=	0.011	ft/ft	flow slope
L=	470	ft	length of flow from berm breach to phase 8 pad, see Fig. A-1
n=	0.025		Manning's n for gravel

Calculation

I= 0.001136 ft/sec

Max y=	**0.228549**	**ft**
	2.7	**in**
Max v=	**2.3**	**ft/s**

APPENDIX B
HEC-HMS OUTPUT

Project: 15052 - CISF Design Simulation Run: Collection Ditch B R

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 04Feb2019, 16:25:04

Basin Model: Collection Ditch B revised
Meteorologic Model: 100 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Collection Ditch B R	0.097	59.7	01Jan2016, 12:34	1.92

Project: 15052 - CISF Design Simulation Run: Collection Ditch B R 500 Yr

Start of Run: 01Jan2016, 00:00
End of Run: 02Jan2016, 12:00
Compute Time: 04Feb2019, 16:26:45

Basin Model: Collection Ditch B revised
Meteorologic Model: 500 yr
Control Specifications: Control 24 HR Storms

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Collection Ditch B R	0.097	128.5	01Jan2016, 12:33	3.87

Project: 15052 - CISF Design Simulation Run: Collection Ditch B R PMP

Start of Run: 01Jan2016, 00:00
End of Run: 05Jan2016, 00:00
Compute Time: 04Feb2019, 16:26:51

Basin Model: Collection Ditch B revised
Meteorologic Model: PMP Distribution A
Control Specifications: Control PMP

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Collection Ditch B R	0.097	250.6	03Jan2016, 06:01	33.47