PERIODIC RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

322 Landfill

Tecumseh Energy Center

PREPARED FOR

Evergy Kansas Central, Inc.

13 OCTOBER 2021

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1.0 Background

1.1 PURPOSE

The purpose of this CCR Run-on and Run-off Control System Plan (Plan) is to document, in accordance with the Coal Combustion Residuals Rule (CCR Rule)[1], how the run-on and run-off control systems for the Tecumseh Energy Center (TEC) 322 landfill have been designed and constructed with recognized and generally accepted good engineering practices and to meet the applicable requirements of 40 CFR 257.81. The following sections provide background information on the facility and related regulatory requirements.

1.2 FACITLITY INFORMATION

Name of Facility:	Tecumseh Energy Center
Name of CCR Unit:	322 Landfill
Name of Operator	Evergy Kansas Central, Inc.
Facility Mailing Address:	5858 S.E. 2nd Street Tecumseh, KS 66542
Location:	Intersection of S.E. 2nd St. and Dupont Rd. in Tecumseh, KS
Facility Description:	The Tecumseh Energy Center had four coal-fired units, the last of which was retired in 2018. CCR from the center was transported to the 32.3 acre TEC landfill for disposal. Related landfill facilities include testing piezometers and an access road. The southern half of the south most landfill cell was closed in 2013. The remainder of the landfill was closed in 2021. The landfill is permitted by the Kansas Department of Health and Environment, Bureau of Waste Management under Solid Waste Permit No. 322.

1.3 REGULATORY REQUIREMENTS

This Plan has been developed for the TEC 322 Landfill in accordance with 40 CFR 257.81 (c). The CCR Rule requires preparation of a Run-on and Run-off Control System Plan for all existing CCR landfills in operation as of October 19, 2015, the effective date of the CCR Rule. The plan must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of 40 CFR 257.81, and must be supported by appropriate engineering calculations[2].

The owner or operator of a CCR unit must prepare a written Plan that documents the performance of the unit as specified in 40 CFR 257.81 (a) and (b). These items and the section of this plan responsive to each follows:

40 CFR 257.81 Run-on and Run-off Controls for CCR landfills

(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate and maintain (Section 2):

(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and

(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm

(b) Run-off from the active portion of CCR unit must be handled in accordance with the surface water requirements under §257.3-3 (Section 3).

Selected definitions from the CCR Rule are provided below.

Closed means placement of CCR in a CCR unit has ceased, and the owner or operator has completed closure of the CCR unit in accordance with § 257.102 and has initiated post-closure care in accordance with § 257.104.

CCR (coal combustion residuals) means fly ash, bottom ash, boiler slag, and flue gas desulfurization materials generated from burning coal for the purpose of generating electricity by electric utilities and independent power producers.

CCR Landfill means an area of land or an excavation that receives CCR and which is not a surface impoundment, an underground injection well, a salt dome formation, a salt bed formation, an underground or surface coal mine, or a cave. For purposes of this subpart, a CCR landfill also includes sand and gravel pits and quarries that receive CCR, CCR piles, and any practice that does not meet the definition of a beneficial use of CCR.

CCR Unit means any CCR landfill, CCR surface impoundment, or lateral expansion of a CCR unit, or a combination of more than one of these units, based on the context of the paragraph(s) in which it is used. This term includes both new and existing units, unless otherwise specified.

Qualified Professional Engineer means an individual who is licensed by a state as a Professional Engineer to practice one or more disciplines of engineering and who is qualified by education, technical knowledge and experience to make the specific technical certifications required under this subpart. Professional engineers making these certifications must be currently licensed in the state where the CCR unit(s) is located.

Run-off means any rainwater, leachate, or other liquid that drains over land from any part of a CCR landfill or lateral expansion of a CCR landfill.

Run-on means any rainwater, leachate, or other liquid that drains over land onto any part of a CCR landfill or lateral expansion of a CCR landfill.

2.0 Landfill Run-On and Run-Off Controls

2.1 DESIGN AND CONSTRUCTION

The design for the TEC 322 Landfill storm water run-on and run-off control system was completed in June 2020 by Black & Veatch.[3] The design was developed and sealed by a professional engineer licensed in the State of Kansas and in accordance with the Kansas Department of Health and Environment (KDHE) rules for Solid Waste Landfills[4] and Solid Waste Permit No. 322. These rules require the run-on and run-off control systems for utility waste landfills to be based on the 24-hour, 25-year storm event. The KDHE reviewed and approved the design of the landfill and storm water management system in 2020[5].

The storm water system design for the landfill consists of ditches, berms, and channels designed with typical slopes ranging between approximately 0.5% and 35%. The components of the storm water management system were constructed commensurate with landfill closure construction. Berms and existing ditches surrounding the landfill prevent run-on. Storm water flowing from capped landfill areas is conveyed using three channels within the landfill area. The two main channels outlet to an existing creek east of the landfill area.

2.2 RUN-ON CONTROLS

The regulatory requirement in 257.81(a)(1) is to control run-on onto the "active portion" of the CCR unit; as this is now a closed landfill this requirement is no longer applicable. However, Evergy has chosen to document that the run-on onto the landfill is handled in accordance with standard engineering best practices. The capped landfill is an elevated area subject to little run-on. In addition, the landfill and access road are bounded on all sides by existing ditches to prevent run-on. High points in the landfill cap grading further prevent run-on along the north and east sides of the landfill. The access road running along the west side of the landfill has small cross slope and a berm along the east side of the road to reduce run-on to the west side of the landfill. The run-on protection system meets or exceeds good engineering practice to provide protection from run-on from the 24-hour, 25-year storm event.

2.3 RUN-OFF CONTROLS

The regulatory requirement in 257.81(a)(2) is to control run-off from the "active portion" of the CCR unit; as this is now a closed landfill this requirement is no longer applicable. However, Evergy has chosen to document that the run-off from the landfill is handled in accordance with standard engineering best practices. The run-off control system design for the capped landfill consists of berms, ditches, and channels. For the current (closure) configuration discussed in Section 2.2, water is contained within the capped landfill area by directing water to the three drainage channels with longitudinal slopes ranging from 1% to 9%. Storm water from the north landfill cell drains to Channel 01, and flow from the middle cell drains to Channel 01 and Channel 02. Flow from the south cell drains to Channel 03, which flows into Channel 02. Storm water captured in all three channels is directed to an existing creek which carries the storm water off the site. See Figure 1 in the Appendix A[2] for the three channels and associated drainage areas.

Calculations were performed to evaluate the drainage channels in the run-off control system. The calculations were developed to evaluate whether the peak storm flow from a 25-year/24-hour storm event could be accommodated without overtopping the channels or exceeding recommended flow velocities for the rip rap selected. See Appendix A[2] for more detailed information about the storm data, software utilized, and calculation method.

Table 1 shows the peak flow rate, velocity and channel free-board at the peak flow for the 25-year/24-hour storm for each of the channels.

Table 1: Run-Off Control Protection

Channel	Peak Flow (cfs)	Velocity at Peak Flow (ft/s)	Freeboard at Peak Flow (ft)
Channel 01	40.3	1.81	0.06
Channel 02	53.5	2.50	3.01
Channel 03	19.9	3.40	1.61

The run-off protection system meets or exceeds good engineering requirements to collect and control at least the water volume resulting from run-off from the 24-hour, 25-year storm event.

3.0 Run-Off Control For §257.3-3

The TEC landfill has been closed under KDHE Solid Waste Permit No. 322[5] and the CCR Rule[1]. The landfill has been vegetated and there is no run-off from the landfill that contacts CCR material. As such, the KDHE Bureau of Water agreed that an NDPES permit is not required for this landfill. Therefore, the facility does not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the NPDES under Section 402 of the Clean Water Act, and therefore meets the requirements of 40 CFR 257.81 (b).

4.0 Amendment of the Run-On and Run-off Control Plan

The owner or operator may amend the written run-off and run-on control system plan at any time provided the revised plan is placed in the facility's operating record as required by § 257.105(g)(3).

The owner or operator must amend the written run-on and runoff control system plan whenever there is a change in conditions that would substantially affect the written plan in effect. Additionally, the owner or operator of the CCR unit must prepare periodic run-on and runoff control system plans every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan.

The owner or operator may complete any required plan prior to the required deadline provided the completed plan is placed into the facility's operating record within a reasonable amount of time.

A written certification from a qualified professional engineer that the initial and any amendment of the written run-on and run-off control system plan meets the requirements of § 257.81 must be obtained. Plan changes will be documented using the Revision History which prefaces this Plan. Changes to this plan will be certified by a Qualified Professional Engineer.

5.0 Engineering Certification

Pursuant to 40 CFR 257.81 (c) (5) and by means of this certification, I attest that:

i. I am a Qualified Professional Engineer licensed in the State of Kansas;

ii. I am familiar with the requirements of the CCR Rule (40 CFR 257);

iii. I, or my agent, have visited and examined the TEC 322 Landfill;

iv. I do hereby certify to the best of my knowledge, information, and belief that this Run-on and Run-off Control System Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards, and with the requirements of the CCR Rule;

v. this Run-on and Run-off Control System Plan meets or exceeds the requirements of 40 CFR 257.81 (c); and

vi. the pages certified herein include Pages 1 through 9, altogether a total of 10 pages in a protected document.

Joshua D. Birk

Printed Name of Qualified Professional Engineer

P.S. SEAL, STATE OF KANSAS

6.0 References

1. U.S. Environmental Protection Agency, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, 40 CFR §257, Federal Register 80, Subpart D, April 17, 2015.

2. Black & Veatch, Appendix A Run-on Run-off Control System Plan Support Calculations, TEC 322 Landfill, Tecumseh Energy Center, Prepared for Evergy, 2021.

3. Black & Veatch, Tecumseh Energy Center CCR Landfill Closure Design KDHE Permit #322, Prepared for Evergy, June 2020.

4. Kansas Department of Health and Environment, Kansas Statutes Chapter 65- Public Health Article 34- Solid Waste and Administration Regulations Article 29 – Solid Waste, April 2015.

5. Kansas Department of Health and Environment, Permit #322, Tecumseh Energy Center, CCR Landfill Closure.

APPENDIX A.
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN SUPPORT CALCULATIONS

322 Landfill

Tecumseh Energy Center

PREPARED FOR

Evergy Kansas Central, Inc.

13 OCTOBER 2021

1.0 Introduction

1.1 FACILITY INFORMATION

The attached documents and calculations were used for certifying the requirements specified in 40 CFR 257.81 for Evergy Tecumseh Energy Center 322 Landfill.

1.2 LIST OF ATTACHMENTS

Attachment 1	Black & Veatch, Run-Off Drainage Calculations – Evergy TEC 322 Landfill, June 9th, 2021
Attachment 2	Black & Veatch, Run-Off Hydraulic Analysis – Evergy TEC 322 Landfill, June 9th, 2021

Attachment 1

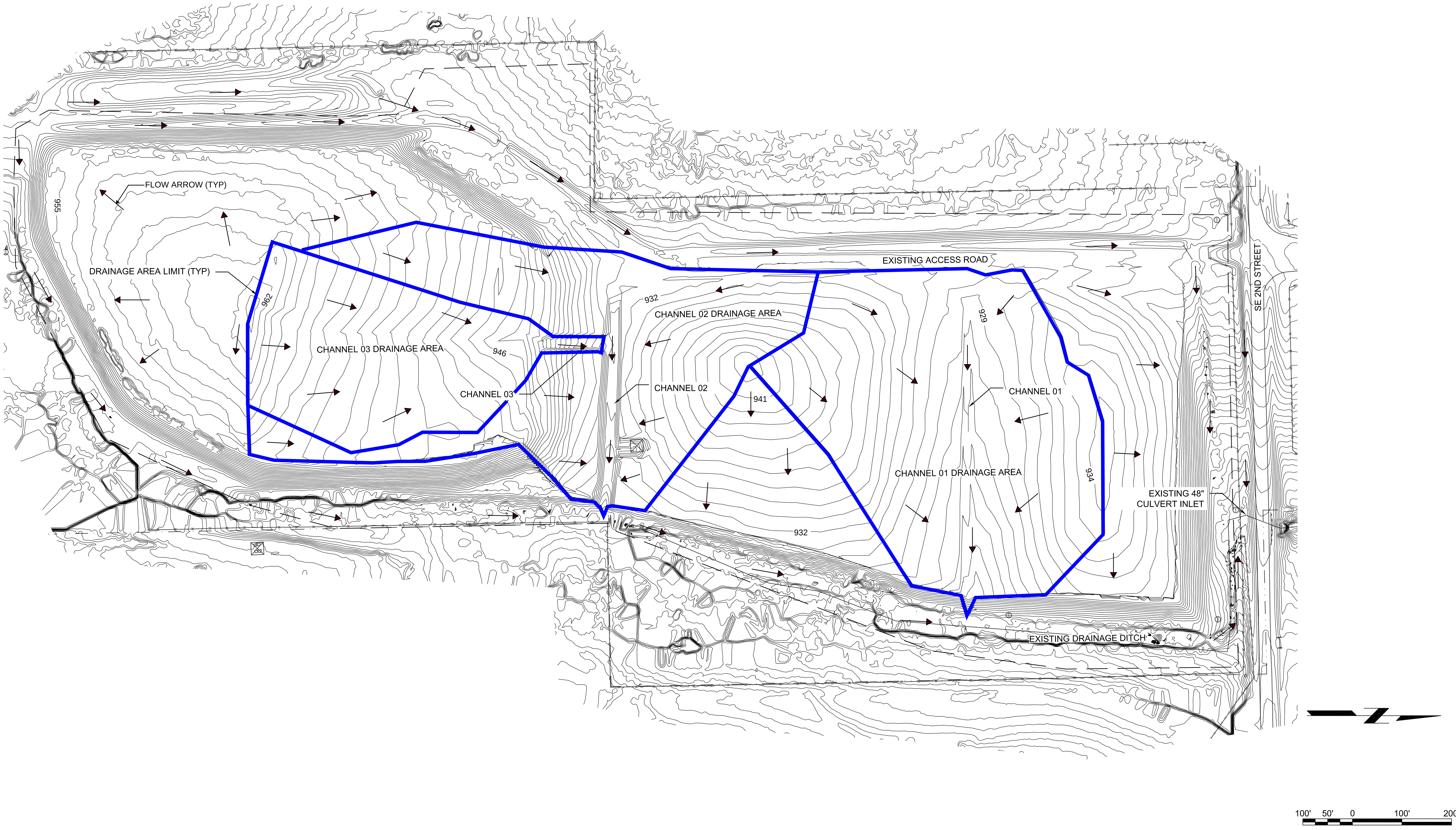
Run-Off Drainage Calculations

Tecumseh Energy Center 322 Landfill Closure

1. Figure 1
2. Drainage Model Input Spreadsheet
    - Appendix A. USDA Soil Map
    - Appendix B. NOAA Storm Data
3. HEC-HMS Model
4. HEC-HMS Model Output

Figure 1

NOTES:



Rev.	Description	Date	Apr.
16			
15			
14			
13			
12			
11			
10			
9			

Rev.	Description	Date	Apr.
8			
7			
6			
5			
4			
3			
2			
1			

Date: 06/10/2021
Designed by: MRL
Drawn by: MJF
Check by: JDB
Submitted by: CNH
File Name:

evergy

BLACK & VEATCH
building a world of difference.

EVERGY KANSAS CENTRAL, INC.
TECUMSEH ENERGY CENTER

FIGURE 1
DRAINAGE AREAS

DRAWING NO.
1

Drainage Calculations

CALCULATION INFORMATION	
Client Name(s):	Evergy
Project Name:	Tecumseh Energy Center CCR Landfill Closure
Project Number:	123456.78.90
Project Location:	Tecumseh, KS
Submittal:	Run-On Run-Off Report
Approval Date:	7/13/2021, Josh Birk
Calculation Status(UNO):	Final
Calculation Title	Drainage Calculations

VERIFICATION AND REVISION LOG

Rev	Status	Prepared By: FML; Verified By: FML
0	*Final*	Prepared By: MEL, 7/9/2021; Verified by: JDB, 7/13/2021

Drainage Model Input Spreadsheet

HEC-HMS Input Values

	Drainage Area (smi)	Curve Number	Lag Time
Channel 01 Drainage Area	0.012	79	7.50
Channel 02 Drainage Area	0.010	79	7.36
Channel 03 Drainage	0.006	79	7.74
Channel 03	N/A	N/A	4.26

Drainage Area

	Drainage Area (sf)	Drainage Area (ac)	Drainage Area (smi)
Channel 01 Drainage Area	334617.017	7.68174969	0.012002045
Channel 02 Drainage Area	283205.710	6.501508494	0.010158024
Channel 03 Drainage Area	174974.033	4.016851079	0.00627597

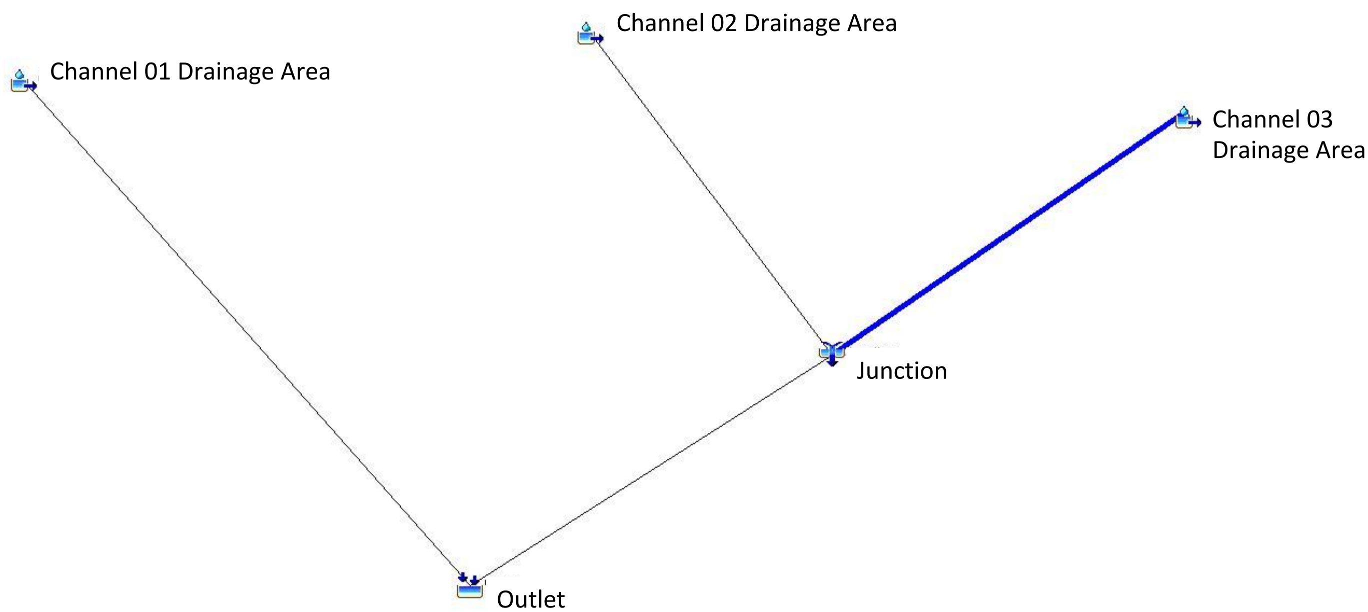
Curve Number

	Undeveloped Area (sf)	Undeveloped Area CN	Capped Area (sf)	Capped Area CN	Composite CN
Channel 01 Drainage Area	0	79	334617.0165	79	79
Channel 02 Drainage Area	0	79	283205.71	79	79
Channel 03 Drainage Area	0	79	174974.033	79	79

Lag Time

	Channel 01 Drainage Area	Channel 02 Drainage Area	Channel 03 Drainage Area	Channel 03
T_L (min) ($0.6*T_C$)	7.50	7.36	7.74	4.26
T_C (min) ($T_i + T_t$)	12.50	12.27	12.91	7.10
T_i (min)	9.98	9.07	9.48	6.68
C	0.30	0.30	0.30	0.30
D (ft)	100.00	100.00	100.00	100.00
S (%)	3.00	4.00	3.50	10.00
L (ft)	423.10	614.40	616.10	130.60
V (ft/s) (found graphically)	2.80	3.20	3.00	5.25
T_t (min)	2.52	3.20	3.42	0.41

HEC-HMS Model



HEC-HMS Model Results				
Hydrologic Element	Area (sq mi)	Peak Discharge (CFS)	Time of Peak	Volume (Acre- ft)
Channel 02 Drainage Area	0.0100	33.7	01 Jan 2020, 12:01	20.70
Channel 03 Drainage Area	0.0060	19.9	01 Jan 2020, 12:01	12.20
Channel 03	0.0060	19.9	01 Jan 2020, 12:05	12.20
Junction	0.0160	53.5	01 Jan 2020, 12:05	32.90
Channel 01 Drainage Area	0.0120	40.3	01 Jan 2020, 12:01	24.70
Outlet	0.0280	93.5	01 Jan 2020, 12:05	57.50

United States Department of Agriculture

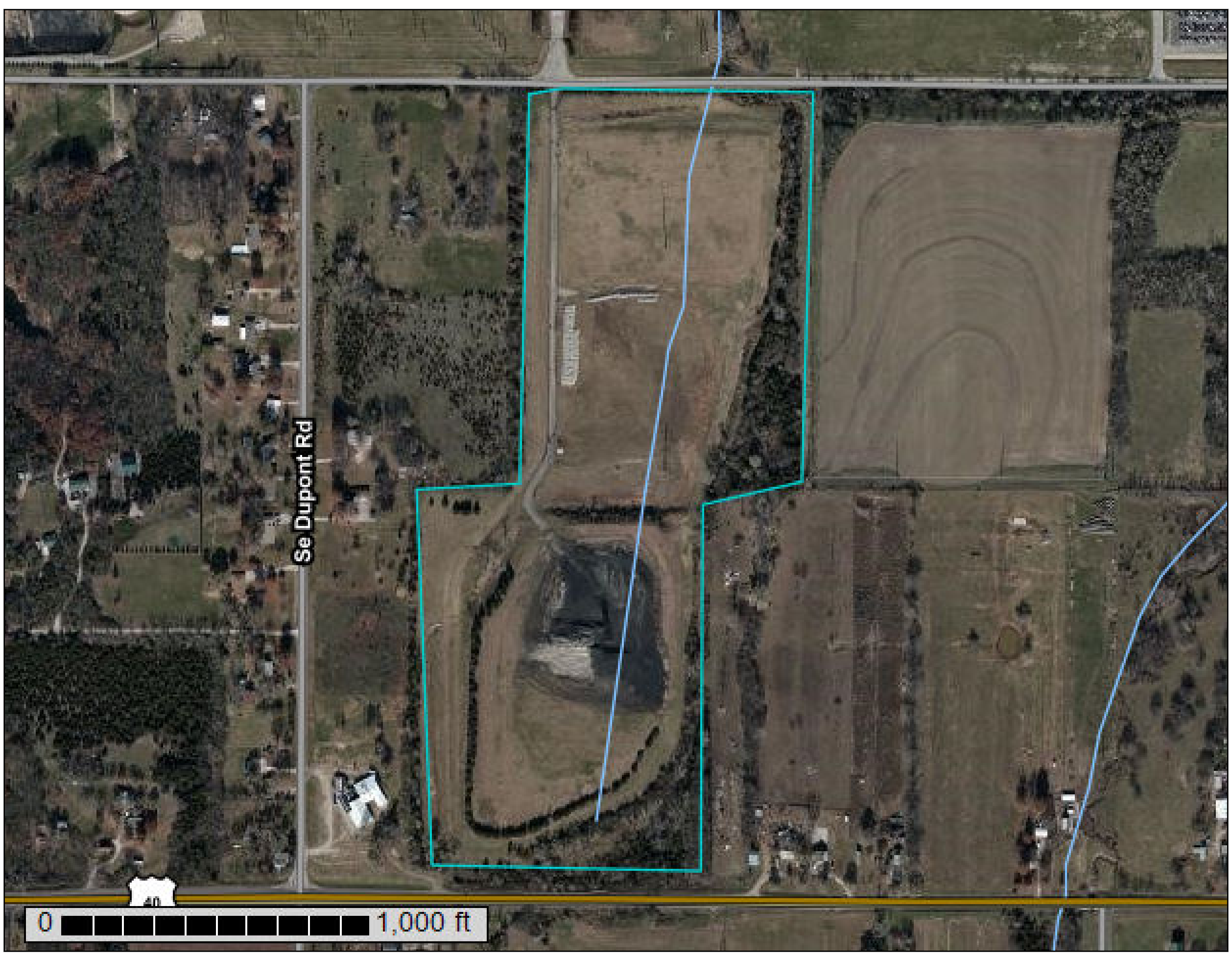
NRCS

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

Shawnee County, Kansas



January 27, 2020

Preface

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

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

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

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

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

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

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Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

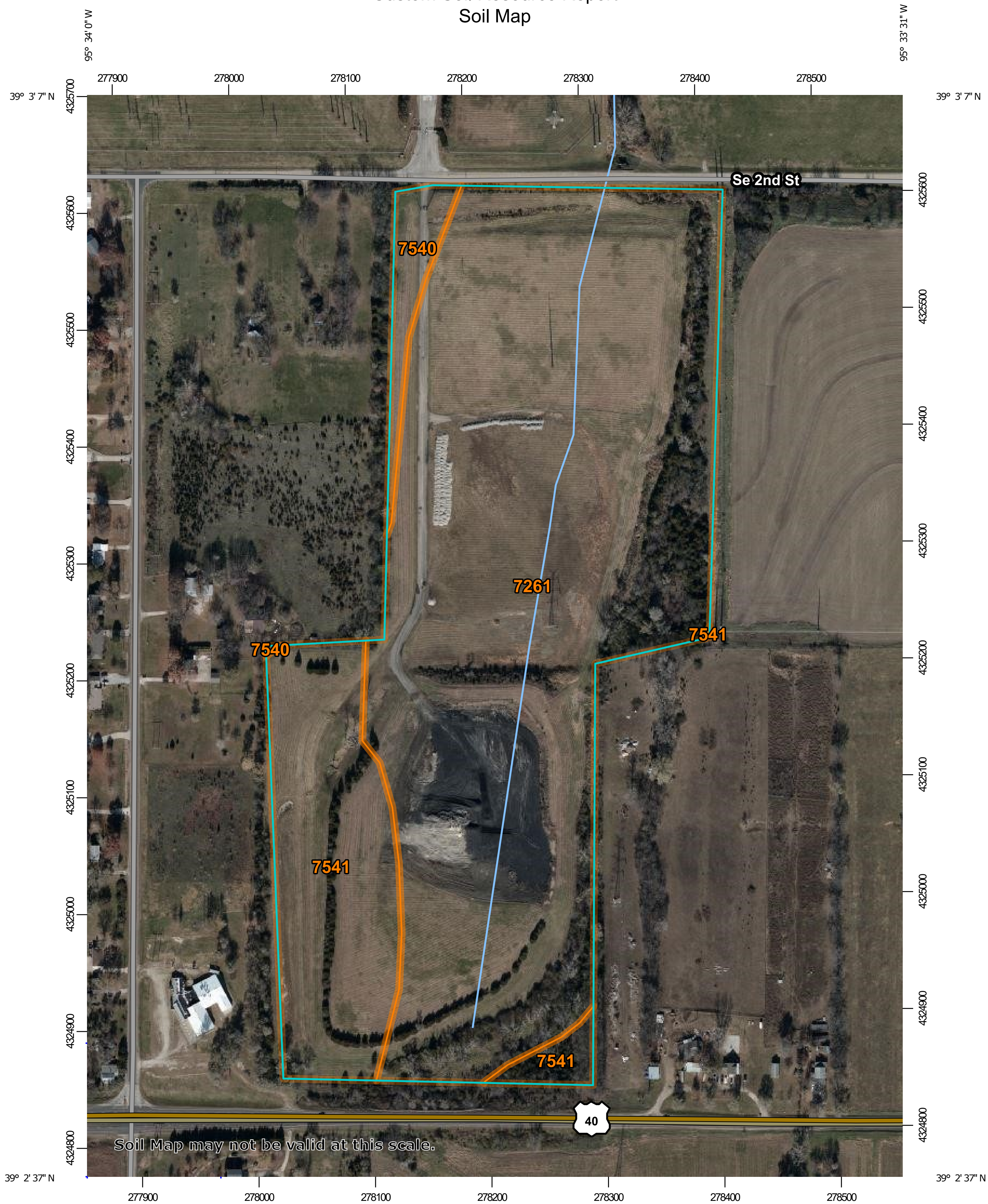
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree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

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

Soil Map

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

Soil Map



Map Scale: 1:4,510 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 200, 400, 800, 1200

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Shawnee County, Kansas
Survey Area Data: Version 18, Sep 16, 2019

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

Date(s) aerial images were photographed: Oct 1, 2018—Nov 30, 2018

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7261	Gymer silt loam, 3 to 7 percent slopes	41.7	79.1%
7540	Sharpsburg silty clay loam, 1 to 4 percent slopes	1.5	2.8%
7541	Sharpsburg silty clay loam, 4 to 8 percent slopes	9.6	18.2%
Totals for Area of Interest		**52.8**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

Shawnee County, Kansas

7261—Gymer silt loam, 3 to 7 percent slopes

Map Unit Setting

National map unit symbol: 2v90k
Elevation: 730 to 1,700 feet
Mean annual precipitation: 28 to 40 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 160 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Gymer

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

Ap - 0 to 6 inches: silt loam
BA - 6 to 14 inches: silty clay loam
Bt1 - 14 to 17 inches: silty clay loam
Bt2 - 17 to 54 inches: silty clay loam
BC - 54 to 64 inches: silty clay loam
C - 64 to 79 inches: silty clay loam

Properties and qualities

Slope: 3 to 7 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 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: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Hydric soil rating: No

Minor Components

Sharpsburg

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Hydric soil rating: No

Morrill

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Loamy Upland (R106XY075NE)
Hydric soil rating: No

Falleaf

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Savannah (R106XY025NE)
Hydric soil rating: No

7540—Sharpsburg silty clay loam, 1 to 4 percent slopes

Map Unit Setting

National map unit symbol: 2q4rw
Elevation: 980 to 1,660 feet
Mean annual precipitation: 28 to 39 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 158 to 203 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Sharpsburg

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loess

Typical profile

Ap - 0 to 6 inches: silty clay loam
A - 6 to 12 inches: silty clay loam
Bt1 - 12 to 18 inches: silty clay loam
Bt2 - 18 to 46 inches: silty clay loam
BC - 46 to 58 inches: silty clay loam
C - 58 to 79 inches: silty clay loam

Properties and qualities

Slope: 1 to 4 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 45 to 50 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Forage suitability group: Loam (G106XY100NE)
Hydric soil rating: No

Minor Components

Pawnee

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clay Upland (PE 30-37) (R106XY007KS)
Hydric soil rating: No

Wymore

Percent of map unit: 5 percent
Landform: Hillslopes

Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: Clay Upland (PE 30-37) (R106XY007KS)
Hydric soil rating: No

Sarcoxie

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear, convex
Across-slope shape: Linear
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Hydric soil rating: No

7541—Sharpsburg silty clay loam, 4 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2scy3
Elevation: 980 to 1,660 feet
Mean annual precipitation: 28 to 39 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 158 to 203 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Sharpsburg

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loess

Typical profile

Ap - 0 to 6 inches: silty clay loam
A - 6 to 11 inches: silty clay loam
Bt1 - 11 to 18 inches: silty clay loam
Bt2 - 18 to 46 inches: silty clay loam
BC - 46 to 58 inches: silty clay loam
C - 58 to 79 inches: silty clay loam

Properties and qualities

Slope: 4 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 45 to 50 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline (0.0 to 0.4 mmhos/cm)
Available water storage in profile: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Forage suitability group: Loam (G106XY100NE)
Hydric soil rating: No

Minor Components

Shelby

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Hydric soil rating: No

Pawnee

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Clayey Upland (R106XY074NE)
Hydric soil rating: No

Martin

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: Loamy Upland (PE 30-37) (R106XY015KS)
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

NOAA Atlas 14, Volume 8, Version 2
Location name: Tecumseh, Kansas, USA*
Latitude: 39.0521°, Longitude: -95.572°
Elevation: m/ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.402** (0.340-0.477)	**0.476** (0.402-0.565)	**0.597** (0.503-0.712)	**0.699** (0.585-0.836)	**0.840** (0.674-1.04)	**0.949** (0.742-1.19)	**1.06** (0.795-1.36)	**1.17** (0.838-1.55)	**1.32** (0.903-1.79)	**1.44** (0.953-1.98)
10-min	**0.588** (0.498-0.699)	**0.696** (0.589-0.828)	**0.874** (0.737-1.04)	**1.02** (0.856-1.23)	**1.23** (0.987-1.52)	**1.39** (1.09-1.74)	**1.55** (1.17-1.99)	**1.72** (1.23-2.26)	**1.93** (1.32-2.63)	**2.10** (1.40-2.90)
15-min	**0.717** (0.607-0.852)	**0.849** (0.718-1.01)	**1.07** (0.898-1.27)	**1.25** (1.04-1.49)	**1.50** (1.20-1.85)	**1.69** (1.33-2.12)	**1.89** (1.42-2.43)	**2.09** (1.50-2.76)	**2.36** (1.61-3.20)	**2.56** (1.70-3.54)
30-min	**1.03** (0.870-1.22)	**1.22** (1.03-1.45)	**1.54** (1.29-1.83)	**1.80** (1.51-2.15)	**2.17** (1.74-2.68)	**2.45** (1.92-3.07)	**2.74** (2.05-3.51)	**3.03** (2.16-3.99)	**3.41** (2.33-4.63)	**3.71** (2.46-5.12)
60-min	**1.34** (1.14-1.60)	**1.61** (1.36-1.91)	**2.04** (1.71-2.42)	**2.39** (2.00-2.86)	**2.89** (2.32-3.56)	**3.27** (2.55-4.09)	**3.65** (2.74-4.68)	**4.04** (2.89-5.33)	**4.55** (3.11-6.18)	**4.94** (3.28-6.82)
2-hr	**1.66** (1.41-1.96)	**1.99** (1.69-2.35)	**2.53** (2.15-3.00)	**2.98** (2.51-3.55)	**3.61** (2.91-4.42)	**4.08** (3.21-5.08)	**4.56** (3.45-5.82)	**5.05** (3.63-6.62)	**5.69** (3.92-7.67)	**6.18** (4.13-8.47)
3-hr	**1.85** (1.58-2.18)	**2.23** (1.90-2.62)	**2.85** (2.42-3.35)	**3.36** (2.83-3.97)	**4.06** (3.29-4.96)	**4.61** (3.63-5.71)	**5.15** (3.91-6.54)	**5.71** (4.12-7.45)	**6.44** (4.45-8.65)	**7.00** (4.70-9.56)
6-hr	**2.20** (1.89-2.57)	**2.64** (2.27-3.08)	**3.37** (2.88-3.94)	**3.98** (3.38-4.67)	**4.82** (3.93-5.86)	**5.49** (4.36-6.76)	**6.15** (4.70-7.77)	**6.83** (4.97-8.87)	**7.75** (5.39-10.3)	**8.44** (5.71-11.5)
12-hr	**2.57** (2.22-2.97)	**3.05** (2.63-3.54)	**3.86** (3.32-4.49)	**4.55** (3.89-5.31)	**5.53** (4.54-6.68)	**6.30** (5.04-7.72)	**7.09** (5.45-8.91)	**7.91** (5.80-10.2)	**9.02** (6.33-12.0)	**9.89** (6.73-13.3)
24-hr	**2.98** (2.59-3.43)	**3.49** (3.02-4.01)	**4.34** (3.75-5.01)	**5.08** (4.37-5.89)	**6.15** (5.09-7.40)	**7.00** (5.65-8.54)	**7.89** (6.12-9.87)	**8.82** (6.52-11.3)	**10.1** (7.14-13.4)	**11.1** (7.61-14.9)
2-day	**3.46** (3.02-3.95)	**3.98** (3.47-4.54)	**4.86** (4.23-5.57)	**5.63** (4.86-6.48)	**6.74** (5.63-8.06)	**7.64** (6.20-9.26)	**8.58** (6.70-10.7)	**9.57** (7.12-12.2)	**10.9** (7.78-14.4)	**12.0** (8.28-16.0)
3-day	**3.77** (3.31-4.29)	**4.32** (3.78-4.91)	**5.25** (4.58-5.99)	**6.06** (5.25-6.94)	**7.21** (6.03-8.57)	**8.14** (6.63-9.81)	**9.10** (7.13-11.2)	**10.1** (7.55-12.8)	**11.5** (8.21-15.0)	**12.6** (8.71-16.7)
4-day	**4.05** (3.56-4.58)	**4.62** (4.06-5.24)	**5.60** (4.89-6.36)	**6.43** (5.59-7.34)	**7.63** (6.39-9.03)	**8.58** (7.00-10.3)	**9.57** (7.51-11.8)	**10.6** (7.93-13.4)	**12.0** (8.60-15.6)	**13.1** (9.10-17.3)
7-day	**4.80** (4.24-5.40)	**5.44** (4.80-6.13)	**6.51** (5.72-7.36)	**7.43** (6.49-8.43)	**8.74** (7.36-10.3)	**9.78** (8.02-11.7)	**10.8** (8.56-13.3)	**12.0** (9.00-15.1)	**13.5** (9.72-17.5)	**14.7** (10.3-19.3)
10-day	**5.45** (4.83-6.11)	**6.16** (5.45-6.92)	**7.36** (6.49-8.28)	**8.38** (7.34-9.48)	**9.82** (8.30-11.5)	**11.0** (9.02-13.0)	**12.1** (9.61-14.8)	**13.4** (10.1-16.7)	**15.0** (10.8-19.3)	**16.3** (11.4-21.3)
20-day	**7.23** (6.44-8.04)	**8.23** (7.32-9.17)	**9.87** (8.75-11.0)	**11.2** (9.90-12.6)	**13.1** (11.1-15.2)	**14.6** (12.1-17.1)	**16.1** (12.8-19.4)	**17.5** (13.3-21.8)	**19.5** (14.2-24.9)	**21.0** (14.9-27.3)
30-day	**8.76** (7.83-9.70)	**9.98** (8.91-11.1)	**12.0** (10.6-13.3)	**13.6** (12.0-15.2)	**15.7** (13.4-18.1)	**17.4** (14.4-20.3)	**19.0** (15.2-22.8)	**20.6** (15.7-25.4)	**22.7** (16.5-28.8)	**24.2** (17.2-31.4)
45-day	**10.8** (9.68-11.9)	**12.3** (11.0-13.5)	**14.6** (13.0-16.1)	**16.4** (14.5-18.2)	**18.8** (16.0-21.4)	**20.6** (17.1-23.8)	**22.2** (17.8-26.4)	**23.9** (18.2-29.2)	**25.9** (18.9-32.6)	**27.3** (19.5-35.2)
60-day	**12.6** (11.3-13.9)	**14.2** (12.8-15.7)	**16.7** (15.0-18.5)	**18.7** (16.6-20.7)	**21.2** (18.0-24.0)	**23.0** (19.1-26.5)	**24.6** (19.7-29.1)	**26.1** (20.0-31.8)	**28.0** (20.5-35.1)	**29.2** (20.9-37.6)

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

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

Please refer to NOAA Atlas 14 document for more information.

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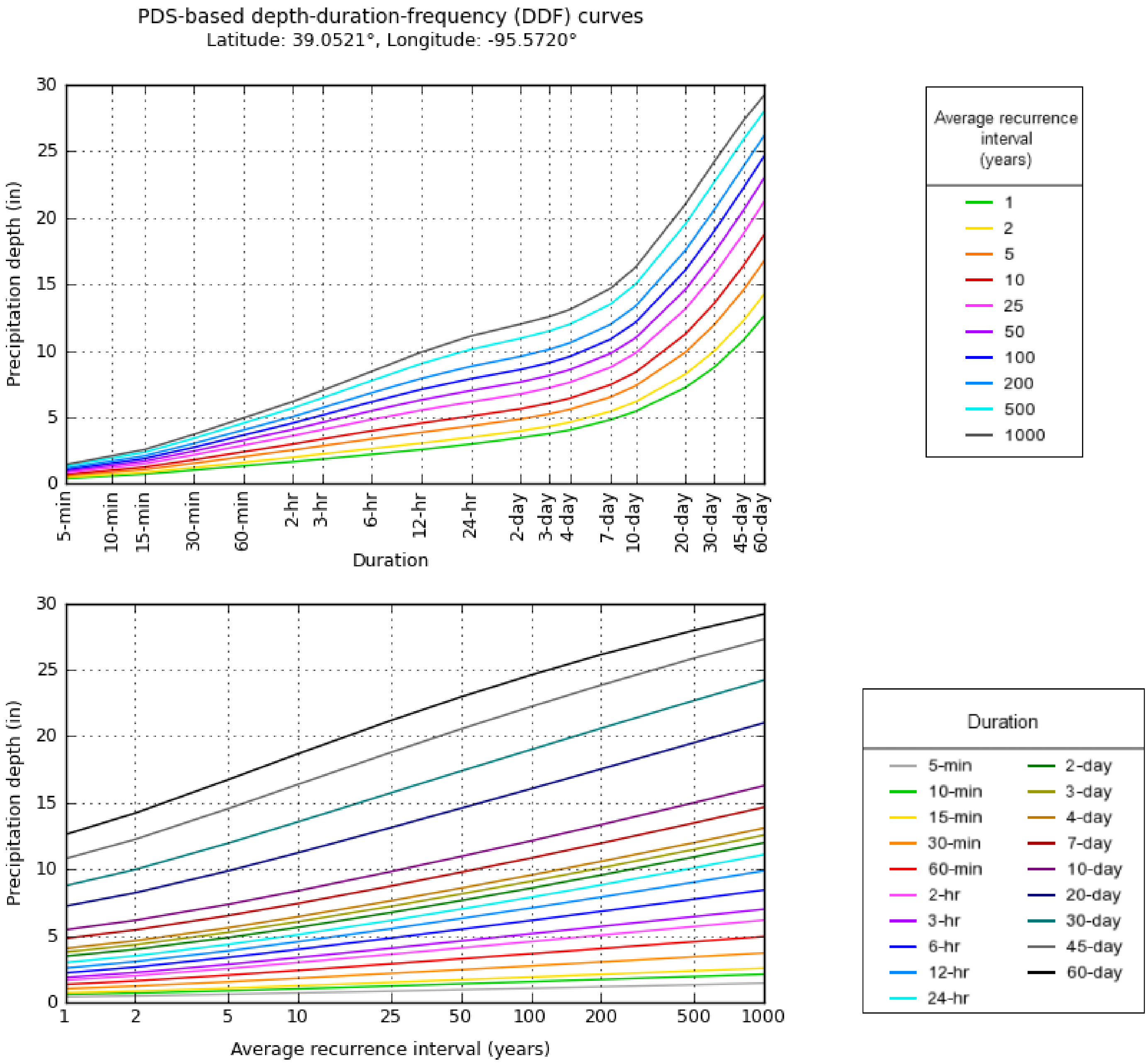
PF graphical



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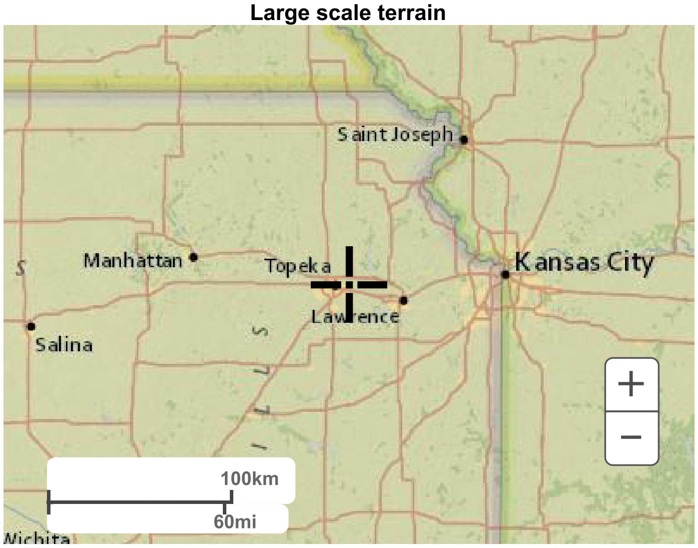
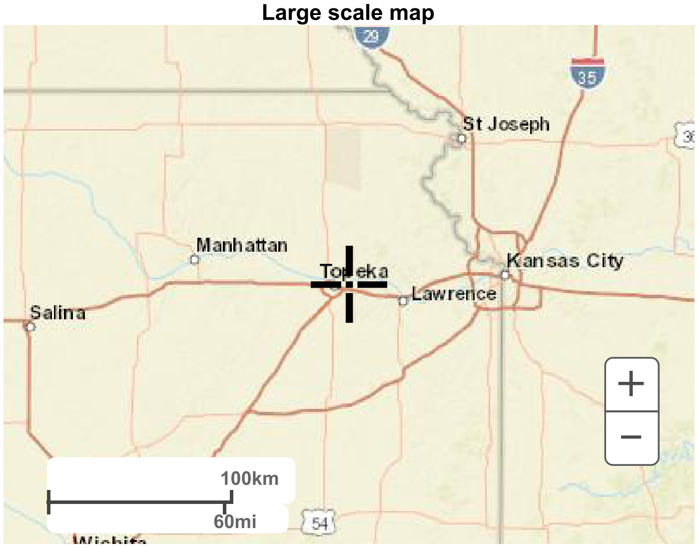
Maps & aerials

Small scale terrain

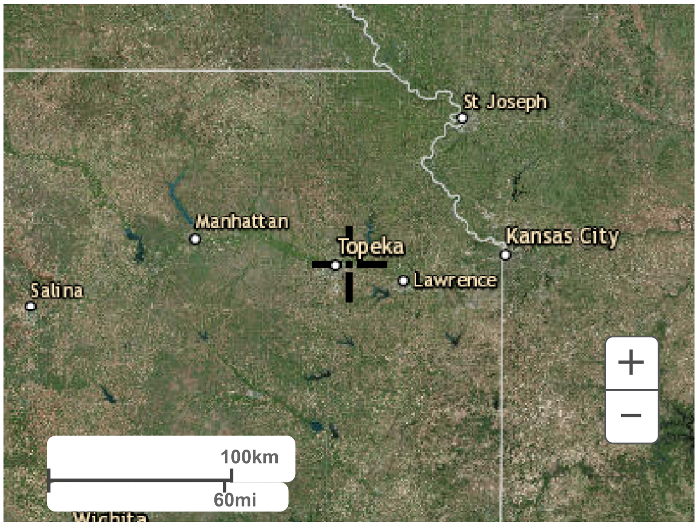
Large scale terrain



Large scale map



Large scale aerial



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Attachment 2

Run-Off Hydraulic Analysis

Tecumseh Energy Center 322 Landfill Closure

1. FlowMaster Model Results Summary
2. FlowMaster Model Reports

    Appendix A. Rip Rap Data

BLACK & VEATCH

Hydraulic Analysis

CALCULATION INFORMATION	
Client Name(s):	Evergy
Project Name:	Tecumseh Energy Center CCR Landfill Closure
Project Number:	123456.78.90
Project Location:	Tecumseh, KS
Submittal:	Run-On Run-Off Report
Approval Date:	7/13/2021, Josh Birk
Calculation Status(UNO):	Final
Calculation Title	Hydraulic Analysis

VERIFICATION AND REVISION LOG		
Rev	**Status**	**Prepared By: FML; Verified By: FML**
0	*Final*	Prepared By: MEL, 7/9/2021; Verified by: JDB, 7/13/2021

FlowMaster Model Results Summary

Flow Master Model Results Summary at Peak Flow				
Channel	Velocity (ft/s)	Minimum Side Height (ft)	Normal Depth (ft)	Freeboard (ft)
Channel 01	1.81	1.0	0.98	0.06
Channel 02	2.50	4.1	1.05	3.01
Channel 03	3.40	2.0	0.40	1.61

Channel 01

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01000	ft/ft
Left Side Slope	8.00	ft/ft (H:V)
Right Side Slope	4.20	ft/ft (H:V)
Bottom Width	16.60	ft
Discharge	40.30	ft^3/s

Results

Normal Depth	0.98	ft
Flow Area	22.24	ft^2
Wetted Perimeter	28.78	ft
Hydraulic Radius	0.77	ft
Top Width	28.60	ft
Critical Depth	0.53	ft
Critical Slope	0.09062	ft/ft
Velocity	1.81	ft/s
Velocity Head	0.05	ft
Specific Energy	1.03	ft
Froude Number	0.36	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.98	ft
Critical Depth	0.53	ft
Channel Slope	0.01000	ft/ft

Channel 01

GVF Output Data

Critical Slope	0.09062	ft/ft

Cross Section for Channel 01

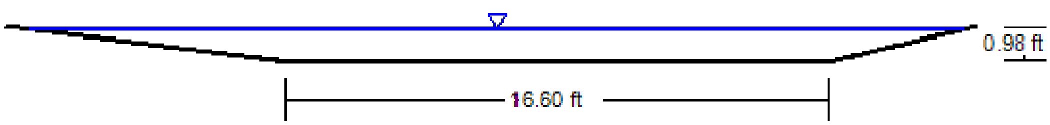
Project Description

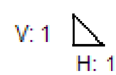
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01000	ft/ft
Normal Depth	0.98	ft
Left Side Slope	8.00	ft/ft (H:V)
Right Side Slope	4.20	ft/ft (H:V)
Bottom Width	16.60	ft
Discharge	40.30	ft³/s

Cross Section Image





Channel 02

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.40	ft/ft (H:V)
Right Side Slope	2.40	ft/ft (H:V)
Bottom Width	17.80	ft
Discharge	53.50	ft³/s

Results

Normal Depth	1.05	ft
Flow Area	21.43	ft²
Wetted Perimeter	23.28	ft
Hydraulic Radius	0.92	ft
Top Width	22.86	ft
Critical Depth	0.64	ft
Critical Slope	0.08410	ft/ft
Velocity	2.50	ft/s
Velocity Head	0.10	ft
Specific Energy	1.15	ft
Froude Number	0.45	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.05	ft
Critical Depth	0.64	ft
Channel Slope	0.01500	ft/ft

Channel 02

GVF Output Data

Critical Slope	0.08410	ft/ft

Cross Section for Channel 02

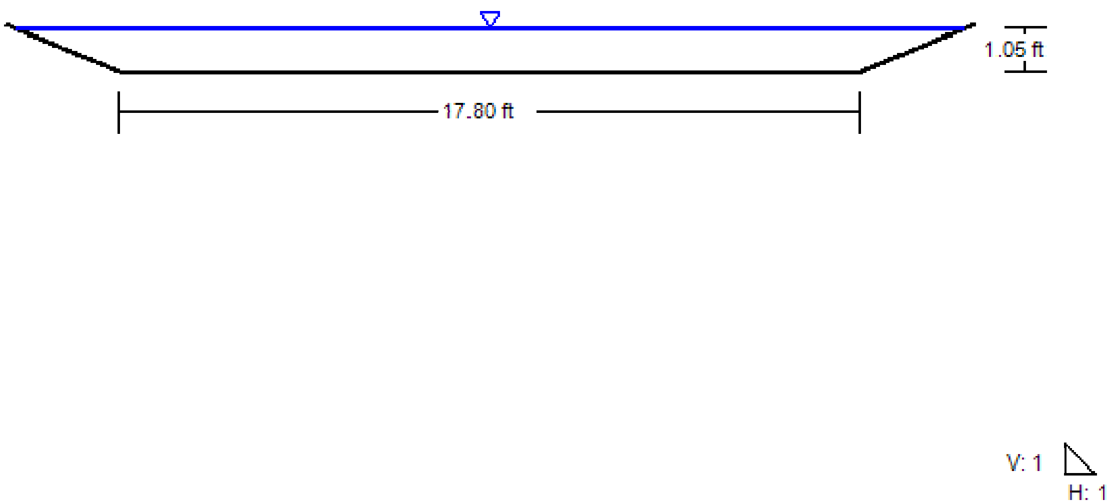
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.01500	ft/ft
Normal Depth	1.05	ft
Left Side Slope	2.40	ft/ft (H:V)
Right Side Slope	2.40	ft/ft (H:V)
Bottom Width	17.80	ft
Discharge	53.50	ft³/s

Cross Section Image



Channel 03

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.10000	ft/ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.10	ft/ft (H:V)
Bottom Width	12.50	ft
Discharge	19.90	ft³/s

Results

Normal Depth	0.40	ft
Flow Area	5.86	ft²
Wetted Perimeter	16.65	ft
Hydraulic Radius	0.35	ft
Top Width	16.57	ft
Critical Depth	0.40	ft
Critical Slope	0.09865	ft/ft
Velocity	3.40	ft/s
Velocity Head	0.18	ft
Specific Energy	0.58	ft
Froude Number	1.01	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.40	ft
Critical Depth	0.40	ft
Channel Slope	0.10000	ft/ft

Channel 03

GVF Output Data

Critical Slope	0.09865	ft/ft

Cross Section for Channel 03

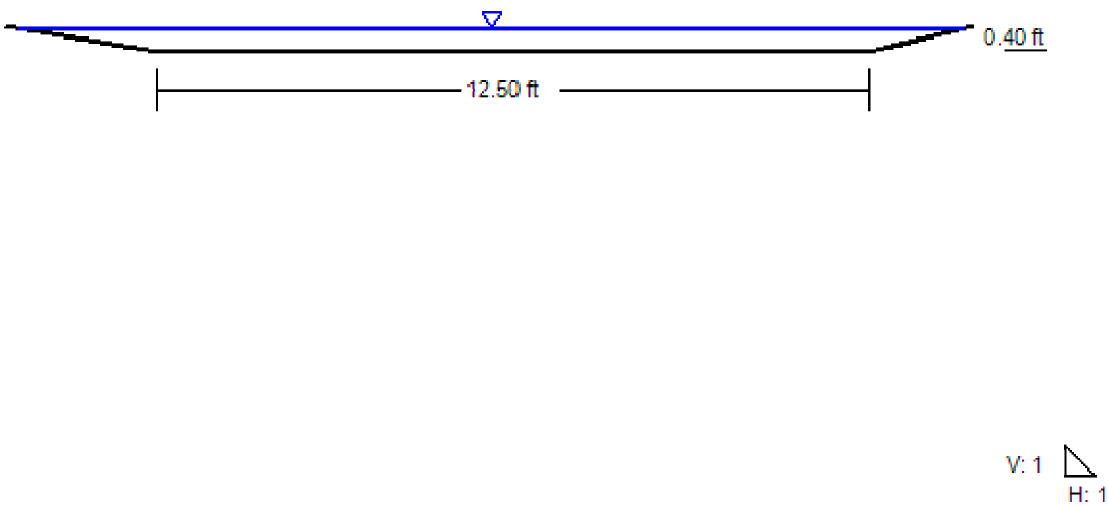
Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.069	
Channel Slope	0.10000	ft/ft
Normal Depth	0.40	ft
Left Side Slope	6.00	ft/ft (H:V)
Right Side Slope	4.10	ft/ft (H:V)
Bottom Width	12.50	ft
Discharge	19.90	ft³/s

Cross Section Image



Rip Rap Data

Sphere

Unit Weight	165.00	lb/cf	
D50	0.50	inches	
Volume	0.00	cubic foot	
Weight	0.01	lb	
W50	0.01	lb	
Velocity	1.81	feet/second	
D100	0.07	0.86	inches
D50	0.04	0.50	inches
Layer Thickness	0.86	0.75	inches
Percent Lighter by Weight (SSD)	Limit of Stone Weght (LBS)		
100	0	0	
50	0	0	
15	0	0	

Sphere

Unit Weight	135.00	lb/cf	
D50	0.71	inches	
Volume	0.00	cubic foot	
Weight	0.01	lb	
W50	0.01	lb	
Velocity	1.81	feet/second	
D100	0.10	1.22	
D50	0.06	0.71	
Layer Thickness	1.22	1.07	
Percent Lighter by Weight (SSD)	Limit of Stone Weght (LBS)		
100	0	0	
50	0	0	
15	0	0	

Unit Weight	165.00	lb/cf	
D50	0.96	inches	
Volume	0.00	cubic foot	
Weight	0.04	lb	
W50	0.04	lb	
Velocity	2.50	feet/second	
D100	0.14	1.64	inches
D50	0.08	0.96	inches
Layer Thickness	1.64	1.44	inches
Percent Lighter by Weight (SSD)	Limit of Stone Weght (LBS)		
100	0	0	
50	0	0	
15	0	0	

Unit Weight	135.00	lb/cf	
D50	1.36	inches	
Volume	0.00	cubic foot	
Weight	0.10	lb	
W50	0.10	lb	
Velocity	2.50	feet/second	
D100	0.19	2.32	
D50	0.11	1.36	
Layer Thickness	2.32	2.04	
Percent Lighter by Weight (SSD)	Limit of Stone Weght (LBS)		
100	1	0	
50	0	0	
15	0	0	

Unit Weight	165.00	lb/cf	
D50	1.78	inches	
Volume	0.00	cubic foot	
Weight	0.28	lb	
W50	0.28	lb	
Velocity	3.40	feet/second	
D100	0.25	3.04	inches
D50	0.15	1.78	inches
Layer Thickness	3.04	2.66	inches
Percent Lighter by Weight (SSD)	Limit of Stone Weght (LBS)		
100	1	1	
50	0	0	
15	0	0	

Unit Weight	135.00	lb/cf	
D50	2.51	inches	
Volume	0.00	cubic foot	
Weight	0.65	lb	
W50	0.65	lb	
Velocity	3.40	feet/second	
D100	0.36	4.29	
D50	0.21	2.51	
Layer Thickness	4.29	3.77	
Percent Lighter by Weight (SSD)	Limit of Stone Weght (LBS)		
100	3	1	
50	1	1	
15	0	0	