Drainage Report

UNITED STATES FISH AND WILDLIFE SERVICE
HURON MULTIPURPOSE BUILDING AND VISITOR CENTER
USFWS Project No. 21-006

Prepared for:

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 6 ENGINEERING

Lakewood, Colorado

Prepared by:

DOWL

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3/22/2022

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5028.27085.01

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1.0 INTRODUCTION

The objective of this report is to analyze the existing and proposed drainage conditions for the development of Huron National Wildlife Refuge, SD. The proposed development constructs a new multipurpose building and visitor center for the USFWS (United States Fish & Wildlife Service) on a greenfield site.

The recommended drainage design will retain water derived from impervious surfaces to improve the water quality of stormwater runoff derived from the new development.

1.1 Location

The project site is located approximately 0.25 miles west of the intersection of 392nd Avenue and US Hwy 14 in Beadle County, South Dakota within the northwest quarter of Section 3, Township 110 North, Range 63 West. The County parcel number is 2385. The parcel is part of the Huron National Wildlife Refuge (NWR) and is owned by the United States Fish and Wildlife Service (USFWS). The City of Huron is located approximately 8 miles to the east. A location map can be seen in Figure 1. An area map can be found in Appendix A.

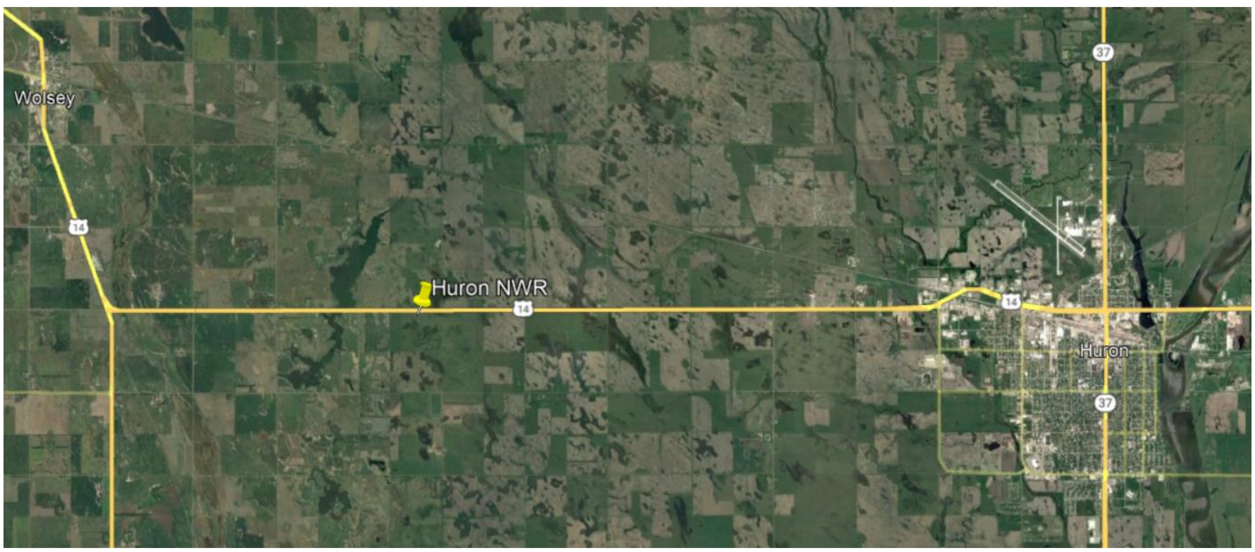


Figure 1: Location Map of Huron National Wildlife Refuge

1.2 Description of the Property

The project site is located on top of a topographical highpoint within a wetland complex at the Huron National Wildlife Refuge (Figure 2). The slopes that define the site are shallow, between 0.5 to 1.0 percent. The site is surrounded by Freshwater Emergent Wetlands (USFW Mapper) there do not appear significant flow paths identified from aerial imagery The surrounding area appears to be undeveloped agricultural fields.

The north side of the project site is bounded by US Hwy 14. Drainage ditches run along the north and south sides of US Hwy 14 and capture runoff from the impervious surfaces. These ditches flow west to east at less than 0.5 percent. There are no significant land features bounding the east, west, or south sides of the project site. Aerial Images show that water levels fluctuate in the wetlands. However, Flood Insurance Rate Map (FIRM) Panel 46005C0675C. FEMA has identified the site as an area of minimal flood hazard (Zone X). An excerpt of the FEMA map covering the project site is included in Appendix B.

Figure 2: Aerial View of Existing Site

2.0 DRAINAGE DESIGN CRITERIA

Hydrologic calculations and assumptions were completed in compliance with the standards established in the SDDOT's *South Dakota Drainage Manual (SDDM), Chapters 7, 12, and 13*.

The retention basin was designed to improve the water quality of runoff by capturing small storms and maximize the removal of sediment and other pollutants.

2.1 Hydrologic Methods

The required design storm is a 10-year return period as stated in Chapter 12 of the SDDM. Chapter 13 of the SDDM requires the design of the retention basins to be assessed against the100-year discharge values.

Precipitation depth and intensity data were obtained from the NOAA Atlas 14, Volume 8, Version 2, and can be found in Appendix C. Runoff quantities for the site basin were determined using the Rational Method as prescribed in Chapter 7.13 "Hydrology" of the SDDM.

2.2 Hydraulic Methods

The ditches and culverts proposed for the developed site were designed Manning's equation and checked against the minimum dimensions specified in SDDM.

The basin was sized using from a simplified triangular-shaped hydrograph procedure that estimates inflow and outflow hydrographs as described in section 13.6 of SDDM.

3.0 DRAINAGE BASINS

3.1 Existing Basin Description

The site sits upon a topographical highpoint within a wetland complex. The site drains in three different directions, but all flow paths appear to be hydrologically connected when the wetlands are seasonally inundated (Appendix C) (Figure 3).

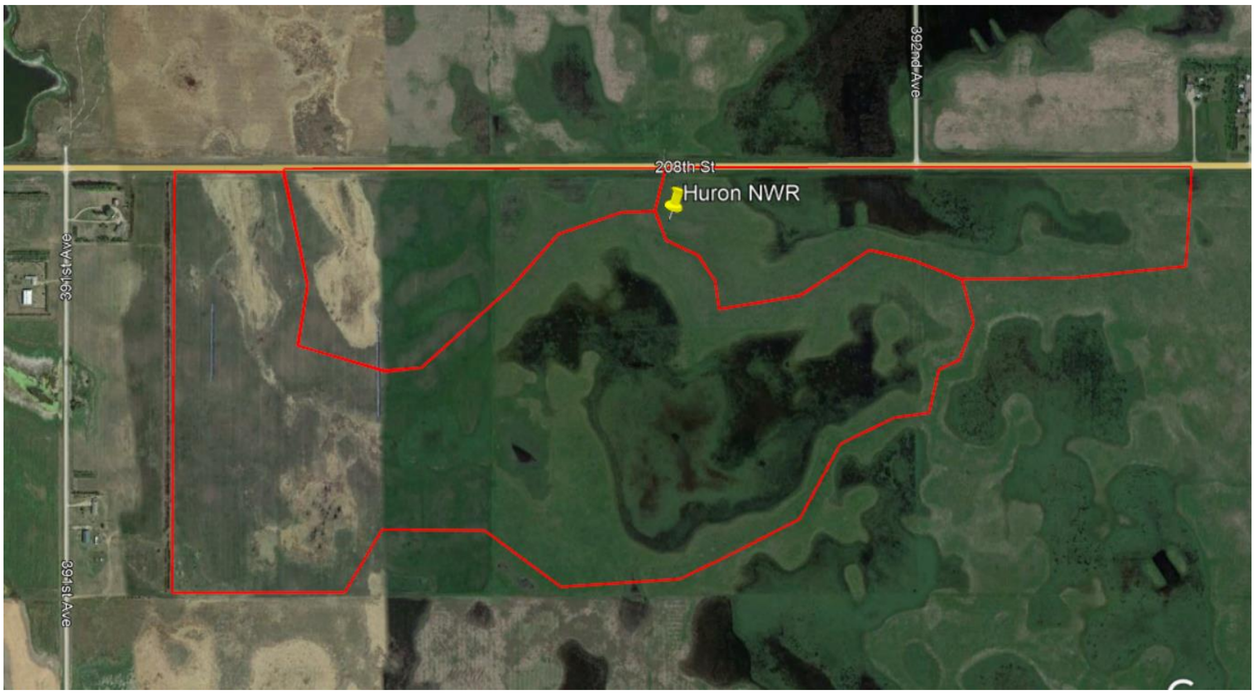


Figure 3: Aerial View of Existing Basins

The National Resources Conservation Service (NRCS) Web Soil Survey indicate that existing soils at the site are Houdek-Ethan and Houdek-Prosper clay loams (Appendix E). DOWL conducted a geotechnical investigation at the site that confirmed the subsurface soil generally consists of stiff to very stiff sandy lean clay with occasional layers of medium dense sand. The corresponding hydrologic soil group is C.

While the area surrounding the site is likely hydrologically connected, for the purposes of the report, three sub-basins can be defined for the analysis. The description of the sub-basins are as follows:

North West Sub-Basin: The basin is approximately 43 acres that primarily drains agricultural and grasslands. The extent of the property that appears to be actively farmed is 24 acres.

North East Sub-Basin: The sub-basin is approximately 51 acres of wetlands that drains water from south of US Highway 14 road. Approximately 19 acres of the basin is occupied by standing water.

South Sub-Basin: The basin is approximately 190 acres that primarily consist of wetlands. The extent of the property that appears to be actively farmed is 73 acres. Approximately 52 acres of the basin is occupied by standing water.

Figure 4: Aerial View of Existing Basins

3.2 Existing Basin Discharges

Due to the hydrologic connectivity of the wetlands and the size of the respective sub-basins, the estimated existing discharge will not accurately capture the changes induced at the site. The changes of the existing basin will only be compared to the footprint of the proposed site. While this does not give a true quantification of flow for the existing hydrologic system, it does provide a baseline to compare the changes to land cover types and grading during development.

The footprint of the proposed site is approximately 3.2 acres The estimated peak discharge for the project footprint within the respective sub-basins are described in Table 1.

Table 1: Existing Basin Peak Discharge

Sub-Basin	Area (ac)	Tc (min)	Runoff Coefficient	10-Year Storm (cfs)	100-Year Storm (cfs)
Northeast	0.29	10	0.3	0.44	0.68
Northwest	0.61	10	0.3	0.95	1.46
South	0.71	10	0.3	1.11	1.69

3.3 Proposed Basin Description

The proposed development consists of a new multipurpose building and visitor center. The location change will see new fill and grading added to the site; the proposed building will be constructed approximately 2-feet above existing grade. A 30,000 square feet gravel parking lot will be constructed adjacent to the building and a gravel entrance drive will tie the parking lot to US Hwy 14. Additional proposed facilities on the site include an Evapotranspiration (E.T.) treatment bed and a retention basin. A plan showing the proposed development can be found in Appendix F.

To accommodate the expected increase in surface runoff and to improve surface water quality, a retention basin will be located adjacent to the site to receive the majority of surface water flow from the new development. The retention basin will be located to the east of the new building and parking lot, with drainageways constructed to collect runoff and drain to the retention basin.

3.3.1 Hydrologic Changes

In the developed condition, the respective drainage basins will remain approximately the same size. Minor changes between the basin boundaries of Northeast and South occur due to changes in grading and pathway curbing, with South seeing a slight decrease in size and Northeast increasing accordingly.

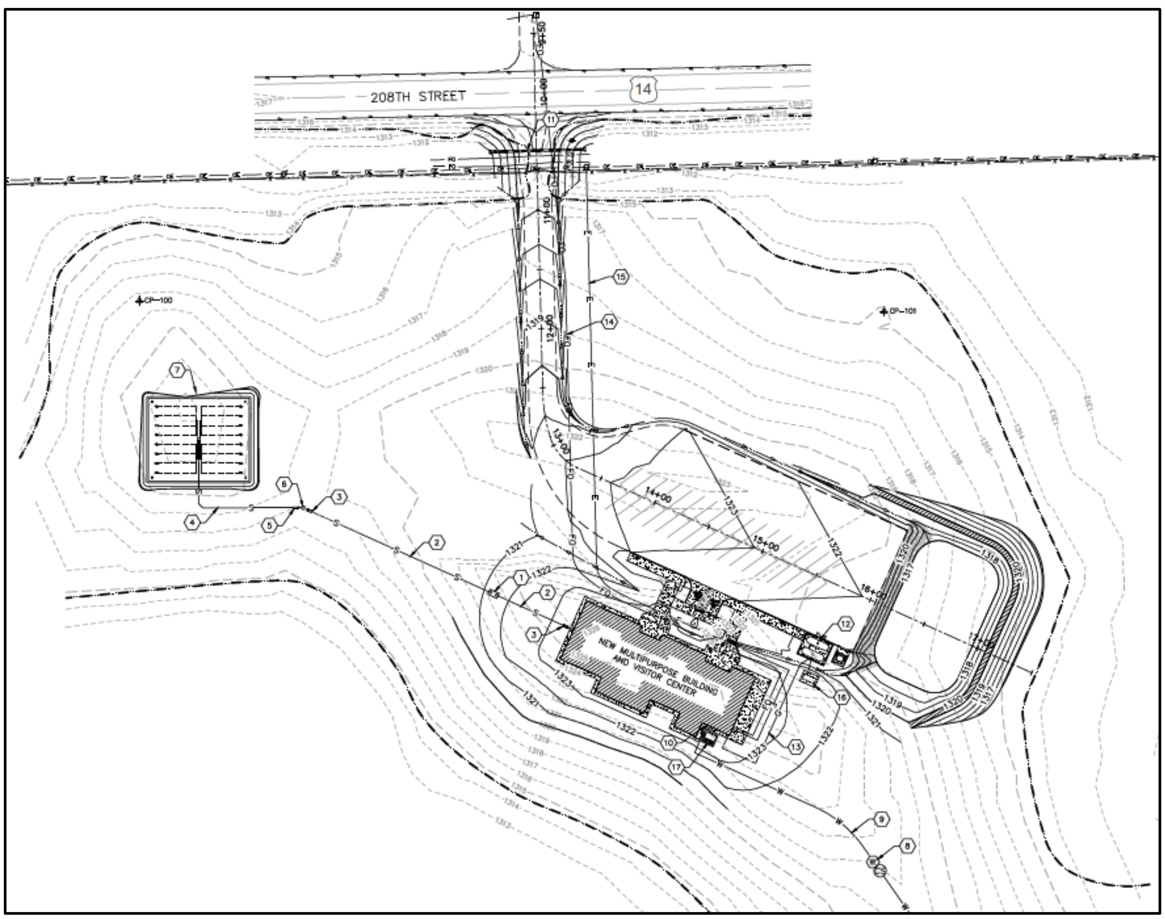


Figure 5: Aerial View of Proposed Plan

The majority of the proposed development occurs in the Northeast sub-basin. The increase in impervious area from the construction of the building, walkways, and concrete parking lot consequently increased the weighted runoff coefficient for Northeast Sub-Basin.

The estimated peak discharge for the basins in the post development condition are described in Table 2. The change in imperviousness for the Northeast sub--basin is reflected in increase in peak discharge for the 10-year and 100-year storm events respectively.

Table 2: Existing Basin Peak Discharge

Basin	Area (ac)	Tc (min)	Runoff Coefficient	10-Year Storm (cfs)	Change (%)	100-Year Storm (cfs)	Change (%)
Northeast	0.29	10	0.72	1.07	59	1.63	58
Northwest	0.61	10	0.67	2.14	56	3.27	55
South	0.71	10	0.43	1.59	30	2.43	30

3.4 Retention Basin Design

Only the runoff that will flow directly into the retention basin from the new development, the parking lot and a portion of the roof drainage from the new visitor center, will be used to size the retention basin. This sub-basin includes part of the proposed building, most of the concrete walks, and the gravel parking lot. The retention basin is proposed to be constructed in the land east of the administration building and visitor center. The location of the retention basin is in line with the DOWL geotechnical report recommendation:

“Do not construct infiltration basins adjacent to or up gradient of the structures. If detention is required by statute, infiltration basins should be located down gradient and at least 30 feet from foundations.”

The base of the retention basin will be below the existing ground elevation at approximately 1317ft above datum. The DOWL geotechnical investigation found that the ground water level at Borehole 3, closest to the retention basin, was at 1309ft above datum, indicating that infiltration from the basin is likely to occur. The observation represents groundwater conditions at the time of the observations only, and may not be indicative of other times. The groundwater conditions can change with varying seasonal and weather conditions, and other factors; groundwater elevation may correspond with the surface water near the site. Infiltration testing was not conducted at the proposed retention basin location however, a constant infiltration rate of 120 minutes per inch was observed at three test pits located at the west of the site. The location of boreholes and percolation test pits can be found in Appendix G.

The storage volume required for peak-flow attenuation was obtained from a simplified triangular-shaped hydrograph procedure that estimates inflow and outflow hydrographs. The basin was sized to retain the 100-year storm runoff volume. Table 3 summarizes the basin sizing analysis.

Table 3: Developed Area Basin

Developed Area Basin (1.29-acres)	10-Year Storm	100-Year Storm
Peak Discharge (cfs)	6.34	9.69
Volume (acre-ft)	0.0436	0.067
Volume (CF)	1900	2907
Weighted Runoff Coefficient:	0.95	0.95

The sub-basin time of concentration is much smaller than similar values for overall existing and developed drainage basins. This is due to the short flow length of stormwater runoff within the developed sub-basin.

The minimum freeboard required for grassed and parking lot detention facilities is 1.0 feet above the computed 100- year water surface elevation. A weir-type outlet will be located at the eastern edge of the basin to convey any water stored greater than the 100-year water level to a riprap-lined channel. The minimum weir length will be 3.25ft wide at the base and located at the elevation of the 100-yr storm.

The retention basin will have a volume of the basin is 7360 ft^3

4.0 CONCLUSIONS

The objective of this report is to analyze the existing and proposed drainage conditions for the development of Huron National Wildlife Refuge, SD. The drainage design, prepared in accordance with the South Dakota Drainage Manual, has been developed to provide sufficient water quality of site runoff.

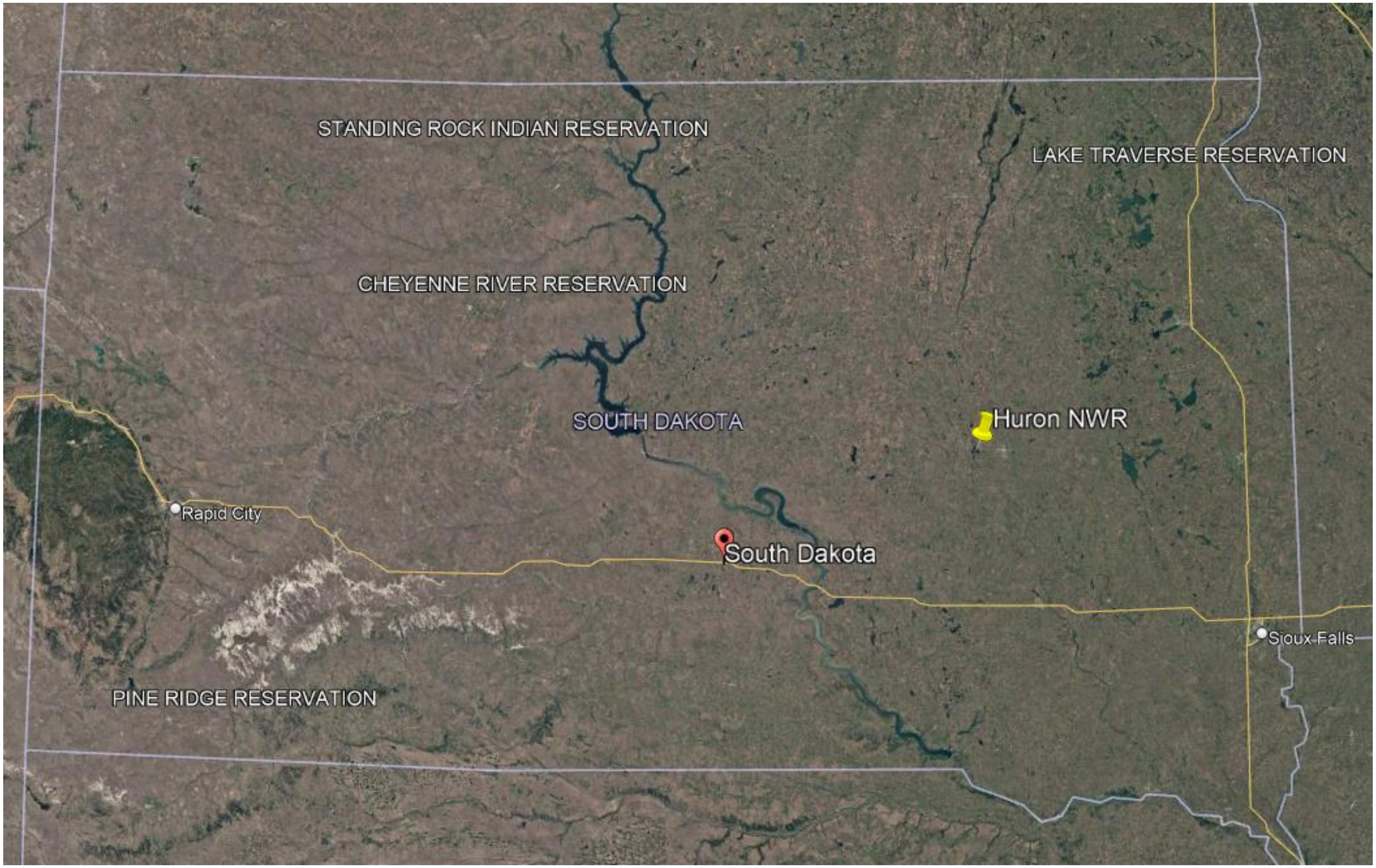
The development of the site will see an increase in runoff in developed basins, but it will be mitigated by the construction of the retention basin.

5.0 REFERENCES

South Dakota Drainage Manual, Chapters 7, 12, and 13, South Dakota Department of Transportation – Office of Bridge Design, October 2011, Revised August 2019.

NOAA Atlas 14, Volume 8, Version 2. Point Precipitation Frequency Estimates. National Oceanic and Atmospheric Administration and National Weather Service. Perica, Sanja, Kane, Douglas, et al. 2012.

APPENDIX A – LOCATION MAP

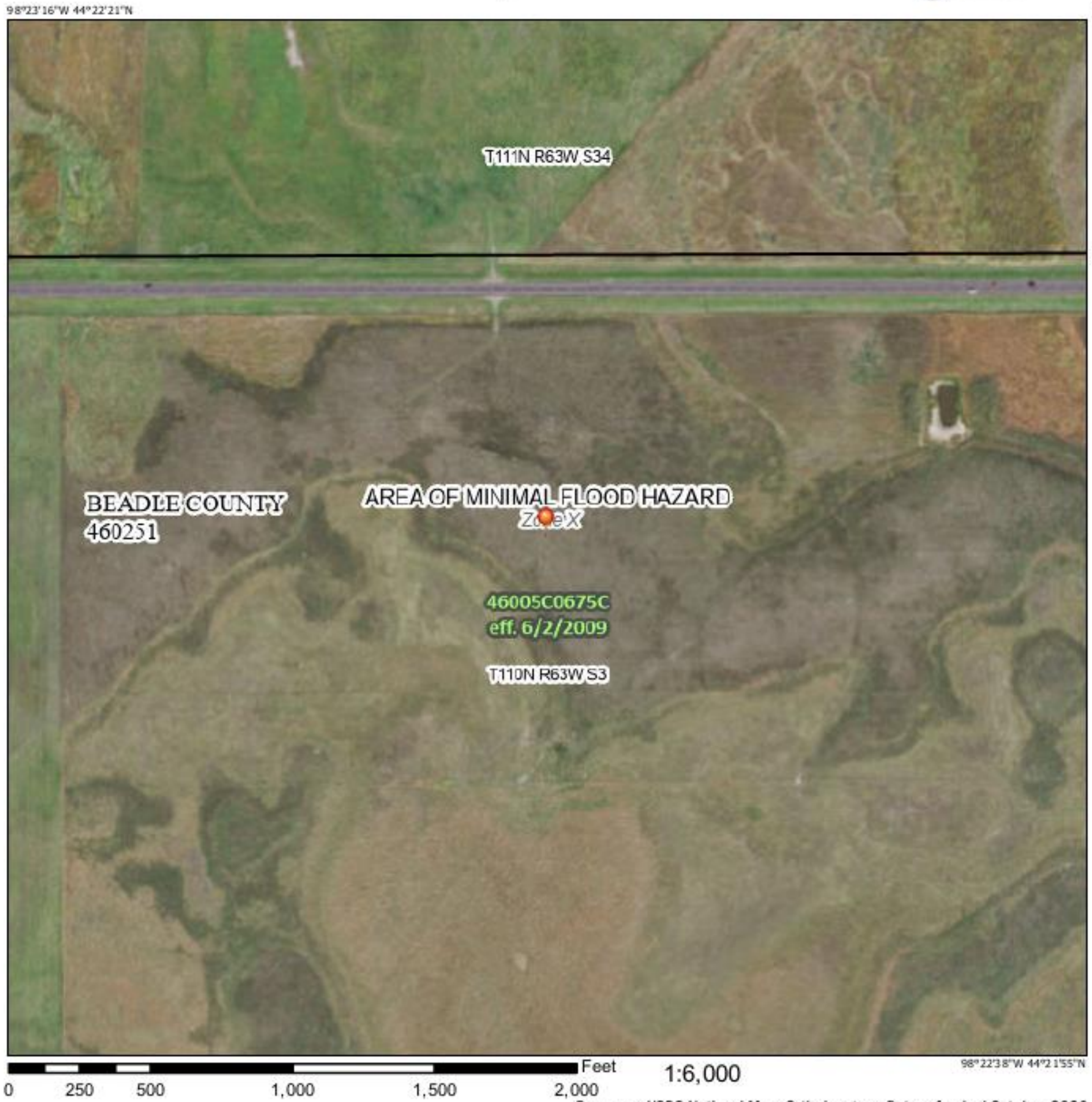


STANDING ROCK INDIAN RESERVATION
LAKE TRAVERSE RESERVATION
CHEYENNE RIVER RESERVATION
SOUTH DAKOTA
Huron NWR
Rapid City
South Dakota
Sioux Falls
PINE RIDGE RESERVATION

APPENDIX B – FEMA MAP

National Flood Hazard Layer FIRMette

FEMA



1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 12/6/2021 at 10:55 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX C– PRECIPITATION DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Wolsey, South Dakota, USA*
Latitude: 44.3701°, Longitude: -98.3828°
Elevation: 1317.81 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	0.338 (0.284-0.410)	0.400 (0.335-0.485)	0.503 (0.420-0.610)	0.590 (0.489-0.718)	0.711 (0.570-0.891)	0.807 (0.631-1.02)	0.904 (0.682-1.17)	1.00 (0.725-1.33)	1.14 (0.789-1.54)	1.24 (0.838-1.70)
10-min	0.495 (0.416-0.600)	0.586 (0.491-0.710)	0.736 (0.615-0.894)	0.863 (0.717-1.05)	1.04 (0.834-1.30)	1.18 (0.923-1.50)	1.32 (0.998-1.71)	1.47 (1.06-1.94)	1.67 (1.16-2.25)	1.82 (1.23-2.49)
15-min	0.604 (0.507-0.731)	0.715 (0.599-0.866)	0.898 (0.750-1.09)	1.05 (0.874-1.28)	1.27 (1.02-1.59)	1.44 (1.13-1.82)	1.61 (1.22-2.08)	1.79 (1.29-2.37)	2.03 (1.41-2.75)	2.22 (1.50-3.03)
30-min	0.837 (0.702-1.01)	0.991 (0.830-1.20)	1.25 (1.04-1.51)	1.46 (1.21-1.78)	1.76 (1.41-2.20)	1.99 (1.56-2.52)	2.23 (1.68-2.88)	2.48 (1.79-3.27)	2.81 (1.94-3.79)	3.06 (2.06-4.18)
60-min	1.05 (0.878-1.27)	1.24 (1.04-1.51)	1.57 (1.31-1.91)	1.86 (1.54-2.26)	2.26 (1.81-2.83)	2.58 (2.02-3.27)	2.90 (2.19-3.75)	3.24 (2.34-4.29)	3.71 (2.57-5.01)	4.07 (2.74-5.56)
2-hr	1.26 (1.06-1.51)	1.50 (1.26-1.80)	1.90 (1.60-2.29)	2.25 (1.88-2.72)	2.75 (2.23-3.43)	3.16 (2.49-3.98)	3.57 (2.72-4.59)	4.01 (2.92-5.27)	4.61 (3.22-6.19)	5.08 (3.45-6.89)
3-hr	1.36 (1.16-1.63)	1.62 (1.38-1.94)	2.07 (1.75-2.48)	2.46 (2.07-2.96)	3.03 (2.47-3.78)	3.50 (2.77-4.39)	3.98 (3.05-5.10)	4.49 (3.29-5.89)	5.20 (3.66-6.97)	5.77 (3.93-7.79)
6-hr	1.56 (1.33-1.84)	1.84 (1.58-2.18)	2.35 (2.00-2.79)	2.80 (2.37-3.33)	3.47 (2.85-4.29)	4.02 (3.22-5.02)	4.60 (3.55-5.87)	5.23 (3.86-6.81)	6.11 (4.33-8.14)	6.81 (4.68-9.14)
12-hr	1.78 (1.53-2.09)	2.08 (1.79-2.44)	2.62 (2.24-3.08)	3.10 (2.65-3.66)	3.83 (3.18-4.71)	4.44 (3.59-5.51)	5.09 (3.96-6.45)	5.80 (4.32-7.51)	6.79 (4.86-9.00)	7.60 (5.26-10.1)
24-hr	2.02 (1.76-2.35)	2.34 (2.03-2.72)	2.90 (2.51-3.39)	3.42 (2.94-4.00)	4.19 (3.51-5.12)	4.85 (3.95-5.96)	5.54 (4.35-6.96)	6.30 (4.73-8.09)	7.37 (5.31-9.69)	8.24 (5.75-10.9)
2-day	2.27 (1.99-2.62)	2.63 (2.30-3.04)	3.26 (2.85-3.77)	3.83 (3.32-4.45)	4.67 (3.94-5.64)	5.37 (4.40-6.55)	6.12 (4.83-7.61)	6.91 (5.22-8.80)	8.03 (5.82-10.5)	8.93 (6.28-11.7)
3-day	2.43 (2.14-2.78)	2.84 (2.50-3.26)	3.55 (3.11-4.08)	4.17 (3.63-4.81)	5.08 (4.29-6.08)	5.82 (4.78-7.03)	6.59 (5.22-8.14)	7.41 (5.62-9.37)	8.55 (6.22-11.1)	9.46 (6.68-12.4)
4-day	2.58 (2.28-2.94)	3.02 (2.67-3.46)	3.78 (3.32-4.33)	4.44 (3.88-5.11)	5.39 (4.56-6.41)	6.15 (5.07-7.40)	6.95 (5.52-8.54)	7.78 (5.92-9.80)	8.94 (6.51-11.5)	9.84 (6.97-12.8)
7-day	3.04 (2.71-3.45)	3.52 (3.13-4.00)	4.33 (3.83-4.92)	5.03 (4.42-5.74)	6.02 (5.12-7.10)	6.82 (5.65-8.13)	7.64 (6.10-9.31)	8.50 (6.49-10.6)	9.67 (7.09-12.4)	10.6 (7.54-13.7)
10-day	3.49 (3.12-3.94)	3.99 (3.56-4.50)	4.83 (4.29-5.46)	5.54 (4.89-6.30)	6.57 (5.61-7.70)	7.38 (6.14-8.76)	8.22 (6.60-9.97)	9.10 (6.98-11.3)	10.3 (7.57-13.1)	11.2 (8.02-14.5)
20-day	4.77 (4.29-5.33)	5.37 (4.83-6.00)	6.36 (5.70-7.13)	7.20 (6.41-8.10)	8.36 (7.19-9.68)	9.28 (7.78-10.9)	10.2 (8.25-12.2)	11.2 (8.62-13.7)	12.4 (9.22-15.7)	13.4 (9.67-17.2)
30-day	5.81 (5.26-6.46)	6.55 (5.92-7.28)	7.75 (6.98-8.64)	8.75 (7.83-9.79)	10.1 (8.72-11.6)	11.2 (9.40-13.0)	12.2 (9.91-14.6)	13.3 (10.3-16.2)	14.7 (10.9-18.4)	15.8 (11.4-20.1)
45-day	7.10 (6.45-7.85)	8.06 (7.32-8.92)	9.61 (8.69-10.7)	10.9 (9.78-12.1)	12.6 (10.9-14.3)	13.9 (11.7-16.0)	15.1 (12.3-17.9)	16.4 (12.8-19.9)	18.0 (13.5-22.5)	19.2 (14.0-24.4)
60-day	8.17 (7.45-9.00)	9.36 (8.53-10.3)	11.3 (10.2-12.4)	12.8 (11.5-14.2)	14.8 (12.9-16.8)	16.4 (13.9-18.8)	17.9 (14.6-21.0)	19.3 (15.1-23.3)	21.2 (15.8-26.3)	22.5 (16.4-28.5)

[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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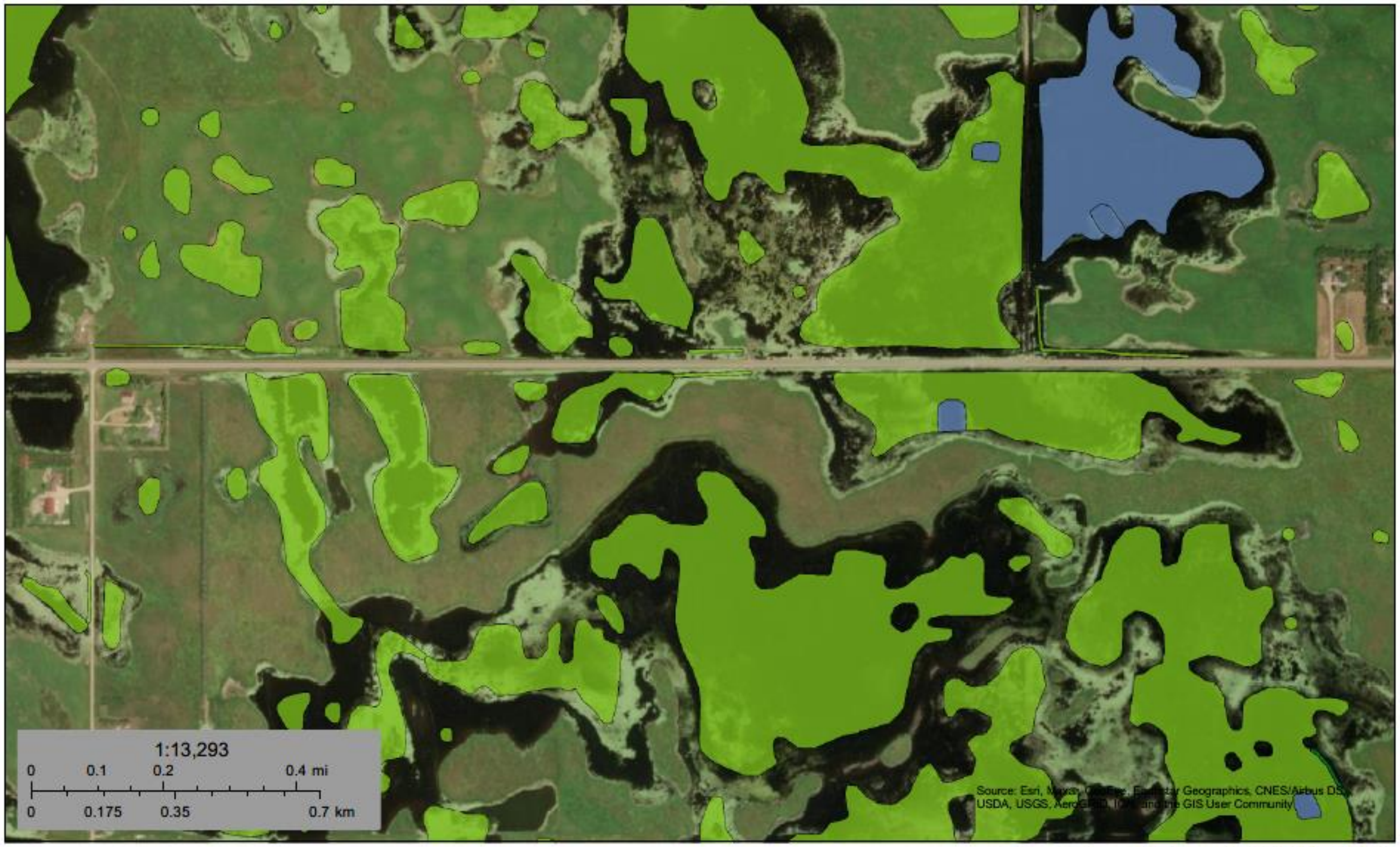
PF graphical

APPENDIX D – USFWS WETLAND MAPPER

U.S. Fish and Wildlife Service

National Wetlands Inventory

Huron NWR Wetlands



March 7, 2022

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

APPENDIX E – SOIL MAP

Map Unit Legend

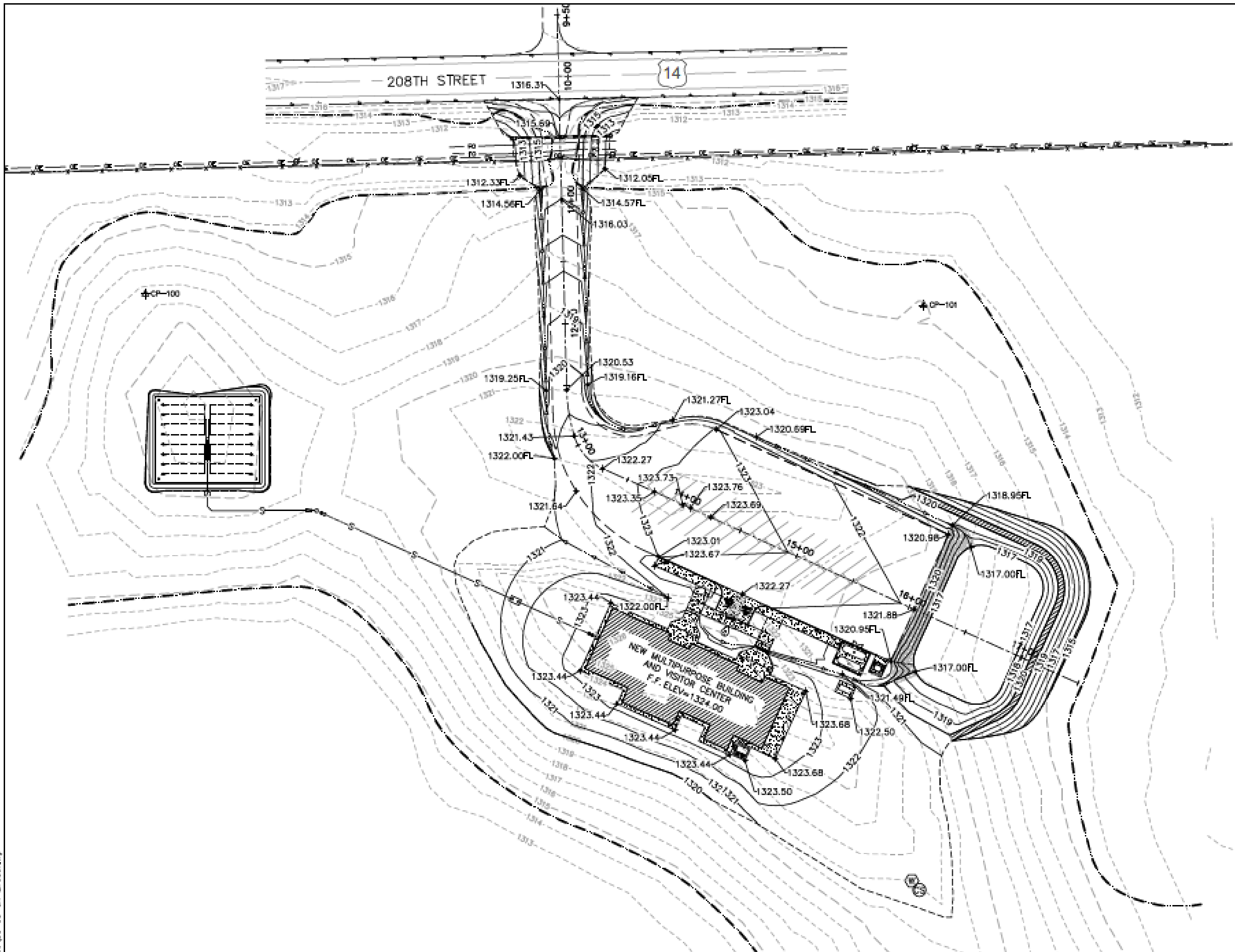
Beadle County, South Dakota (SD005)

Beadle County, South Dakota (SD005)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
DtA	Dudley-Tetonka silt loams	52.5	44.6%
HeC	Houdek-Ethan loams, 6 to 9 percent slopes	29.3	24.9%
HoB	Houdek-Prosper loams, 1 to 6 percent slopes	27.4	23.2%
Te	Tetonka-Hoven silt loams	8.5	7.2%
Totals for Area of Interest		**117.7**	**100.0%**

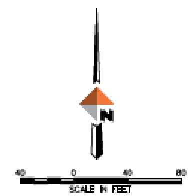
Scale (not to scale)

APPENDIX F – SITE PLAN



GRADING PLAN NOTES

1. SURFACE CONTOURS BASED ON TOPOGRAPHICAL SURVEY PERFORMED BY DOWL OCTOBER 2021
2. FINISH CONTOURS ARE TO TOP OF FINISHED GRADE.
3. CURB ELEVATIONS ARE FLOW LINE (FL) OR TOP BACK OF CURB (TBC) AS LABELED.
4. TOP OF CURB IS 6" ABOVE CURB FLOW LINE UNLESS OTHERWISE NOTED.
5. DISTURBED AREAS SHALL BE PREPARED FOR SEEDING. RE-SEEDING SHALL BE CONDUCTED BY USFWS PERSONNEL.



HURON WMD

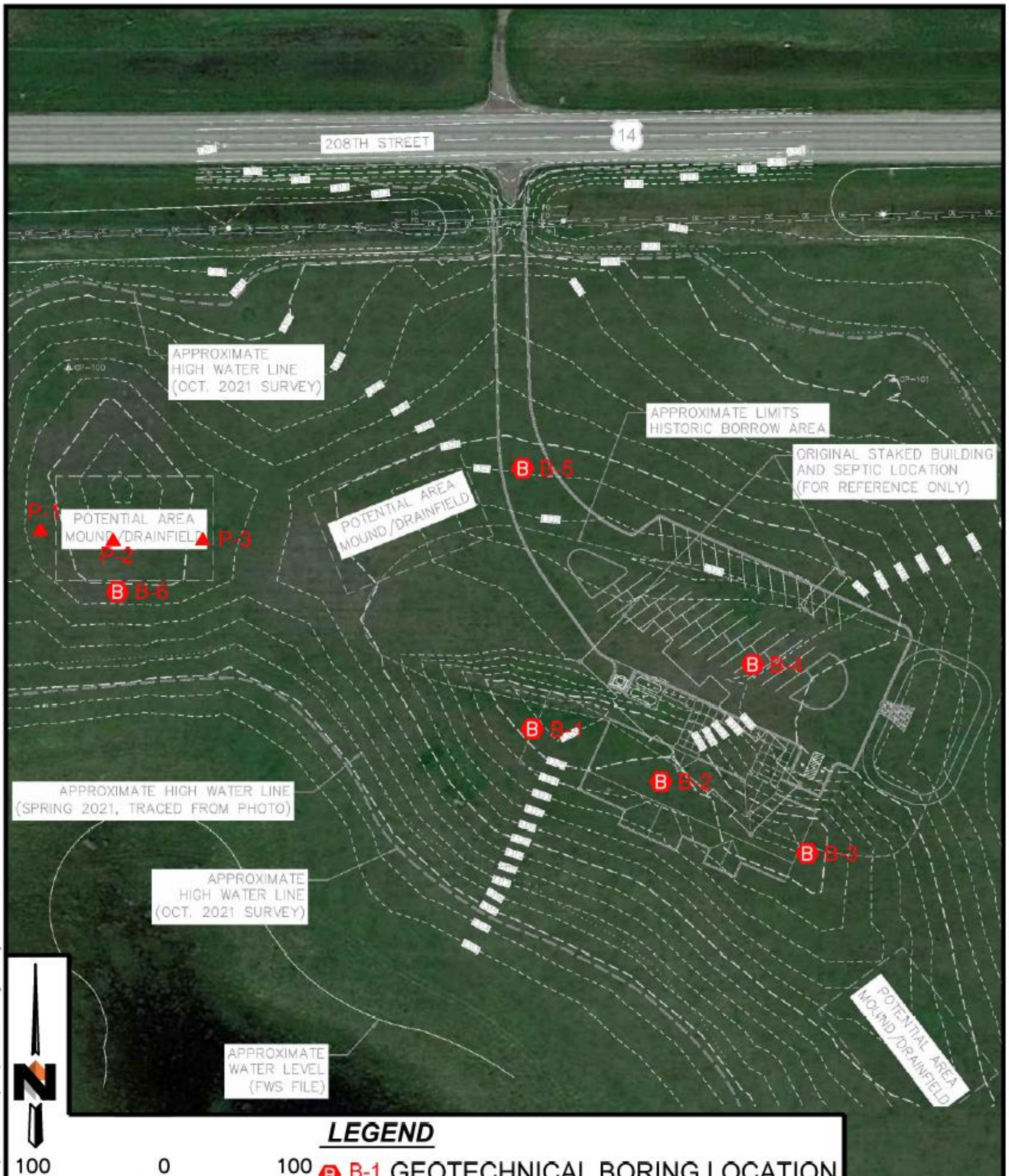
GRADING PLAN

MULTIPURPOSE BUILDING AND VISITOR CENTER

SUB-SHEET
C401

DESIGNED	DRAWN	CHECKED	DATE	DRAWING NO.	SHEET
MH	JB	BD	2022.03.01	00-00-000-00-000	6 OF 64

APPENDIX G– GEOTECHNICAL INVESTIGATION PLAN



LEGEND

100 0 100

SCALE IN FEET

B-1 GEOTECHNICAL BORING LOCATION

▲ P-1 PERCOLATION TEST LOCATION

DOWL

WWW.DOWL.COM

HURON MULTIPURPOSE BUILDING
GEOTECHNICAL INVESTIGATION
EXPLORATION LOCATIONS

PROJECT	5028.27083.01
DATE	11/15/2021

FIGURE 2

\\dowl.com\J\Projects\28\27083-01\31Geoscience\CAD\LakeHuronGeoFigures.dwg PLOT DATE 2021-12-20 13:58 SAVED DATE 2021-12-20 13:44 USER: drussell

APPENDIX H – PEAK RUNOFF CALCULATIONS

Peak Flow Calculations: 10-Year Northwest Basin

Rational Method - South Dakota Drainage Manual: Chapter 7: Hydrology

Design Year	10
Area (ft^2)	26720
Length (ft)	286
High Elevation (ft)	1321
Low Elevation (ft)	1311.67
Runoff Coefficient	0.672305
Type A %	100%
Type B %	0%
Type C %	0%
Type D %	0%
Sum of Soil Types	100%
Area (acres)	0.61
Length (mi)	0.054
Slope (ft/ft)	0.033
k value	0.491
Velocity (ft/sec)	2.927

Final T_c (min)	10.0
Final T_c (hr)	0.17
Intensity (in/hr)	5.178
Peak Flow (cfs)	2.14

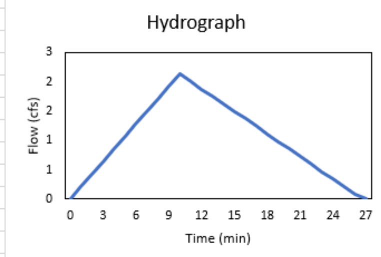
Intensity (in/hr)			Frequency			
Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-min	4.800	6.036	7.080	8.532	9.684	10.848
10-min	3.516	4.416	5.178	6.240	7.080	7.920
15-min	2.860	3.592	4.200	5.080	5.760	6.440
30-min	1.982	2.500	2.920	3.520	3.980	4.460
1-hr	1.240	1.570	1.860	2.260	2.580	2.900

$$V = 33kS^{0.5} \quad \text{(Equation 7.10)}$$

in which V is the velocity (fps) and S is the slope (ft/ft). The value of k is a function of the land cover, with values for selected land covers given in Figure 7.13-E.

k	Land Cover/Flow Regime
0.076	Forest with heavy ground litter; hay meadow (overland flow)
0.152	Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)
0.213	Short grass pasture (overland flow)
0.274	Cultivated straight row (overland flow)
0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
0.457	Grassed waterway (shallow concentrated flow)
0.491	Unpaved (shallow concentrated flow)
0.619	Paved area (shallow concentrated flow); small upland gullies

Figure 7.13-E — INTERCEPT COEFFICIENTS (k) FOR VELOCITY VS. SLOPE RELATIONSHIP OF EQUATION 7.10



Peak Flow Calculations: 100-Year Northwest Basin

Rational Method - South Dakota Drainage Manual: Chapter 7: Hydrology

Design Year	100
Area (ft^2)	26720
Length (ft)	286
High Elevation (ft)	1321
Low Elevation (ft)	1311.67
Runoff Coefficient	0.672305
Type A %	100%
Type B %	0%
Type C %	0%
Type D %	0%
Sum of Soil Types	100%
Area (acres)	0.61
Length (mi)	0.054
Slope (ft/ft)	0.033
k value	0.491
Velocity (ft/sec)	2.927

Final T_c (min)	10.0
Final T_c (hr)	0.17
Intensity (in/hr)	7.920
Peak Flow (cfs)	3.27

Intensity (in/hr)			Frequency			
Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-min	4.800	6.036	7.080	8.532	9.684	10.848
10-min	3.516	4.416	5.178	6.240	7.080	7.920
15-min	2.860	3.592	4.200	5.080	5.760	6.440
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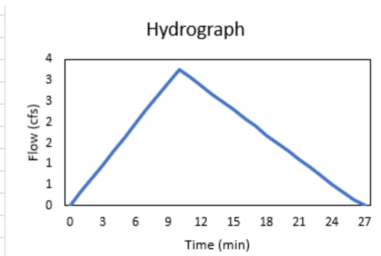
0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
0.457	Grassed waterway (shallow concentrated flow)
0.491	Unpaved (shallow concentrated flow)
0.619	Paved area (shallow concentrated flow); small upland gullies

Figure 7.13-E — INTERCEPT COEFFICIENTS (k) FOR VELOCITY VS. SLOPE RELATIONSHIP OF EQUATION 7.10



Peak Flow Calculations: 10-Year Northeast Basin

Rational Method - South Dakota Drainage Manual: Chapter 7: Hydrology

Design Year	10
Area (ft^2)	12467
Length (ft)	250
High Elevation (ft)	1322
Low Elevation (ft)	1311.63
Runoff Coefficient	0.719764
Type A %	100%
Type B %	0%
Type C %	0%
Type D %	0%
Sum of Soil Types	100%
Area (acres)	0.29
Length (mi)	0.047
Slope (ft/ft)	0.041
k value	0.491
Velocity (ft/sec)	3.300

Final T_c (min)	10.0
Final T_c (hr)	0.17
Intensity (in/hr)	5.178
Peak Flow (cfs)	1.07

Intensity (in/hr)		Frequency			
Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-min	4.800	6.036	7.080	8.532	9.684	10.848
10-min	3.516	4.416	5.178	6.240	7.080	7.920
15-min	2.860	3.592	4.200	5.080	5.760	6.440
30-min	1.982	2.500	2.920	3.520	3.980	4.460
1-hr	1.240	1.570	1.860	2.260	2.580	2.900

$$V = 33kS^{0.5} \quad \text{(Equation 7.10)}$$

in which V is the velocity (fps) and S is the slope (ft/ft). The value of k is a function of the land cover, with values for selected land covers given in Figure 7.13-E.

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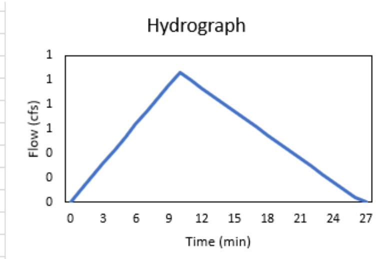
0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
0.457	Grassed waterway (shallow concentrated flow)
0.491	Unpaved (shallow concentrated flow)
0.619	Paved area (shallow concentrated flow); small upland gullies

Figure 7.13-E — INTERCEPT COEFFICIENTS (k) FOR VELOCITY VS. SLOPE RELATIONSHIP OF EQUATION 7.10



Peak Flow Calculations: 100-Year Northeast Basin

Rational Method - South Dakota Drainage Manual: Chapter 7: Hydrology

Design Year	100
Area (ft^2)	12467
Length (ft)	250
High Elevation (ft)	1322
Low Elevation (ft)	1311.63
Runoff Coefficient	0.719764
Type A %	100%
Type B %	0%
Type C %	0%
Type D %	0%
Sum of Soil Types	100%
Area (acres)	0.29
Length (mi)	0.047
Slope (ft/ft)	0.041
k value	0.491
Velocity (ft/sec)	3.300

Final T_c (min)	10.0
Final T_c (hr)	0.17
Intensity (in/hr)	7.920
Peak Flow (cfs)	1.63

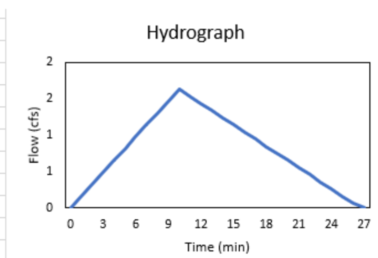
Intensity (in/hr)		Frequency			
Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-min	4.800	6.036	7.080	8.532	9.684	10.848
10-min	3.516	4.416	5.178	6.240	7.080	7.920
15-min	2.860	3.592	4.200	5.080	5.760	6.440
30-min	1.982	2.500	2.920	3.520	3.980	4.460
1-hr	1.240	1.570	1.860	2.260	2.580	2.900

$$V = 33kS^{0.5} \quad \text{(Equation 7.10)}$$

in which V is the velocity (fps) and S is the slope (ft/ft). The value of k is a function of the land cover, with values for selected land covers given in Figure 7.13-E.

k	Land Cover/Flow Regime
0.076	Forest with heavy ground litter; hay meadow (overland flow)
0.152	Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)
0.213	Short grass pasture (overland flow)
0.274	Cultivated straight row (overland flow)
0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
0.457	Grassed waterway (shallow concentrated flow)
0.491	Unpaved (shallow concentrated flow)
0.619	Paved area (shallow concentrated flow); small upland gullies

Figure 7.13-E — INTERCEPT COEFFICIENTS (k) FOR VELOCITY VS. SLOPE RELATIONSHIP OF EQUATION 7.10



Peak Flow Calculations: South Basin

Rational Method - South Dakota Drainage Manual: Chapter 7: Hydrology

Design Year	10
Area (ft^2)	31050
Length (ft)	115
High Elevation (ft)	1323.94
Low Elevation (ft)	1320.15
Runoff Coefficient	0.430841
Type A %	100%
Type B %	0%
Type C %	0%
Type D %	0%
Sum of Soil Types	100%
Area (acres)	0.71
Length (mi)	0.022
Slope (ft/ft)	0.033
k value	0.491
Velocity (ft/sec)	2.941
Final T_c (min)	10.0
Final T_c (hr)	0.17
Intensity (in/hr)	5.178
Peak Flow (cfs)	1.59

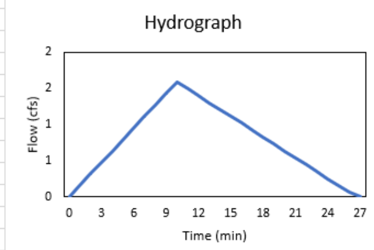
Intensity (in/hr)			Frequency			
Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-min	4.800	6.036	7.080	8.532	9.684	10.848
10-min	3.516	4.416	5.178	6.240	7.080	7.920
15-min	2.860	3.592	4.200	5.080	5.760	6.440
30-min	1.982	2.500	2.920	3.520	3.980	4.460
1-hr	1.240	1.570	1.860	2.260	2.580	2.900

$$V = 33kS^{0.5} \quad \text{(Equation 7.10)}$$

in which V is the velocity (fps) and S is the slope (ft/ft). The value of k is a function of the land cover, with values for selected land covers given in Figure 7.13-E.

k	Land Cover/Flow Regime
0.076	Forest with heavy ground litter; hay meadow (overland flow)
0.152	Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)
0.213	Short grass pasture (overland flow)
0.274	Cultivated straight row (overland flow)
0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
0.457	Grassed waterway (shallow concentrated flow)
0.491	Unpaved (shallow concentrated flow)
0.619	Paved area (shallow concentrated flow); small upland gullies

Figure 7.13-E — INTERCEPT COEFFICIENTS (k) FOR VELOCITY VS. SLOPE RELATIONSHIP OF EQUATION 7.10



Peak Flow Calculations: 100-Year Sub-Basin Watershed

Rational Method - South Dakota Drainage Manual: Chapter 7: Hydrology

Design Year	100
Area (ft^2)	31050
Length (ft)	115
High Elevation (ft)	1323.94
Low Elevation (ft)	1320.15
Runoff Coefficient	0.430841
Type A %	100%
Type B %	0%
Type C %	0%
Type D %	0%
Sum of Soil Types	100%
Area (acres)	0.71
Length (mi)	0.022
Slope (ft/ft)	0.033
k value	0.491
Velocity (ft/sec)	2.941
Final T_c (min)	10.0
Final T_c (hr)	0.17
Intensity (in/hr)	7.920
Peak Flow (cfs)	2.43

Intensity (in/hr)			Frequency			
Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-min	4.800	6.036	7.080	8.532	9.684	10.848
10-min	3.516	4.416	5.178	6.240	7.080	7.920
15-min	2.860	3.592	4.200	5.080	5.760	6.440
30-min	1.982	2.500	2.920	3.520	3.980	4.460
1-hr	1.240	1.570	1.860	2.260	2.580	2.900

$$V = 33kS^{0.5} \quad \text{(Equation 7.10)}$$

in which V is the velocity (fps) and S is the slope (ft/ft). The value of k is a function of the land cover, with values for selected land covers given in Figure 7.13-E.

k	Land Cover/Flow Regime
0.076	Forest with heavy ground litter; hay meadow (overland flow)
0.152	Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)
0.213	Short grass pasture (overland flow)
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0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
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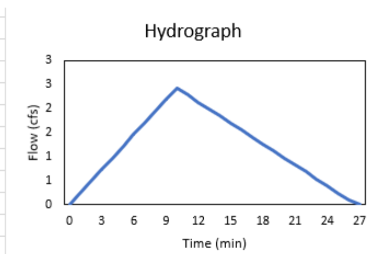
0.619	Paved area (shallow concentrated flow); small upland gullies

Figure 7.13-E — INTERCEPT COEFFICIENTS (k) FOR VELOCITY VS. SLOPE RELATIONSHIP OF EQUATION 7.10



APPENDIX I – RETENTION BASIN CALCULATIONS

RETENTION BASIN CALCULATIONS

Vs = 0.5*Ti*(Qi-Qo) — Equation 13.7 of the SDDM

Where:
Vs = Storage Volume Required (ft^3)
Qi = peak inflow rate (cfs)
Qo = peak outflow rate (cfs) - assumed zero
Ti = duration of basin inflow (seconds)

	Qi	Ti	Vs	Vs	Depth
Storm Event	*(cfs)*	*(seconds)*	*(ft^3)*	*(ac-ft)*	*(ft)*
10yr	6.34	600	1900.561	0.0436	0.125
100yr	9.69	600	2907	0.0667	0.195