CCR Rule Operating Criteria | §257.81
Run-on and Run-off Control for CCR Landfills
Final

Coal Combustion Residual Landfill
Hunter Power Plant
Castle Dale, Utah

September 27, 2024

PREPARED FOR

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PROFESSIONAL ENGINEER CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Utah, that the information in this document was assembled under my direct supervisory control. This report is not intended or represented to be suitable for reuse by PacifiCorp or others without specific verification or adaptation by the Engineer.

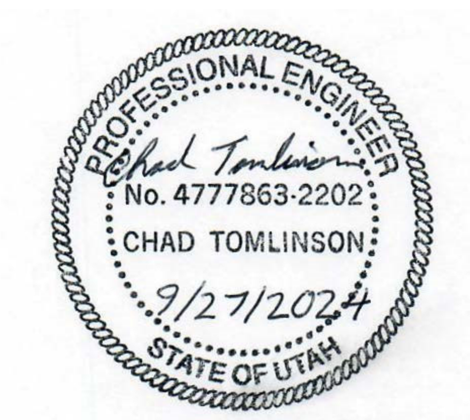
I hereby certify, as a Professional Engineer in the State of Utah that this report has been prepared in accordance with and meets the requirements of 40 Code of Federal Regulations §257.81.

Chad Tomlinson

9/27/2024

Chad Tomlinson, P.E.

Date



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1. INTRODUCTION

The Hunter Power Plant (the Plant) is located approximately 2.5 miles south of Castle Dale, Utah. The site vicinity is shown on **Figure 1**.

This Run-On and Run-Off Control System Plan is an amendment to the Run-On and Run-Off Control System Plan dated October 7, 2021 [6] to provide calculations to confirm that the sizing of the run-off control ditches and stormwater basin presented in the Hunter Plant CCR Landfill Draft Basis of Design Memorandum and CCR Landfill Design Documents prepared by URS dated November 2015 and December 2015, respectively [2,3], and the initial Run-On and Run-Off Control System Plan prepared by URS in September 2016 [4] are adequate to convey and contain run-off from the landfill during the design storm event.

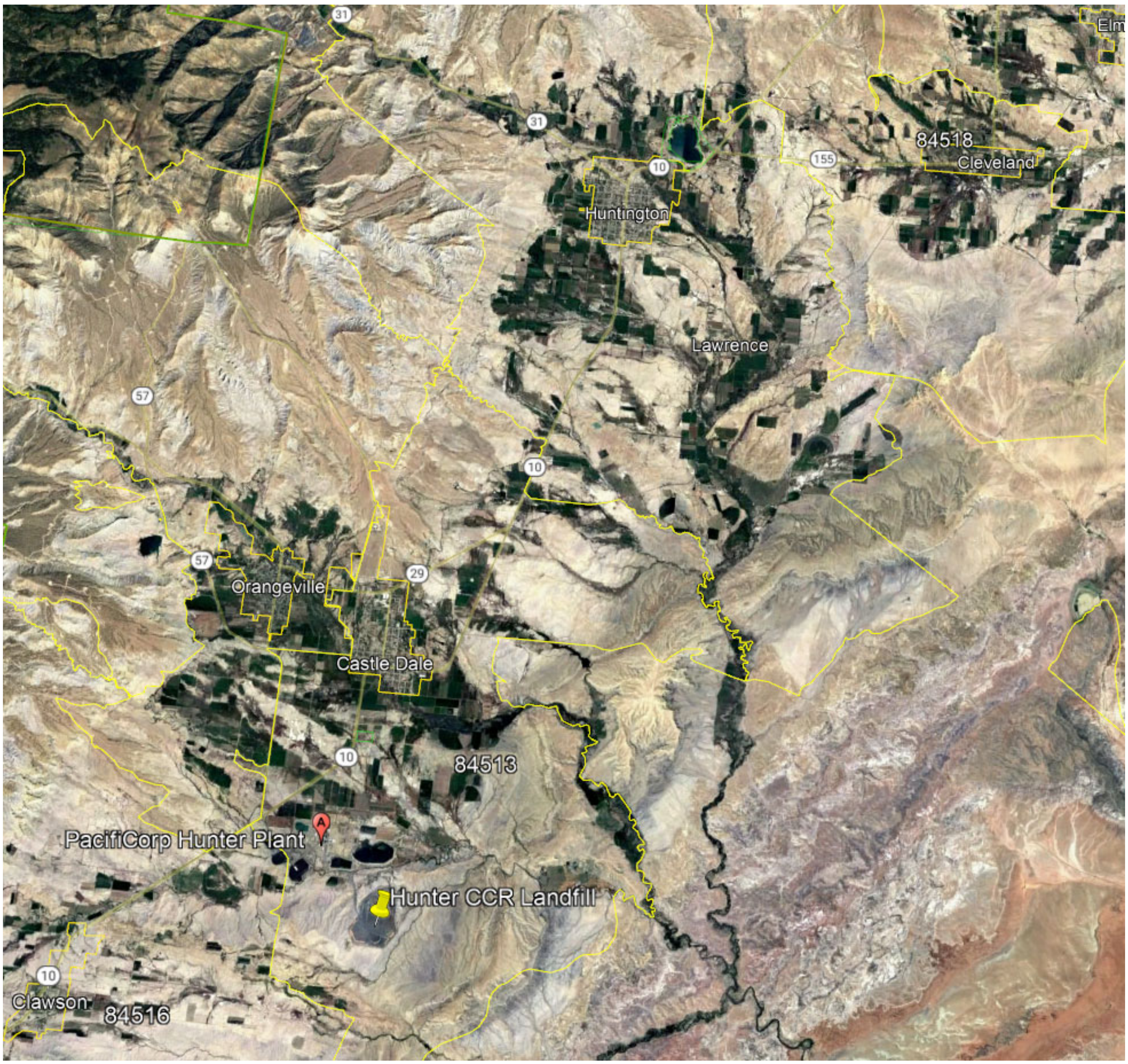

Figure 1. Hunter Power Plant Vicinity Map

2. EXISTING CONDITIONS

The PacifiCorp Hunter Power Plant is a coal-fueled steam-electric operation with three operating units having a total generating capacity of 1,577.2 MW. The CCR Landfill is located approximately 1.4 miles southeast of the plant. The majority of the CCR Landfill is used for disposal of dry bottom ash, fly ash, and flue gas desulfurization (FGD) material with a smaller portion permitted as a Class IIIb Industrial Waste Landfill (see **Figure 2**).

The CCR Landfill occupies approximately 340 acres and includes existing access roads, perimeter ditch and the zero-discharge stormwater retention basin (104 acre-ft capacity). Based on a review of design documents, the total capacity of the CCR Landfill is 44.5 million cubic yards (MCY).

Based on the annual inspections of the CCR Landfill completed in 2021, 2022, 2023, and 2024, conducted in accordance with the requirements of §257.84(b), Tetra Tech did not find any changes in the operation and construction of the CCR Landfill that deviated from the designs discussed in this assessment. Tetra Tech confirmed that all the stormwater control features installed for the operation of the landfill, including the run-off perimeter channel and Stormwater Basin and run-on berm, were being maintained in a manner to conserve their design capacity.

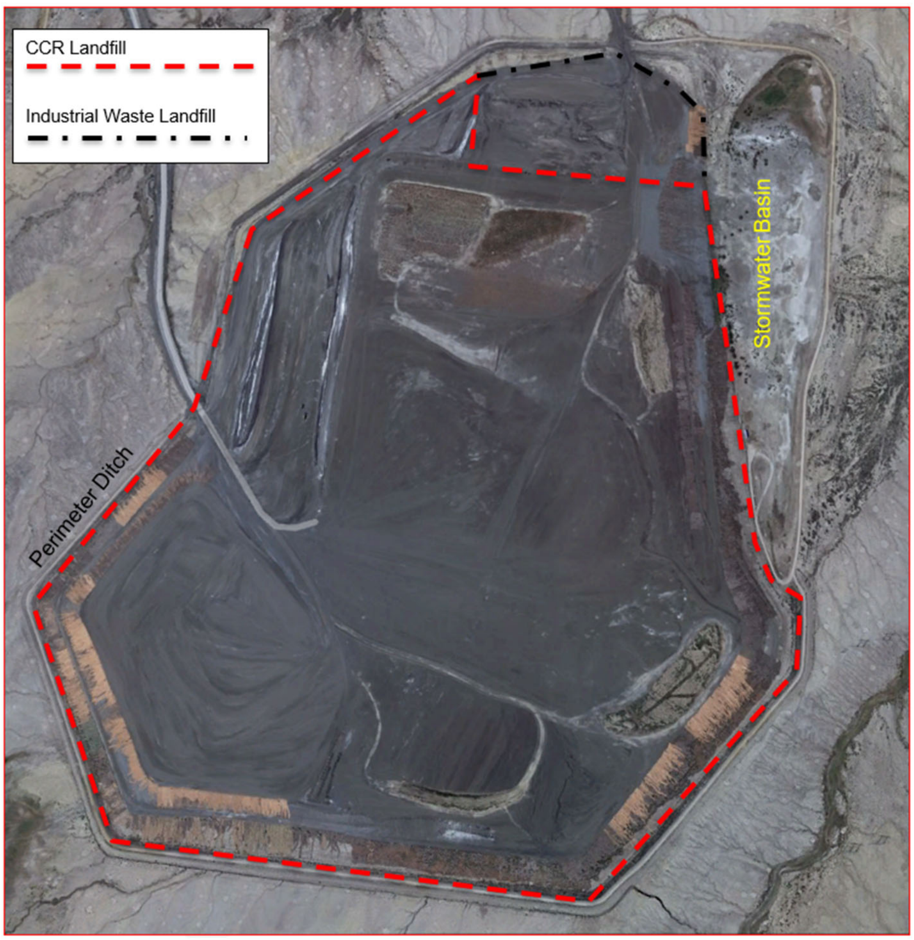

Figure 2. Hunter Power Plant CCR Landfill Layout

3. RUN-ON / RUN-OFF PLAN

3.1 CCR Rule Requirements

Rule §257.81 [1] requires CCR regulated landfills to adequately collect and manage run-off from a 24-hour, 25-year storm, and maintain a run-on control system to prevent upland run-off from entering a landfill. Run-on, as defined by the EPA, includes any rainwater, leachate, or other liquid that drains over land onto any part of a CCR landfill. Run-off, as defined by the EPA, includes any rainwater, leachate, or other liquid that drains over land from any part of a CCR landfill. The rule also requires that the run-on and run-off systems be supported by adequate design documentation and calculations certified by a registered professional engineer.

3.2 Run-Off Control System

The design of the CCR Landfill was developed to control the direction and velocity of run-off to prevent erosion. During operation of the landfill this is achieved by sloping the CCR Landfill surface to maintain a positive slope toward the edges and collecting the water in perimeter channels located at the toe of the slopes. The perimeter drainage channels ultimately discharge to the stormwater basin. Refer to **Figure 3** for a layout of the Landfill and run-off control features.

As part of the closure of the CCR Landfill, which has not yet initiated, each area will be sloped to prevent ponding of stormwater (to minimize infiltration into the CCR Landfill), and the positive slopes for each watershed drain to channels installed on two 20-foot wide benches, one at elevation 5700 ft above mean sea level (amsl) and one at 5750 ft amsl, to collect side slope drainage. The benches will be sloped inwards towards the Landfill. The run-off from the benches and from upstream slopes will be collected in rock lined ditches and routed to the downdrains. The downdrains consist of rock-lined chutes to dissipate energy, underlain by a geotextile liner and a permeable bedding layer to prevent erosion of the underlying cover and CCR materials.

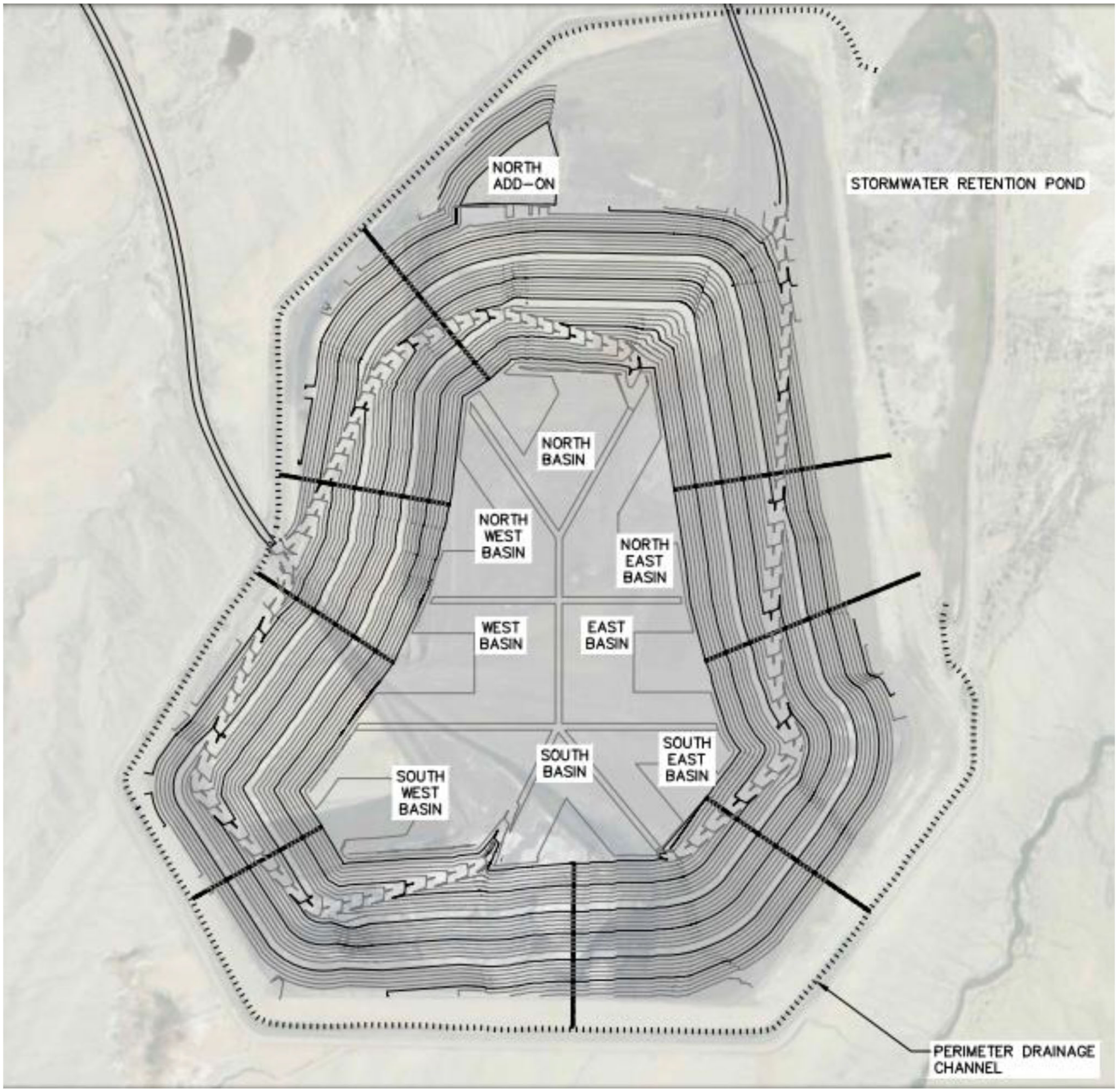

Figure 3. Watershed Delineations of the CCR Landfill at Closure

Each downdrain includes stilling basins at the benches and at the connections to the perimeter drainage channel. The rock-lined stilling basins were designed to create a hydraulic jump to dissipate energy from the water. **Figure 4** shows a detail of the chute and stilling basin design based on the guidance in Design of Rock Chutes [5]. At the time of the August 22, 2024 inspection, Tetra Tech did not observe that the benches, side slope channels or downdrains had been constructed. However, it was confirmed that these features would be constructed as part of the final closure of the various areas of the CCR Landfill. Tetra Tech did confirm that all surface water run-off from the landfill was being effectively collected in the perimeter ditches.

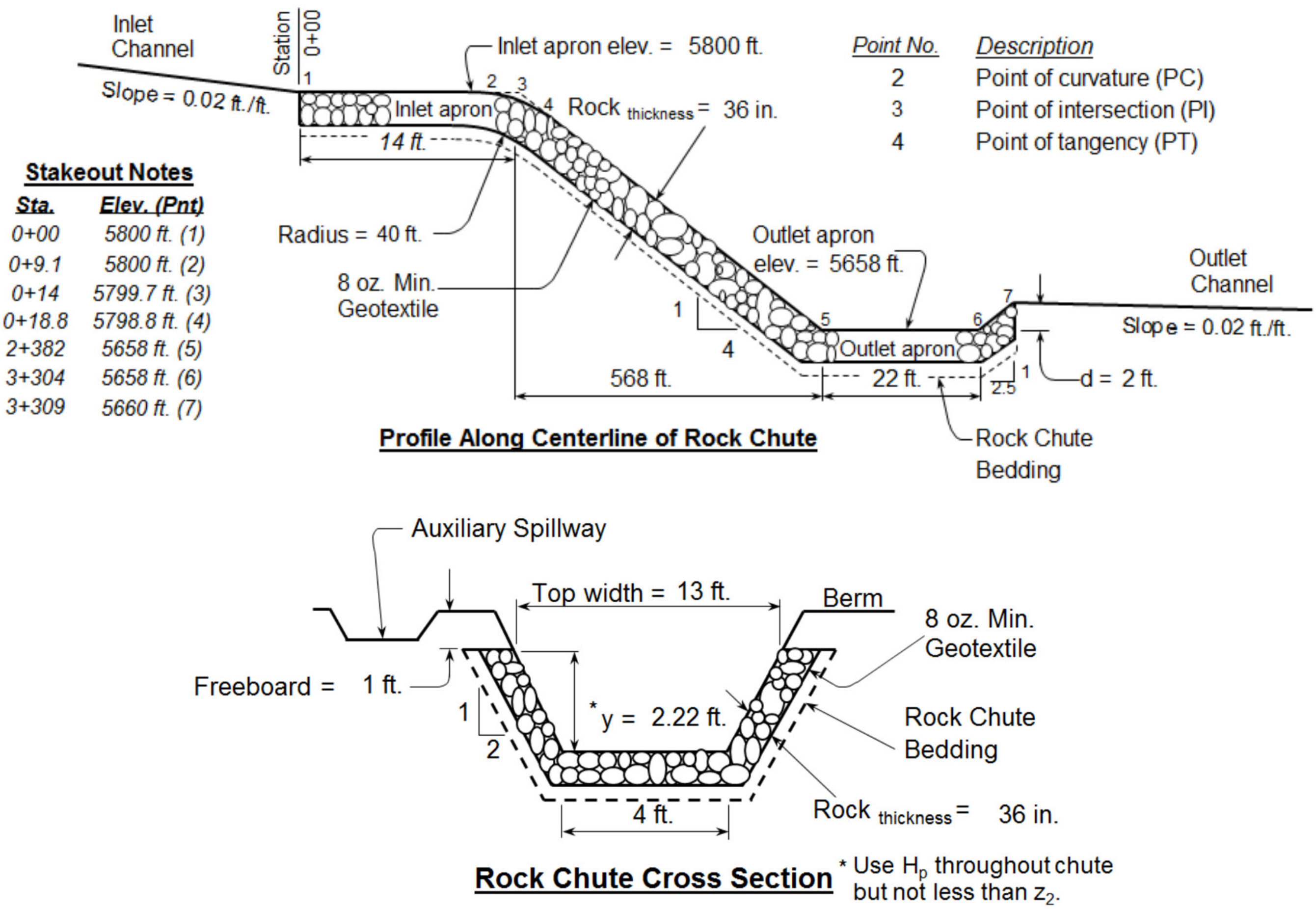

Figure 4. Typical Chute and Stilling Basin from Design of Rock Chutes

Culverts have been installed where downdrains cross haul roads. Culverts and channels were designed to convey water at low velocity and have an impermeable liner. Culverts and channels will include rock material to dissipate energy and prevent erosion or transport of materials as detailed in the Design Documents [3].

3.4 Run-On Control System

Due to the location of the CCR Landfill and the surrounding topography of the area, adjacent off-site areas primarily drain away from the site. The perimeter ditch system described above has been constructed with a berm on the west side to prevent surface water from running on to the CCR Landfill. On the southern side of the landfill, a ditch has been constructed to intercept run-on and graded to covey run-on away from the site.

3.5 Design Storm

The 25-year, 24-hour design storm rainfall depth is required to meet the CCR rule requirements. All temporary diversion ditches and berms have been designed for this storm event. The downdrains, stilling basins, culverts, roadways, and benches were also designed for this storm event. The permanent perimeter drainage channel and stormwater retention pond have been designed based on a 100-year, 24-hour storm which exceeds CCR rule requirements. The storm events were modeled with a SCS Type II distribution hyetograph. The design rainfall depth was determined from the latest National Weather Service Rainfall Atlas for Utah (Atlas 14, Volume I) [4]. The 25-year, 24-hour rainfall depth for the Hunter Plant vicinity was determined to be 1.82 inches. The existing stormwater retention basin and perimeter drainage channels were constructed to accommodate a 100-year, 24-hour rainfall depth which for the Hunter Plant vicinity was determined to be 2.23 inches. Based on Tetra Tech's review of the 100-year 24-hour and 25-year 24-hour storm event for the site, the actual rainfall depth is reported as 2.24 and 1.83 inches Refer to Appendix A for tabulated National Weather Service rainfall depth and intensity tables.

4. HYDROLOGIC AND HYDRAULIC ANALYSIS

The Hydrologic and Hydraulic modeling was performed by URS [3] and has been reviewed by Tetra Tech. The Soil Conservation Service (SCS) Technical Release 55 (TR-55) method was selected to model hydrology and time of concentration. Run-off losses were modeled using the SCS Runoff Curve Number (CN) Method. For concentration times, TR-55 methodology was used to calculate sheet and shallow flows, and Manning's Equation was used to calculate channelized flow.

The final cover material for the CCR Landfill will consist of 24 inches of compacted native soils overlaid by six inches of native topsoil and revegetated with a combination of native grasses [6]. A CN of 88 was selected to represent the surface of the CCR Landfill. Although information pertaining to the cover material was not available, a curve number of 88, which corresponds to a natural desert landscape based on a hydrologic soil group D is appropriate.

The permanent drainage ditches of the CCR Landfill and the stormwater retention pond were sized for the 100-year, 24-hour storm, and the stormwater retention pond was designed to adequately store 120% of the run-off from that storm. The additional 20% capacity accounts for sediment which may enter the stormwater retention pond with the run-off. This exceeds the requirements of the CCR rule.

Updated topographical data was not available at the time of this analysis. However, based on a 2022 Google Earth image, the perimeter of the landfill including the limits of the stormwater basin is approximately 340 acres (refer to **Figure 5)**.

Tetra Tech performed calculations to confirm that the stormwater run-off conveyance and retention systems currently installed to support operation of the landfill has been sized appropriately to manage the 25-yr 24-hr storm event. Refer to Appendix B for calculations. The adequacy of the run-on system consisting of a perimeter berm and ditch were not evaluated given lack of available topographic data from areas where run-on would be generated. However, where run-on is possible is from very flat topography and the existing run-on systems are observed to be more than adequate to prevent run-on from off-site areas.

4.1.1 Perimeter Drainage Channel Design

The perimeter drainage channel currently collects run-off from the graded slopes and top of the landfill and conveys it to the Stormwater Basin. A high point exists in the southwest corner of the Landfill and a northwest and southeast channel segment drain from the high point around the CCR Landfill to the stormwater retention pond. The calculated 100-year, 24-hour peak flow is 175.36 cubic feet per second (cfs) for the northwest segment and 80.72 cfs for the southeast segment. Previous investigations by URS [3] indicated sections of the channel have been silted in and did not provide the necessary flood carrying capacity. A 2 ft minimum channel depth and 4-foot minimum bottom width with 3:1 side slopes were determined to be required to carry the peak flows without overtopping. A site inspection performed by Tetra Tech documented that channel segments are currently free of sediment and meet these geometric requirements to contain the peak flows.

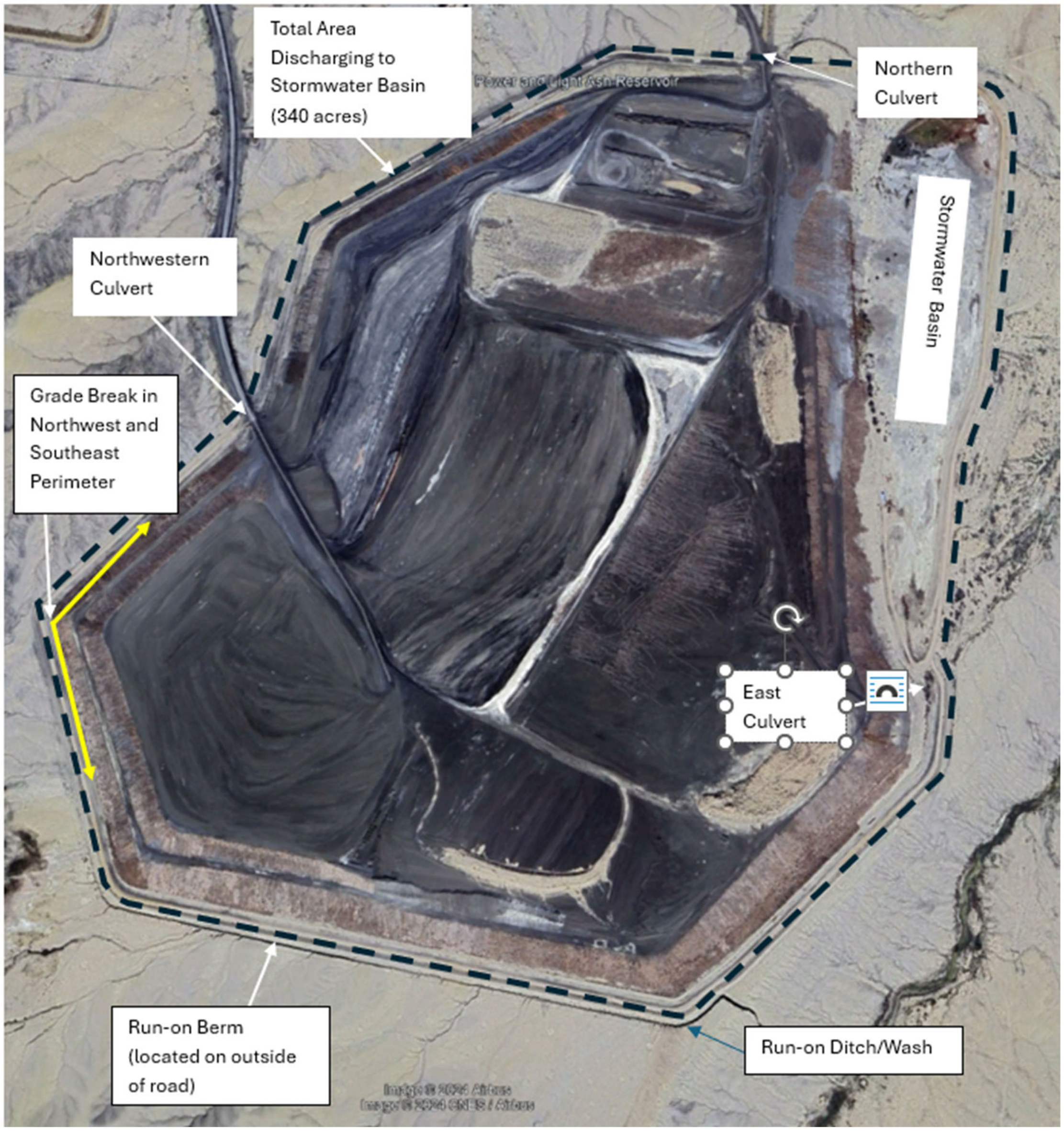

Figure 5. 2022 Google Earth Image of Landfill

Tetra Tech evaluated the run-off discharging to the perimeter drainage channels using the rational method. Given that updated topography was not available at the time of the analysis, Tetra Tech relied on a 2022 Google Earth image to estimate the drainage basin areas discharging to the northwest and southeast perimeter channel segments. Both northwest and southeast drainage channel segments have approximate dimensions of 4-foot bottom width, 2-foot depth, and 3:1 side slopes (refer to **Figures 6 and 7**). Based on the Google image it does not appear that the majority of the landfill is graded to promote flow in a particular direction; however, for the purpose of this analysis it was assumed that currently 50% of the entire landfill area, approximated to be 340 acres would discharge to one of the two drainage channels. However, upwards of 50 acres of the east portion of the landfill likely discharge directly to the stormwater basin via overland sheet flow. A time of concentration of 30 min was estimated based on average sheet flow distances and slopes resulting in corresponding rainfall intensity of 1.58 inches/hour. Using a calculated weighted runoff coefficient of 0.27, to account for flat and steep areas, a peak discharge of 73 cubic feet per second (cfs) was calculated. Using the FlowMaster® Software, based on a flow rate of 73 cfs and assuming an average channel slope of 1.5%, the channels would have a normal flow depth of 15.3-inches, which provides for approximately 8.7-inches of freeboard in each channel segment.

Figure 6. 2024 Photograph of Northwest Segment of Run-Off Drainage Channel at High Point

Figure 7. 2024 Photograph of Southeast Segment of Run-Off Drainage Channel at High Point

4.1.2 Road Culverts

The northwest perimeter drainage channel is culverted under two haul roads Northwestern and North Culverts as shown in **Figure 5**. The culverts were designed to convey the 100-year, 24-hour peak flow within the channel. The western culvert was designed for a smaller tributary area and is designed for 55 cfs. The northern culvert has a larger tributary area and is designed for 175 cfs. Modeling by URS [3] indicated that both culverts overtopped when subject to the 100-year, 24-hour peak flows. Ponded water at the northern culvert inlet flows off site and, therefore, was directed to be upgraded to a 4-foot diameter culvert. Tetra Tech's site inspections confirmed that this upgrade is complete.

Based on culvert flow calculations completed by Tetra Tech and assuming a conservative peak flow of 85 cfs, the existing culverts are recommended to be replaced with two 36-inch diameter culverts. It should be noted that based on previous annual inspections of the landfill and discussions with site personnel that the capacity of the existing culverts has never been exceeded suggesting that the discharge rates through the perimeter ditch are likely significantly less than calculated.

4.1.3 Bench Drainage Ditch Design

The bench drainage ditches were designed to convey runoff collected on two benches constructed around the Landfill at elevations 5700 ft and 5750 ft to the nearest downdrain. The flow capacity of the bench drainage ditch is 1.76 cfs. The flow capacity of the bench drainage ditch, including the capacity of the inward sloping bench, is

35.60 cfs. The greatest bench drainage ditch 25-year, 24-hour peak flow was calculated to be 11.23 cfs and the 100-year, 24-hour peak flow was calculated to be 15.57 cfs. Runoff from both storm events can be contained on the benches. During Tetra Tech's August 22, 2024 inspection, the bench drainage ditches had not been constructed as the CCR Landfill is still in operation. These bench drainage ditches will be installed as part of the final closure of the CCR Landfill.

4.1.4 Downdrains and Stilling Basin Designs

The downdrains, once installed as part of the final closure, will convey runoff from the top of the CCR Landfill and the bench drainage ditches down the CCR Landfill sideslopes and into the perimeter drainage channels. Stilling basins will be installed and will serve as energy dissipators and will be constructed where the downdrains cross the benches and terminate in the perimeter drainage channel. Several downdrains are culverted under the Landfill haul roads.

4.1.5 Stormwater Retention Pond Design

The stormwater retention pond was designed and constructed to retain all surface water run-off throughout development of the CCR Landfill. The stormwater retention pond was sized to contain run-off from the 100-yr 24-hr storm event and has a total capacity of 104 acre-ft. It also includes an overflow system to prevent overtopping during extreme events. During Tetra Tech's inspection, plant personnel indicated that they have never observed ponded water throughout the entire extent of the stormwater retention basin. Tetra Tech also observed that there was negligeable deposition of sediment in the stormwater retention pond suggesting that the original design capacity has been preserved.

Based on the delineated area of the landfill, stormwater basin and perimeter road of approximately 330 acres and assuming 100-percent of the 25-yr 24-hr design storm event of 1.83 inches reports to the stormwater basin, the required volume of the stormwater basin would be approximately 52 acre-ft. Based on the designed stormwater basin volume of 104 acre-ft, the design storm event would consume approximately half of the available storage volume. Note the estimated total drainage area of 340 acres is significantly greater than the total drainage area presented in the 2016 Stormwater Run-On and Run-Off Plan [5] of 224 acres.

4.2 Stormwater Best Management Practices

Per the CCR Rule, under Section 257.81(b), storm water best management practices (BMPs) shall be employed at the site to comply with CFR 257.3-3, which stipulates that a facility shall not cause a discharge of pollutants, dredged material, or fill material to waters of the United States or cause non-point source pollution of waters of the United States. The collection of all storm water on the active portion of the CCR Landfill, as discussed earlier in this section, is performed with drainage channels and a single stormwater retention pond.

4.3 Compliance Summary

The run-on and run-off control system plan described above meets the requirements of §257.81.

5. SOURCE(S)

[1] Environmental Protection Agency (EPA) 40 CFS § 257 Disposal of Coal Combustion Residuals from Electric Utilities. Dated April 17, 2015. 201 pp.

[2] URS, 2015. Hunter Power Plant CCR Landfill Draft Basis of Design Memorandum. November 2015

[3] URS, 2015. Hunter Plant PacifiCorp CCR Landfill Design Documents. December 2015.

[4] URS, 2016. Run-On and Run-Off Control System Plan Hunter Power Plant. Coal Combustion Residual Landfill. September 2016.

[5] Design of Rock Chutes, 1998. Robinson, Rice, Kadavy, ASAE.

[6] CCR Landfill Closure Plan Hunter Power Plant. Coal Combustion Residual Landfill. Revision 3. January 2017

6. REVISIONS

Revision Number	Date	Revision Made	By Whom
B	9/14/2021	Draft Issued to PacifiCorp	Chad Tomlinson
0	10/7/2021	Final Issued to PacifiCorp (revised per comments received)	Chad Tomlinson
1	9/27/2024	Updated plan to include calculations to confirm sizing of stormwater basin and perimeter ditch.	Chad Tomlinson

APPENDIX A: NOAA Atlas 14, Volume 1, Version 5 | Point Precipitation Frequency Estimates for Hunter Plant CCR Landfill

NOAA Atlas 14, Volume 1, Version 5
Location name: Ferron, Utah, USA*
Latitude: 39.1567°, Longitude: -111.0121°
Elevation: 5681 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.104** (0.090-0.124)	**0.134** (0.116-0.159)	**0.187** (0.161-0.221)	**0.234** (0.199-0.278)	**0.310** (0.256-0.368)	**0.378** (0.306-0.451)	**0.458** (0.362-0.548)	**0.550** (0.422-0.663)	**0.696** (0.509-0.854)	**0.826** (0.584-1.03)
10-min	**0.159** (0.136-0.188)	**0.204** (0.176-0.242)	**0.285** (0.244-0.336)	**0.357** (0.303-0.424)	**0.472** (0.390-0.560)	**0.575** (0.465-0.686)	**0.697** (0.551-0.834)	**0.837** (0.642-1.01)	**1.06** (0.775-1.30)	**1.26** (0.889-1.56)
15-min	**0.197** (0.169-0.233)	**0.253** (0.218-0.300)	**0.353** (0.303-0.416)	**0.442** (0.376-0.525)	**0.585** (0.484-0.695)	**0.713** (0.577-0.851)	**0.864** (0.683-1.03)	**1.04** (0.796-1.25)	**1.31** (0.961-1.61)	**1.56** (1.10-1.94)
30-min	**0.265** (0.228-0.314)	**0.340** (0.294-0.404)	**0.475** (0.408-0.561)	**0.595** (0.507-0.707)	**0.788** (0.651-0.936)	**0.961** (0.776-1.14)	**1.16** (0.919-1.39)	**1.40** (1.07-1.68)	**1.77** (1.29-2.17)	**2.10** (1.48-2.61)
60-min	**0.328** (0.282-0.389)	**0.421** (0.364-0.500)	**0.588** (0.505-0.694)	**0.737** (0.627-0.875)	**0.975** (0.806-1.16)	**1.19** (0.961-1.42)	**1.44** (1.14-1.72)	**1.73** (1.33-2.09)	**2.19** (1.60-2.68)	**2.60** (1.84-3.23)
2-hr	**0.393** (0.343-0.457)	**0.496** (0.431-0.578)	**0.669** (0.582-0.778)	**0.828** (0.712-0.961)	**1.08** (0.909-1.26)	**1.31** (1.08-1.54)	**1.58** (1.26-1.86)	**1.89** (1.47-2.25)	**2.39** (1.78-2.90)	**2.84** (2.04-3.51)
3-hr	**0.438** (0.390-0.504)	**0.551** (0.489-0.637)	**0.722** (0.641-0.832)	**0.876** (0.768-1.01)	**1.12** (0.965-1.29)	**1.33** (1.12-1.54)	**1.59** (1.32-1.88)	**1.90** (1.53-2.27)	**2.40** (1.86-2.93)	**2.85** (2.14-3.55)
6-hr	**0.550** (0.494-0.621)	**0.685** (0.617-0.774)	**0.866** (0.777-0.977)	**1.02** (0.910-1.15)	**1.24** (1.09-1.41)	**1.44** (1.25-1.64)	**1.68** (1.43-1.93)	**1.96** (1.64-2.28)	**2.46** (2.00-2.96)	**2.91** (2.31-3.58)
12-hr	**0.665** (0.605-0.735)	**0.823** (0.750-0.913)	**1.02** (0.921-1.13)	**1.18** (1.06-1.31)	**1.40** (1.26-1.56)	**1.58** (1.40-1.76)	**1.77** (1.55-1.99)	**2.01** (1.73-2.31)	**2.49** (2.08-2.99)	**2.94** (2.39-3.62)
24-hr	**0.901** (0.815-0.997)	**1.12** (1.01-1.24)	**1.36** (1.23-1.51)	**1.56** (1.41-1.73)	**1.83** (1.64-2.03)	**2.03** (1.81-2.26)	**2.24** (1.98-2.49)	**2.45** (2.15-2.74)	**2.72** (2.36-3.06)	**2.96** (2.52-3.65)
2-day	**1.01** (0.923-1.12)	**1.25** (1.14-1.38)	**1.52** (1.39-1.68)	**1.74** (1.58-1.92)	**2.04** (1.83-2.24)	**2.26** (2.02-2.49)	**2.49** (2.22-2.76)	**2.72** (2.40-3.03)	**3.03** (2.63-3.40)	**3.26** (2.81-3.69)
3-day	**1.08** (0.988-1.20)	**1.34** (1.22-1.48)	**1.63** (1.48-1.80)	**1.87** (1.69-2.06)	**2.18** (1.96-2.40)	**2.42** (2.17-2.67)	**2.67** (2.37-2.96)	**2.92** (2.57-3.25)	**3.25** (2.81-3.65)	**3.51** (3.00-3.96)
4-day	**1.16** (1.05-1.28)	**1.43** (1.30-1.58)	**1.74** (1.58-1.92)	**1.99** (1.80-2.19)	**2.33** (2.09-2.56)	**2.59** (2.31-2.85)	**2.85** (2.53-3.16)	**3.12** (2.73-3.47)	**3.48** (3.00-3.89)	**3.75** (3.20-4.23)
7-day	**1.29** (1.18-1.42)	**1.60** (1.46-1.76)	**1.95** (1.77-2.13)	**2.23** (2.02-2.43)	**2.59** (2.34-2.83)	**2.87** (2.58-3.14)	**3.16** (2.82-3.46)	**3.43** (3.04-3.79)	**3.80** (3.32-4.24)	**4.08** (3.52-4.59)
10-day	**1.43** (1.31-1.56)	**1.77** (1.62-1.94)	**2.16** (1.98-2.35)	**2.47** (2.25-2.68)	**2.87** (2.60-3.11)	**3.16** (2.85-3.45)	**3.46** (3.10-3.78)	**3.75** (3.33-4.12)	**4.13** (3.62-4.57)	**4.40** (3.83-4.92)
20-day	**1.73** (1.58-1.90)	**2.15** (1.96-2.36)	**2.65** (2.41-2.89)	**3.03** (2.76-3.31)	**3.52** (3.19-3.84)	**3.90** (3.50-4.26)	**4.27** (3.81-4.68)	**4.63** (4.11-5.09)	**5.11** (4.47-5.66)	**5.46** (4.74-6.09)
30-day	**2.05** (1.86-2.25)	**2.54** (2.32-2.78)	**3.08** (2.82-3.37)	**3.50** (3.19-3.81)	**4.03** (3.66-4.39)	**4.42** (3.99-4.81)	**4.79** (4.31-5.24)	**5.16** (4.59-5.66)	**5.61** (4.95-6.20)	**5.94** (5.19-6.61)
45-day	**2.40** (2.20-2.62)	**2.97** (2.72-3.25)	**3.60** (3.31-3.93)	**4.08** (3.74-4.44)	**4.69** (4.28-5.09)	**5.12** (4.66-5.56)	**5.53** (5.00-6.01)	**5.93** (5.34-6.47)	**6.40** (5.72-7.04)	**6.72** (5.98-7.44)
60-day	**2.72** (2.49-2.98)	**3.37** (3.09-3.69)	**4.10** (3.75-4.48)	**4.64** (4.24-5.06)	**5.34** (4.86-5.81)	**5.84** (5.30-6.36)	**6.32** (5.70-6.91)	**6.77** (6.06-7.44)	**7.32** (6.50-8.09)	**7.70** (6.78-8.56)

[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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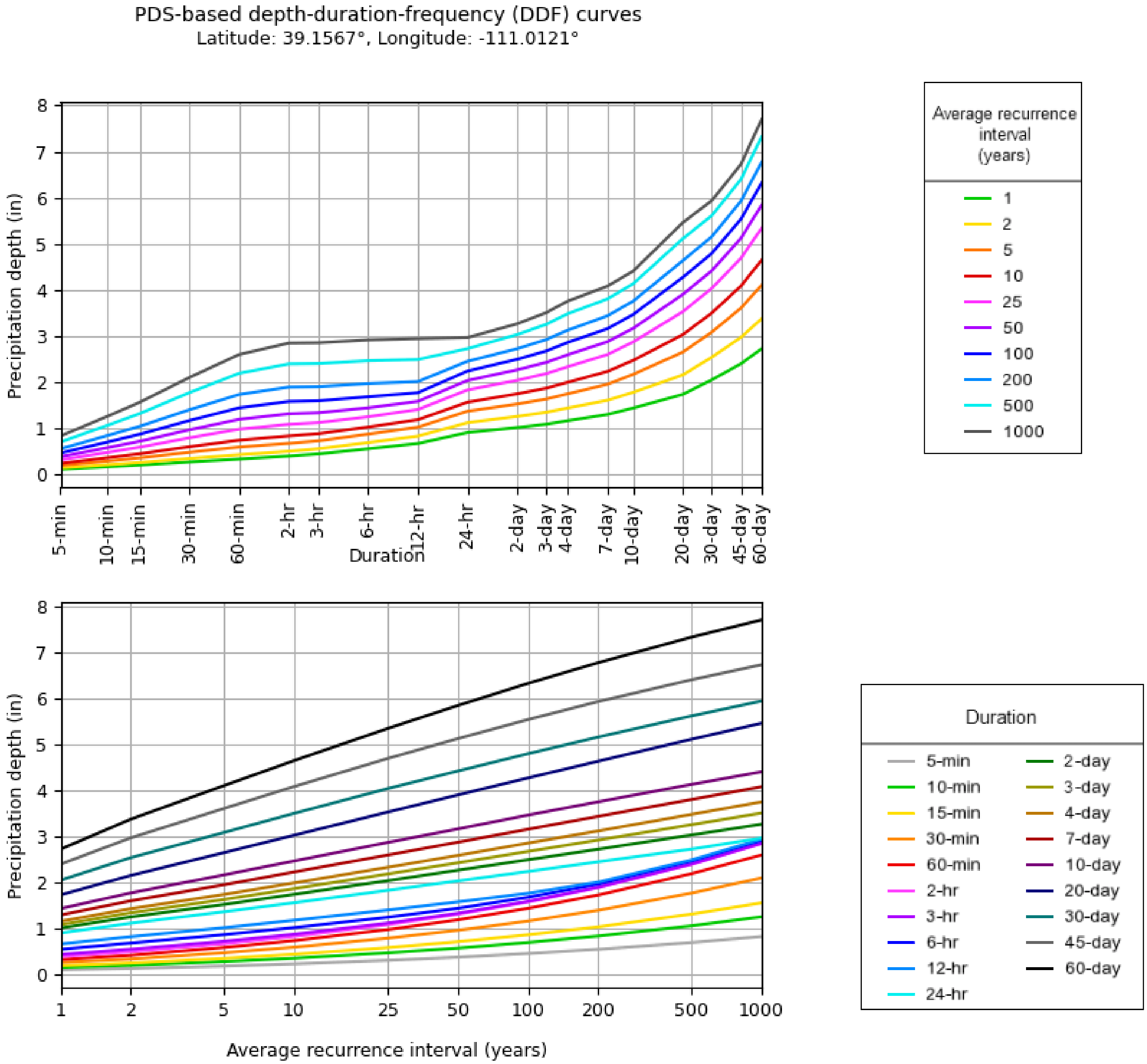
PF graphical



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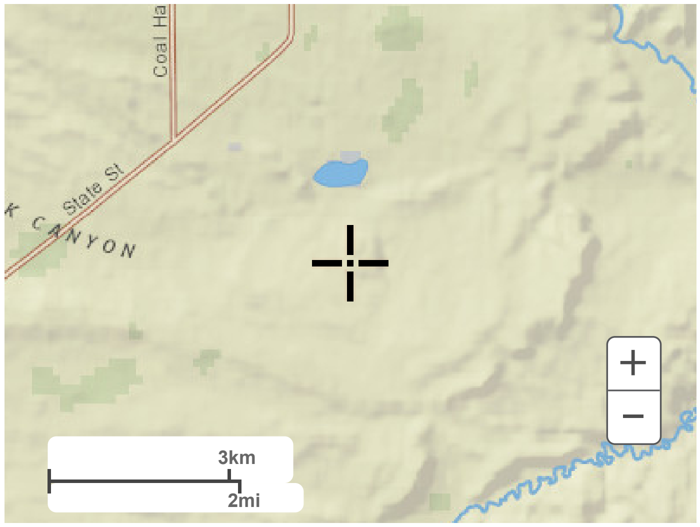
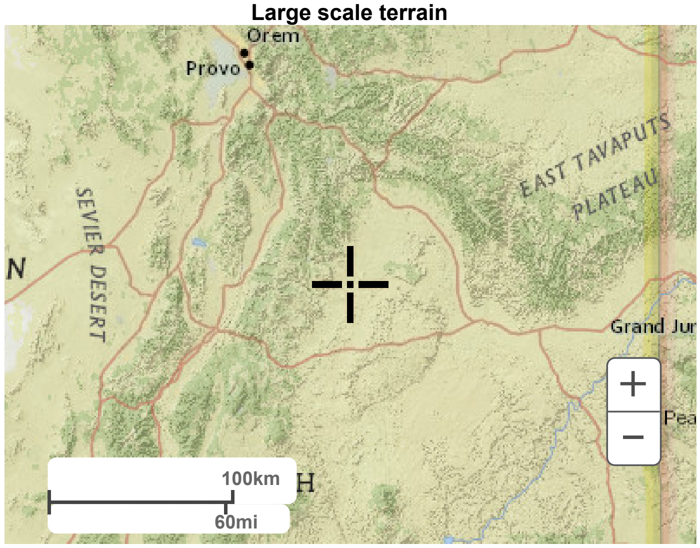
Maps & aerials

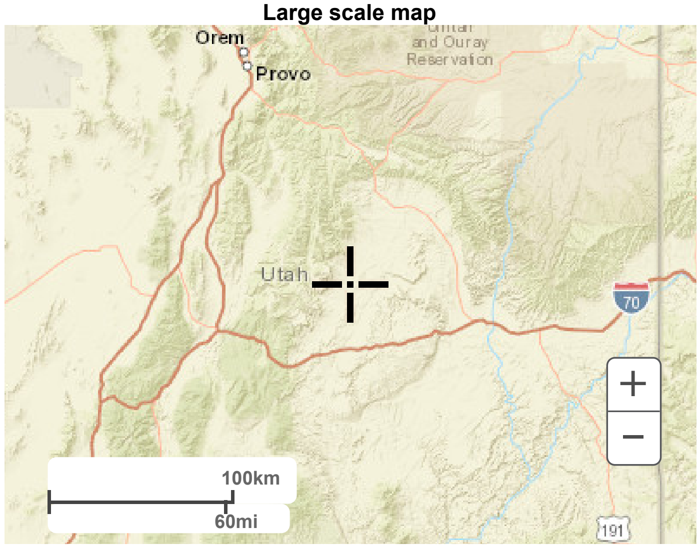
Small scale terrain



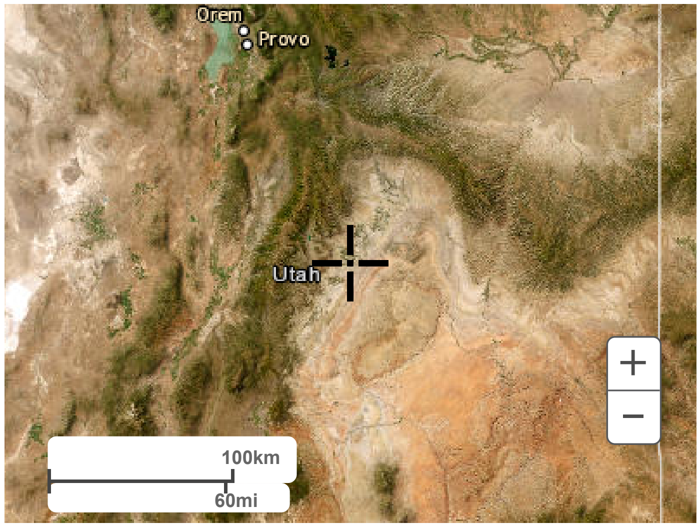
Large scale terrain



Large scale map



Large scale aerial



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National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)

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USA.gov

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: UT

Data description

Data type: Precipitation intensity **Units:** English **Time series type:** Partial duration

Select location

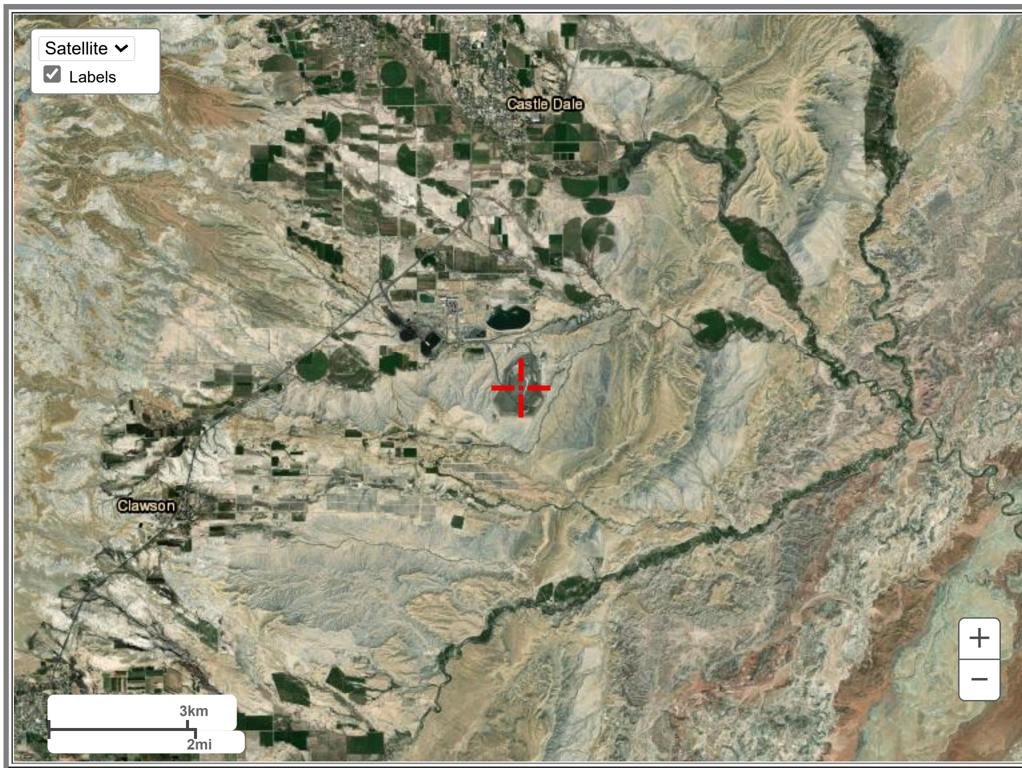
1) Manually:

a) **By location** (decimal degrees, use "-" for S and W): Latitude: Longitude: Submit

b) **By station** (list of UT stations): Select station

c) **By address** Search

2) Use map:



a) Select location
Move crosshair or double click

b) Click on station icon
Show stations on map

Location information:
Name: Ferron, Utah, USA*
Latitude: 39.1570°
Longitude: -111.0112°
Elevation: 5679 ft **

* Source: ESRI Maps
** Source: USGS

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 1, Version 5

PF tabular PF graphical Supplementary information Print page

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**1.25** (1.08-1.49)	**1.61** (1.39-1.91)	**2.24** (1.93-2.65)	**2.81** (2.39-3.34)	**3.72** (3.07-4.42)	**4.54** (3.67-5.41)	**5.50** (4.34-6.58)	**6.60** (5.06-7.96)	**8.35** (6.11-10.2)	**9.91** (7.01-12.3)
10-min	**0.954** (0.816-1.13)	**1.22** (1.06-1.45)	**1.71** (1.46-2.02)	**2.14** (1.82-2.54)	**2.83** (2.34-3.36)	**3.45** (2.79-4.12)	**4.18** (3.31-5.00)	**5.02** (3.85-6.06)	**6.35** (4.65-7.79)	**7.54** (5.33-9.38)
15-min	**0.788** (0.676-0.932)	**1.01** (0.872-1.20)	**1.41** (1.21-1.66)	**1.77** (1.50-2.10)	**2.34** (1.94-2.78)	**2.85** (2.31-3.40)	**3.46** (2.73-4.14)	**4.15** (3.18-5.01)	**5.25** (3.84-6.44)	**6.23** (4.41-7.76)
30-min	**0.530** (0.456-0.628)	**0.680** (0.588-0.808)	**0.950** (0.816-1.12)	**1.19** (1.01-1.41)	**1.58** (1.30-1.87)	**1.92** (1.55-2.29)	**2.33** (1.84-2.78)	**2.79** (2.14-3.37)	**3.54** (2.59-4.34)	**4.20** (2.97-5.22)
60-min	**0.328** (0.282-0.389)	**0.421** (0.364-0.500)	**0.588** (0.505-0.694)	**0.737** (0.627-0.875)	**0.975** (0.806-1.16)	**1.19** (0.961-1.42)	**1.44** (1.14-1.72)	**1.73** (1.33-2.09)	**2.19** (1.60-2.68)	**2.60** (1.84-3.23)
2-hr	**0.196** (0.171-0.228)	**0.248** (0.215-0.289)	**0.334** (0.291-0.389)	**0.414** (0.356-0.480)	**0.541** (0.454-0.630)	**0.655** (0.538-0.767)	**0.788** (0.631-0.931)	**0.945** (0.734-1.12)	**1.20** (0.888-1.45)	**1.42** (1.02-1.76)
3-hr	**0.145** (0.129-0.167)	**0.183** (0.162-0.212)	**0.240** (0.213-0.277)	**0.291** (0.255-0.335)	**0.371** (0.321-0.429)	**0.443** (0.374-0.513)	**0.529** (0.438-0.626)	**0.632** (0.510-0.756)	**0.798** (0.620-0.975)	**0.949** (0.712-1.18)

6-hr	**0.091** (0.082-0.103)	**0.114** (0.103-0.129)	**0.144** (0.129-0.163)	**0.170** (0.151-0.192)	**0.207** (0.182-0.235)	**0.240** (0.208-0.273)	**0.280** (0.238-0.322)	**0.328** (0.274-0.381)	**0.410** (0.333-0.494)	**0.486** (0.385-0.598)
12-hr	**0.055** (0.050-0.061)	**0.068** (0.062-0.075)	**0.084** (0.076-0.093)	**0.097** (0.088-0.108)	**0.116** (0.104-0.129)	**0.130** (0.116-0.146)	**0.146** (0.128-0.164)	**0.166** (0.143-0.191)	**0.206** (0.172-0.248)	**0.244** (0.198-0.300)
24-hr	**0.037** (0.033-0.041)	**0.046** (0.041-0.051)	**0.056** (0.051-0.062)	**0.065** (0.058-0.072)	**0.076** (0.068-0.084)	**0.084** (0.075-0.094)	**0.093** (0.082-0.103)	**0.102** (0.089-0.114)	**0.113** (0.098-0.127)	**0.123** (0.104-0.152)
2-day	**0.021** (0.019-0.023)	**0.026** (0.023-0.028)	**0.031** (0.028-0.034)	**0.036** (0.032-0.039)	**0.042** (0.038-0.046)	**0.047** (0.042-0.051)	**0.051** (0.046-0.057)	**0.056** (0.050-0.063)	**0.063** (0.054-0.070)	**0.067** (0.058-0.076)
3-day	**0.015** (0.013-0.016)	**0.018** (0.016-0.020)	**0.022** (0.020-0.024)	**0.025** (0.023-0.028)	**0.030** (0.027-0.033)	**0.033** (0.030-0.037)	**0.037** (0.032-0.041)	**0.040** (0.035-0.045)	**0.045** (0.039-0.050)	**0.048** (0.041-0.055)
4-day	**0.012** (0.010-0.013)	**0.014** (0.013-0.016)	**0.018** (0.016-0.020)	**0.020** (0.018-0.022)	**0.024** (0.021-0.026)	**0.026** (0.024-0.029)	**0.029** (0.026-0.032)	**0.032** (0.028-0.036)	**0.036** (0.031-0.040)	**0.039** (0.033-0.044)
7-day	**0.007** (0.007-0.008)	**0.009** (0.008-0.010)	**0.011** (0.010-0.012)	**0.013** (0.012-0.014)	**0.015** (0.013-0.016)	**0.017** (0.015-0.018)	**0.018** (0.016-0.020)	**0.020** (0.018-0.022)	**0.022** (0.019-0.025)	**0.024** (0.020-0.027)
10-day	**0.005** (0.005-0.006)	**0.007** (0.006-0.008)	**0.009** (0.008-0.009)	**0.010** (0.009-0.011)	**0.011** (0.010-0.012)	**0.013** (0.011-0.014)	**0.014** (0.012-0.015)	**0.015** (0.013-0.017)	**0.017** (0.015-0.019)	**0.018** (0.015-0.020)
20-day	**0.003** (0.003-0.003)	**0.004** (0.004-0.004)	**0.005** (0.005-0.006)	**0.006** (0.005-0.006)	**0.007** (0.006-0.008)	**0.008** (0.007-0.008)	**0.008** (0.007-0.009)	**0.009** (0.008-0.010)	**0.010** (0.009-0.011)	**0.011** (0.009-0.012)
30-day	**0.002** (0.002-0.003)	**0.003** (0.003-0.003)	**0.004** (0.003-0.004)	**0.004** (0.004-0.005)	**0.005** (0.005-0.006)	**0.006** (0.005-0.006)	**0.006** (0.005-0.007)	**0.007** (0.006-0.007)	**0.007** (0.006-0.008)	**0.008** (0.007-0.009)
45-day	**0.002** (0.002-0.002)	**0.002** (0.002-0.003)	**0.003** (0.003-0.003)	**0.003** (0.003-0.004)	**0.004** (0.003-0.004)	**0.004** (0.004-0.005)	**0.005** (0.004-0.005)	**0.005** (0.004-0.005)	**0.005** (0.005-0.006)	**0.006** (0.005-0.006)
60-day	**0.001** (0.001-0.002)	**0.002** (0.002-0.002)	**0.002** (0.002-0.003)	**0.003** (0.002-0.003)	**0.003** (0.003-0.004)	**0.004** (0.003-0.004)	**0.004** (0.003-0.004)	**0.004** (0.004-0.005)	**0.005** (0.004-0.005)	**0.005** (0.004-0.005)

[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.

Estimates from the table in CSV format: Precipitation frequency estimates Submit

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National Oceanic and Atmospheric Administration
National Weather Service
Office of Water Prediction (OWP)
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster
Page last modified: April 21, 2017

Appendix B: Calculations

ESTIMATING RUNOFF

Rational Method

User Input Data
Calculated Value
Reference Data

Designed By:	Chad Tomlinson	**Date:**	9/23/2024
Checked By:	Kyle Avery	**Date:**	9/24/2024
Company:	Tetra Tech		
Project Name:	Hunter Run-on/Run-off Plan		
Project No.:	117-8245038		

Site Location (City/Town)	Hunter Power Plant Ash Landfill
Watershed Basin Id.	Northwest and Southeast Channel Basins

The rational formula is:

Comments

$$Q = CIA$$

where:
- Q = peak rate of runoff in cubic feet per second (cfs)
- C = runoff coefficient, an empirical coefficient representing the relationship between rainfall rate and runoff rate
- I = average intensity of rainfall in inches/hour, for a storm duration equal to the time of concentration, T_C
- A = drainage area in acres

The general procedure for determining peak discharge using the rational formula is presented below and illustrated in Sample Problem 8.03a.

Step 1. Determine the drainage area in acres.

Total Drainage Area	170	Assumed area of each subbasin

Step 2. Determine the runoff coefficient, C, for the type of soil/cover in the drainage area (Table 8.03b).

If the land use and soil cover is homogenous over the drainage area, a C value can be determined directly from Table 8.03b. If there are multiple soil cover conditions, a weighted average must be calculated, or the area may be subdivided.

Subarea A (acres)	101.5	Top portion of landfill not graded and relatively flat.	
Subarea A Runoff Coefficient	0.25	Corresponds to heavy soil flat with average slopes of 2 to 7%	Runoff Coefficient
Subarea B (acres)	33	Area of landfill graded .	
Subarea B Runoff Coefficient	0.35	Corresponds to heavy soil steep to account for graded sloped portion of landfill. Graded slopes are covered with hay.	
Subarea C (acres)	35.5	Portion of flat land adjacent to landfill including perimeter road and run-on berm.	
Subarea C Runoff Coefficient	0.25	Corresponds to heavy soil flat with average slopes of 2 to 7%.	
Subarea D (acres)			
Subarea D Runoff Coefficient			
Weighted Runoff Coefficient	**0.27**		

Step 3.

Go to Intensity Worksheet

Step 4.

25-year 24-hrRainfall Intensity, i (in/hr)	1.58	Refer to Appendix A for precipitation intensity for 25-yr 30-min event; corresponding to 30-min Tc estimated in Intensity Worksheet from Google Earth imagery and topo.

Step 5. Determine peak discharge, Q (cubic feet per second), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a);

$$Q = CIA$$

Q_2 Flow (cfs)	**73**

Intensity

Step 3. Time of Concentration

Overland flow Tc -- Kinematic Wave Theory

Length of overland flow	100.0	feet
Mannings "n" for surface	0.035	Manning's n
Average watershed slope	0.030	ft./ft.
Constant alpha	7.4	
Constant m	1.67	
Weighted Runoff Coefficient	0.269412	

Shallow Conc Flow Tc

Slope	
Length of Conc Flow	
V (unpaved)	0.0

Channel/Pipe Flow Tc

Slope	0
Length of Channel/Pipe Flow	0
R	0.00
n	0
V	

Tc Overland (min)	**27.05**
Tc Shallow Conc (min)	
Tc Channel/Pipe (min)	
Tc Total (min)	

1) Enter the rainfall intensity values for the corresponding times of duration ir table below. Rainfall intensity can be found from the following NWS hyperl
http://hdsc.nws.noaa.gov/hdsc/pfds/orb/nc_pfds.ht

2) Select the rainfall Intensity that corresponds to the trial time of duration th is equal to or less than the calculated time of concentration.

3) Copy the selected rainfall intensity into cell below.

0-year Rainfall Intensity, i (in/hr) 1.58

Step 3. Determine the time of concentration, T_C, for the drainage area. The Kinematic Wave Theory defines time of concentration as the "travel time of a wave to move from the hydraulically most distant point in the catchment to the outlet (Bedient and Huber, 1992)". The formula for the time of concentration is:

$$T_C = (L/(\alpha * I_e)^{m-1})^{1/m}$$

where:

T_C= time of concentration, in minutes. It consists of the total time for overland sheet flow.
L = length of overland flow plane (feet);
I_e = rainfall excess = $I_i * C/43{,}200$ (43,200 converts inches per hour to feet per second in the overall equation).
I_i = rainfall intensity;
C = rational runoff coefficients;

This equation contains two sets of parameters that need further definition, α and m. For turbulent flow, which is the normal field condition,

$$m = 5/3 = 1.667$$

$$\alpha = \frac{(1.49 * S^{1/2})}{n}$$

where:

S = slope (ft/ft);
n = Manning's roughness.

Since m will always be 5/3, this equation can be simplified to:

$$T_C = \frac{\left[\dfrac{L}{\alpha\ (I_i * C/43{,}200)^{2/3})}\right]^{2/3}}{60\ (\text{minutes})}$$

Because both time of concentration and rainfall intensity are unknown variables in one equation, the solution must be found through iterations. The use of a spreadsheet is recommended. An example is shown in Table 8.03a.

Trail Time of Duration tr (min)	Rainfall Intensity (IDF), i (in/hr)	Calculation of Time of Concentration, tc (min)
5	3.72	5.70
10	2.83	6.36
15	2.34	6.86
30	1.58	8.03
60 (1 hour)	0.975	9.74
120 (2 hours)	0.541	12.33
180 (3 hours)	0.371	14.34
360 (6 hours)	0.207	18.12
720 (12 hours)	0.116	22.84
1440 (24 hours)	0.076	27.05

Table 8.03b: Value of Runoff Coefficient (C) for Rational Formula

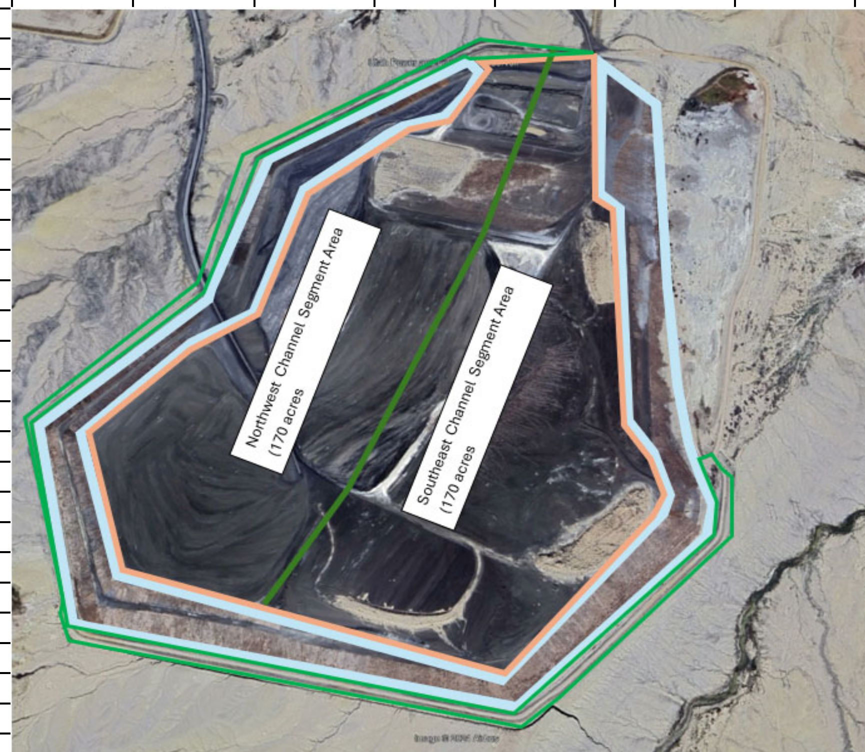
Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, Attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave.,	0.10-0.15
2-7%	0.15-0.20
Sandy soil, steep,	0.13-0.17
7%	0.18-0.22
Heavy soil, flat, 2%	0.25-0.35
Heavy soil, ave.,	
2-7%	
Heavy soil, steep,	
7%	0.30-0.60
	0.20-0.50
Agricultural land:	
Bare packed soil	0.30-0.60
Smooth	0.20-0.50
Rough	0.20-0.40
Cultivated rows	0.10-0.25
Heavy soil no crop	
Heavy soil with	0.15-0.45
crop	0.05-0.25
Sandy soil no crop	0.05-0.25
Sandy soil with	
crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

NOTE: The designer must use judgement to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

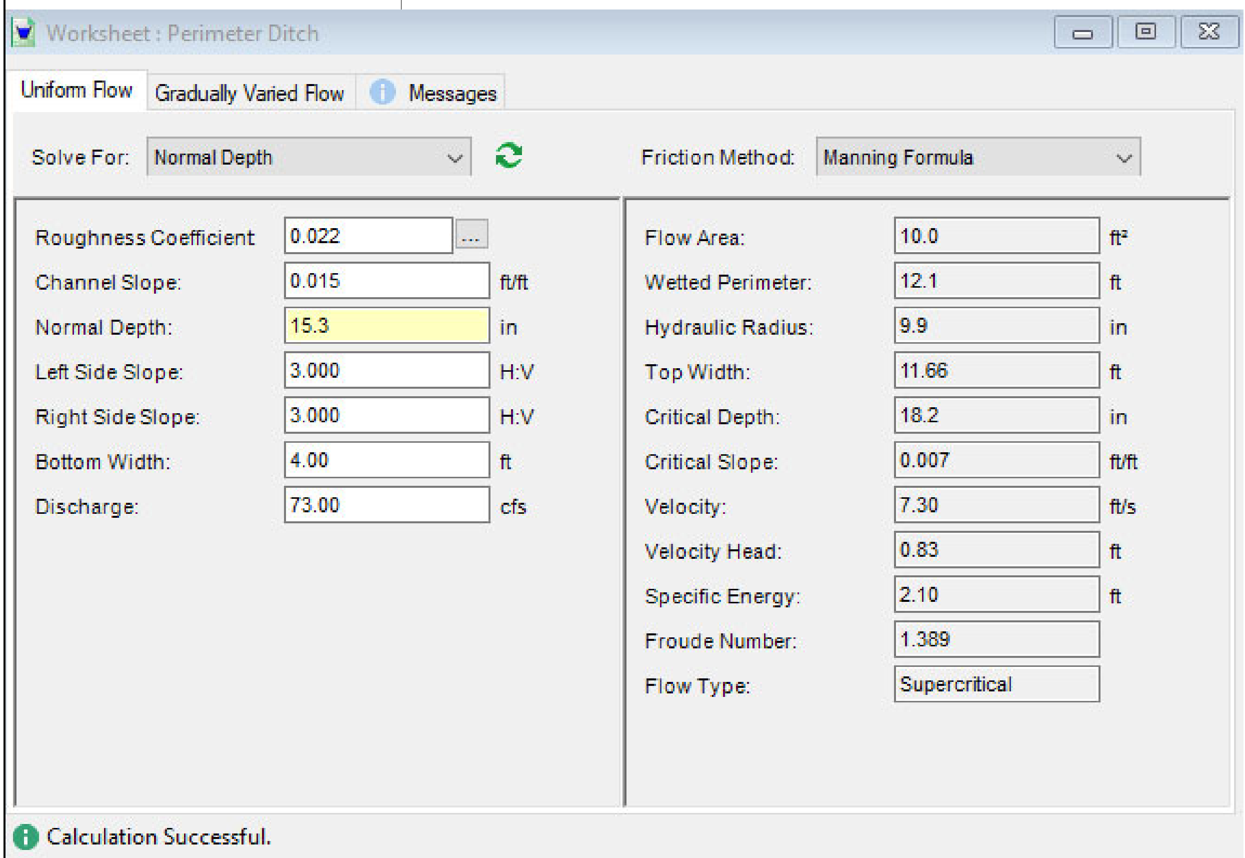
Return to Main Worksheet



CHANNEL SIZING

Mannings Equation

Designed By:	Chad Tomlinson	**Date:**	9/23/2024
Checked By:	Kyle Avery	**Date:**	9/24/2024
Company:	Tetra Tech		
Project Name:	Hunter Run-on/Run-off Plan		
Project No.:	117-8245038		


Worksheet : Perimeter Ditch

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth

Friction Method: Manning Formula

Roughness Coefficient	0.022	
Channel Slope:	0.015	ft/ft
Normal Depth:	15.3	in
Left Side Slope:	3.000	H:V
Right Side Slope:	3.000	H:V
Bottom Width:	4.00	ft
Discharge:	73.00	cfs

Flow Area:	10.0	ft²
Wetted Perimeter:	12.1	ft
Hydraulic Radius:	9.9	in
Top Width:	11.66	ft
Critical Depth:	18.2	in
Critical Slope:	0.007	ft/ft
Velocity:	7.30	ft/s
Velocity Head:	0.83	ft
Specific Energy:	2.10	ft
Froude Number:	1.389	
Flow Type:	Supercritical	

Calculation Successful.

Sedimentation Pond Sizing

Designed By:	Chad Tomlinson	**Date:**	9/23/2024
Checked By:	Kyle Avery	**Date:**	9/24/2024
Company:	Tetra Tech		
Project Name:	Hunter Run-on/Run-off Plan		
Project No.:	117-8245038		

Parameter	Value	Unit	Comment
Drainage Area	340	acres	Based on Google Earth Image for Total Perimeter of Landfill, Perimeter Road, and Stormwater Basin
25-yr 24-hr Rainfall Depth	1.83	inches	Refer to Appendix A
Total Discharge Volume	52	acre-ft	Drainage area multiplied by rainfall depth.Assumes 100% of storm depth enters pond.
Stormwater Pond Design Storage Volume	104	acre-ft	Based on 2016 Run-on and Run-off Plan
% of Stormwater Pond Remaining	50%	acre-ft	Percent of pond remaining after 25-yr 24-hr storm event.