Hugo CCR Landfill Run-On and Run-Off Control

Western Farmers Electric Cooperative

Project No. 85009

Revision 0
October 16, 2016

Hugo CCR Landfill
Run-On and Run-Off Control

Prepared for

Western Farmers Electric Cooperative
Project No. 85009
Hugo, Oklahoma

Revision 0
October 16, 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Western Farmers Electric Cooperative
Hugo CCR Landfill
Run-On and Run-Off Control

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Oklahoma, that the information in this document and Appendix was assembled under my direct personal charge. I am a "Qualified Professional Engineer" as defined by 40 C.F.R. § 257.53 by the fact that I have the technical knowledge and experience to make the specific technical certifications set forth herein. This Control Plan meets the requirements of 40 C.F.R. § 257.81. This Control Plan is not intended or represented to be suitable for reuse by Western Farmers Electric Cooperative or others without specific verification or adaptation by the Engineer.

This document has been digitally signed.
Oct 17 2016

Vivian L. Larson P.E. (No. 27534)

Date:

TABLE OF CONTENTS

Page No.

LIST OF FIGURES

Page No.

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
ALM	Asset Life Management
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
C.F.R.	Code of Federal Regulations
CMMS	Computerized Maintenance Management System
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
OAC	Oklahoma Administrative Code
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
USC	United States Code
USGS	United States Geological Survey
WFEC	Western Farmers Electric Cooperative

1.0 INTRODUCTION

Burns & McDonnell (BMcD) has compiled information and prepared this Run-on and Run-off Control System Plan (Control Plan) for the existing CCR Landfill, designated CCR Unit 1 (Landfill), at the Western Farmers Electric Cooperative (WFEC) Hugo Power Plant (Plant). The purpose of this Control Plan is to comply with the United States Environmental Protection Agency's (EPA) Coal Combustion Residual Rule (CCR Rule), and the counterpart rule of the Oklahoma Department of Environmental Quality (ODEQ).

On April 17, 2015, the EPA published the CCR Rule relating to the disposal of coal combustion residual (CCR) materials generated at electric utilities' coal-fired units. The CCR Rule was promulgated pursuant to the Resource Conservation and Recovery Act (RCRA, 42 U.S.C. §§ 6901 *et seq*.), using the Subtitle D approach and is found at 40 C.F.R. § 257.50 *et seq*. Additionally, ODEQ adopted counterpart regulations to the CCR Rule effective September 15, 2016, which are found at Oklahoma Administrative Code (OAC) 252:517.

The owner or operator of a CCR Landfill subject to the CCR Rule must prepare a Run-on and Run-off Control System Plan in accordance with 40 C.F.R. § 257.81 and OAC 252:517-13-2. This Control Plan provides the documentation and engineering calculations for the Landfill at the Plant. The Control Plan must contain the following in accordance with 40 C.F.R. § 257.81(c):

- Documentation of how the run-on and run-off control systems have been designed and constructed to meet the following requirements:
  - A run-on control system to prevent flow onto the active portion of the Landfill during peak discharge from a 24-hour, 25-year storm; and
  - A run-off control system from the active portion of the Landfill to collect and control at least the water volume resulting from a 24-hour, 25-year storm.
- Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under 40 C.F.R. § 257.3-3.
- Supporting engineering calculations for the plan.
- Certification by a qualified professional engineer.

The following run-on and run-off control system terms are defined per the CCR Rule:

- Active Portion – That part of the Landfill that has received or is receiving CCR or non-CCR waste and that has not completed closure in accordance with 40 C.F.R. § 257.102.

- Run-off – 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 – 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 EXISTING CONDITIONS

The Plant is a single, coal-fired unit rated at 450 MW. The Plant is located south of highway US-70, west of the Town of Fort Towson, Oklahoma, and is owned and operated by WFEC. Bottom ash is available for beneficial reuse and managed in two cells of the Plant's CCR surface impoundment (Impoundment). Fly ash and economizer ash generated by the Plant are beneficially reused or managed in the Landfill as described below.

Fly ash is pneumatically transported from the electrostatic precipitator (ESP) and stored temporarily in silos during normal operations. Fly ash is unloaded directly from the silo and sold for beneficial use. The remaining portion of the fly ash is placed in the Landfill where it is managed or later excavated for sale for beneficial use. Fly ash is conditioned at the Landfill with water when unloading.

The Landfill is a special waste landfill registered with the State of Oklahoma. The Landfill is located on the west side of the Plant and is divided into two cells. See Figure 2-1 for a Site Plan.

Since material is sent to the Landfill in a dry condition, and no other plant runoff streams are sent to the Landfill, the only source of water to the Landfill is the stormwater runoff that fall directly within the watershed of the Landfill. This water is collected at a low area at the east side of south cell and at the north side of the north cell of the Landfill and pumped to the Impoundment.

2.1 Project Mapping

2.1.1 Aerial Survey

An aerial survey was performed in January 2016 by Survey and Aerial Mapping, LLC. The aerial survey included topography, planimetric features, and orthoimagery.

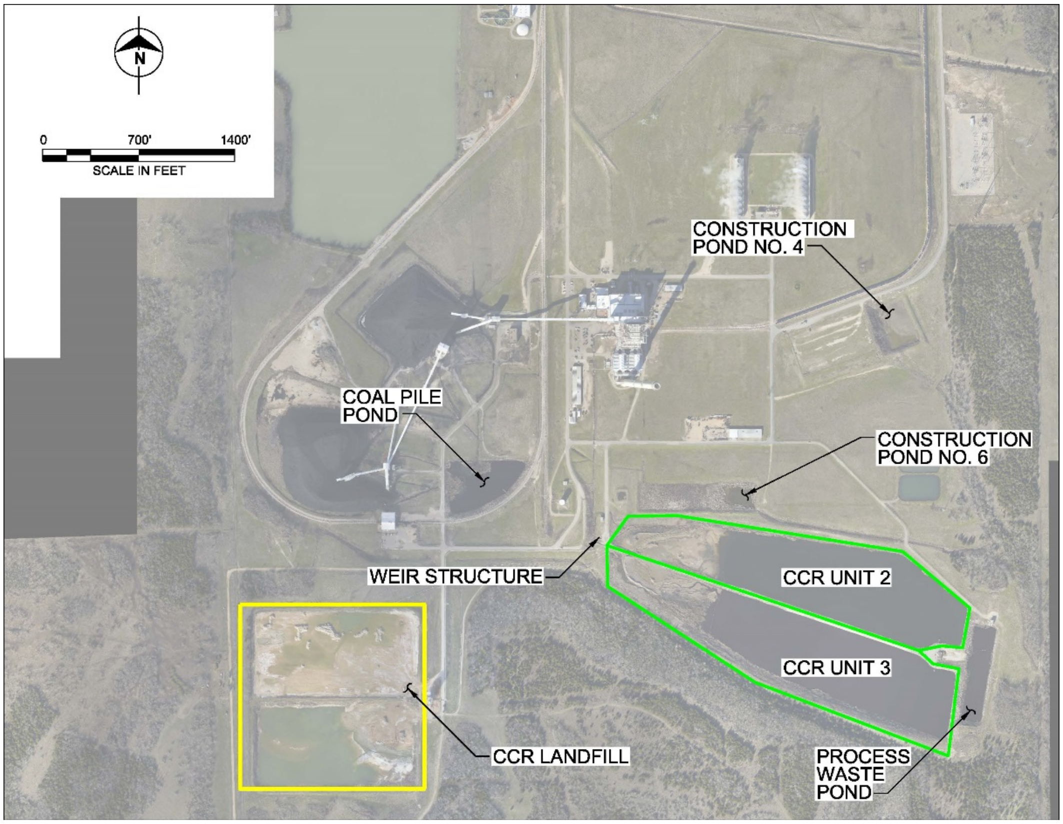
2.1.2 Vertical Datum

Mapping sources referenced were in the North American Vertical Datum of 1988 (NAVD 88).

2.1.3 Horizontal Coordinate System

North American Datum (NAD) 1983 State Plane Oklahoma South 3502 (U.S. feet) coordinate system was utilized as the basis for mapping and modeling efforts.

Figure 2-1 Hugo Site Plan



3.0 RUN-ON AND RUN-OFF CONTROL SYSTEM

3.1 Run-on Control System

The run-on control system consists of combination of berm and perimeter ditches around the Landfill. The berm around the perimeter of the Landfill is at approximate elevation 515'. The existing grade to the north, east, and south of the Landfill is lower, ranging from elevation 514' to 495'. In general, stormwater runoff drains away from the Landfill on the north, east and south sides of the Landfill.

The grade on the west side of the Landfill is higher than the berm around the Landfill, and is as high as elevation 525', sloping down towards the Landfill. The berm on the west side of the Landfill has been built up to elevations as high as 517', and there is a perimeter ditch between the adjacent slope and the western berm of the Landfill. This ditch directs water away from the Landfill, where it can drain to the north or south.

3.2 Run-off Control System

The run-off control system consists of contouring the ash to direct runoff to the low spot in each cell of the Landfill. The water is collected at the low spots and pumped to the Impoundment.

3.3 Run-on and Run-off System Criteria

3.3.1 Capacity Criteria

40 C.F.R. § 257.81 (a)(1) and (a)(2) state the following:

> *"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:*
>
> *(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."*

4.0 HYDROLOGIC AND HYDRAULIC CAPACITY

4.1 Calculation Approach

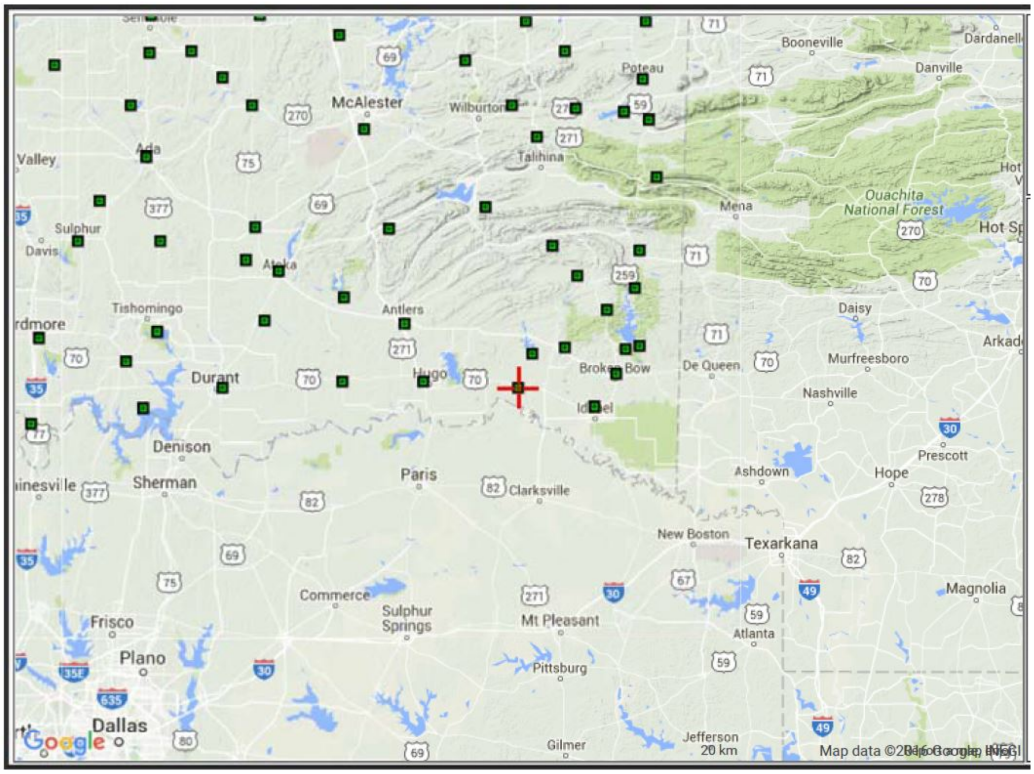
To simulate the peak flow of the design storm run-on and volume resulting from the design storm run-off, a hydrologic and hydraulic model was created. The computer Program Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) was used to generate this model. HEC-HMS is software developed by the U.S. Army Corps of Engineers for the evaluation of watersheds and hydrologic processes. The HEC-HMS model breaks down the hydrologic and hydraulic processes into a precipitation model, a runoff model, and other elements, such as culverts, storage ponds, and pumps. The detailed calculation and model description are contained in Appendix A.

In addition to calculating the peak discharge, Bentley FlowMaster software was used to determine the capacity of the perimeter ditches. The detailed calculations and model description are contained in Appendix B.

The run-on/run-off design event for this Control Plan, as indicated in 40 C.F.R. § 257.81 (a)(1) and (a)(2), is the 24-hour, 25 year storm. The precipitation depth used for the run-on and run-off is 7.55 inches. This precipitation data was acquired from the National Weather Service (NOAA, 2016). The point precipitation location, where the precipitation values are derived for, is shown in Figure 4-1. The table of rainfall depths for various frequencies and durations is presented in The Plant watersheds were delineated using the mapping sources as discussed in Section 2.1 and are shown in Figure 4-3. Watersheds D and E represent the interior portion of the Landfill. Watershed B is the area the runs off to the north, and around the Landfill. Only a small portion of Watershed B contributes to the ditches on the west side of the Landfill, and so Watershed B was further divided into Watershed B' and Watershed B'' to evaluate the capacity of the ditch along the north half of the west side of the Landfill. Watershed C drains to the area west of south half of the Landfill. Watershed C was subdivided into Watershed C' to evaluate the capacity of the ditch along the south half of the west side of the Landfill. Properties of the watersheds were determined using the topographical and planimetric features from the mapping. These properties were used to build the HEC-HMS model. The engineering calculation utilizing the HEC-HMS Model is included in Appendix A.

Figure 4-2.

Figure 4-1. Point Precipitation Location



4.1.1 Watershed Delineation and Hydrologic Characteristics

The Plant watersheds were delineated using the mapping sources as discussed in Section 2.1 and are shown in Figure 4-3. Watersheds D and E represent the interior portion of the Landfill. Watershed B is the area that runs off to the north, and around the Landfill. Only a small portion of Watershed B contributes to the ditches on the west side of the Landfill, and so Watershed B was further divided into Watershed B' and Watershed B'' to evaluate the capacity of the ditch along the north half of the west side of the Landfill. Watershed C drains to the area west of south half of the Landfill. Watershed C was subdivided into Watershed C' to evaluate the capacity of the ditch along the south half of the west side of the Landfill. Properties of the watersheds were determined using the topographical and planimetric features from the mapping. These properties were used to build the HEC-HMS model. The engineering calculation utilizing the HEC-HMS Model is included in Appendix A.

Figure 4-2. NOAA Point Precipitation Frequency Estimates

SS 257.81 (a), 24-hour 25-year storm

PDS-based 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	0.468 (0.377–0.582)	0.534 (0.430–0.665)	0.644 (0.517–0.803)	0.737 (0.590–0.920)	0.867 (0.680–1.10)	0.969 (0.748–1.24)	1.07 (0.811–1.39)	1.18 (0.868–1.54)	1.32 (0.949–1.75)	1.44 (1.01–1.91)
10-min	0.685 (0.552–0.853)	0.782 (0.629–0.974)	0.943 (0.757–1.18)	1.08 (0.863–1.35)	1.27 (0.996–1.61)	1.42 (1.10–1.81)	1.57 (1.19–2.03)	1.73 (1.27–2.26)	1.94 (1.39–2.57)	2.10 (1.48–2.80)
15-min	0.836 (0.673–1.04)	0.954 (0.767–1.19)	1.15 (0.923–1.43)	1.32 (1.05–1.64)	1.55 (1.21–1.97)	1.73 (1.34–2.21)	1.92 (1.45–2.47)	2.11 (1.55–2.75)	2.37 (1.70–3.13)	2.56 (1.81–3.41)
30-min	1.23 (0.986–1.52)	1.40 (1.13–1.74)	1.69 (1.36–2.11)	1.94 (1.55–2.42)	2.28 (1.79–2.89)	2.55 (1.97–3.25)	2.82 (2.13–3.64)	3.10 (2.28–4.05)	3.48 (2.50–4.61)	3.77 (2.66–5.02)
60-min	1.62 (1.31–2.02)	1.86 (1.49–2.31)	2.25 (1.80–2.80)	2.58 (2.06–3.22)	3.05 (2.39–3.88)	3.42 (2.65–4.37)	3.81 (2.88–4.92)	4.21 (3.10–5.50)	4.75 (3.41–6.29)	5.17 (3.64–6.88)
2-hr	2.02 (1.64–2.49)	2.31 (1.88–2.85)	2.80 (2.27–3.45)	3.22 (2.60–3.98)	3.82 (3.03–4.81)	4.30 (3.35–5.44)	4.79 (3.65–6.14)	5.31 (3.94–6.89)	6.01 (4.34–7.90)	6.56 (4.65–8.67)
3-hr	2.27 (1.86–2.78)	2.60 (2.12–3.18)	3.15 (2.57–3.86)	3.63 (2.95–4.46)	4.32 (3.45–5.43)	4.88 (3.83–6.16)	5.46 (4.19–6.97)	6.08 (4.53–7.85)	6.92 (5.03–9.07)	7.59 (5.40–9.98)
6-hr	2.76 (2.28–3.34)	3.14 (2.60–3.81)	3.81 (3.14–4.62)	4.39 (3.61–5.35)	5.26 (4.25–6.55)	5.96 (4.73–7.47)	6.71 (5.19–8.50)	7.50 (5.64–9.63)	8.60 (6.30–11.2)	9.48 (6.79–12.4)
12-hr	3.31 (2.77–3.97)	3.76 (3.14–4.52)	4.56 (3.80–5.48)	5.26 (4.37–6.34)	6.31 (5.15–7.80)	7.17 (5.75–8.90)	8.08 (6.32–10.2)	9.06 (6.88–11.5)	10.4 (7.69–13.5)	11.5 (8.31–14.9)
24-hr	3.89 (3.28–4.62)	4.45 (3.76–5.29)	5.43 (4.57–6.45)	6.29 (5.27–7.49)	7.55 (6.21–9.22)	8.58 (6.93–10.5)	9.66 (7.61–12.0)	10.8 (8.26–13.6)	12.4 (9.21–15.9)	13.7 (9.93–17.6)
2-day	4.49 (3.83–5.28)	5.20 (4.43–6.11)	6.40 (5.44–7.53)	7.43 (6.29–8.76)	8.91 (7.39–10.8)	10.1 (8.22–12.3)	11.3 (8.99–13.9)	12.6 (9.71–15.8)	14.4 (10.7–18.2)	15.8 (11.5–20.1)
3-day	4.93 (4.23–5.75)	5.68 (4.88–6.63)	6.96 (5.96–8.14)	8.06 (6.86–9.44)	9.62 (8.02–11.5)	10.9 (8.89–13.1)	12.2 (9.69–14.9)	13.5 (10.4–16.8)	15.3 (11.5–19.3)	16.8 (12.3–21.3)
4-day	5.27 (4.54–6.12)	6.05 (5.22–7.03)	7.37 (6.34–8.58)	8.50 (7.28–9.92)	10.1 (8.47–12.1)	11.4 (9.36–13.7)	12.7 (10.2–15.5)	14.1 (10.9–17.4)	16.0 (12.0–20.1)	17.5 (12.8–22.1)
7-day	6.06 (5.27–6.98)	6.91 (6.01–7.96)	8.33 (7.22–9.61)	9.54 (8.24–11.0)	11.3 (9.49–13.3)	12.6 (10.4–15.0)	14.0 (11.3–16.9)	15.5 (12.1–19.0)	17.4 (13.2–21.7)	19.0 (14.0–23.8)
10-day	6.77 (5.92–7.75)	7.66 (6.70–8.78)	9.15 (7.98–10.5)	10.4 (9.04–12.0)	12.2 (10.3–14.3)	13.6 (11.3–16.1)	15.0 (12.1–18.0)	16.5 (12.9–20.1)	18.5 (14.0–22.9)	20.0 (14.9–25.1)
20-day	8.94 (7.92–10.1)	9.95 (8.80–11.3)	11.6 (10.2–13.2)	13.0 (11.4–14.8)	14.9 (12.7–17.2)	16.3 (13.7–19.1)	17.8 (14.5–21.1)	19.3 (15.2–23.3)	21.2 (16.2–26.1)	22.7 (17.0–28.2)
30-day	10.8 (9.61–12.1)	12.0 (10.6–13.5)	13.8 (12.3–15.6)	15.4 (13.6–17.4)	17.4 (14.9–20.0)	19.0 (16.0–22.0)	20.5 (16.8–24.1)	22.0 (17.4–26.3)	23.9 (18.3–29.2)	25.4 (19.0–31.3)
45-day	13.1 (11.8–14.7)	14.6 (13.1–16.3)	16.9 (15.1–18.9)	18.7 (16.6–21.0)	21.1 (18.1–24.0)	22.8 (19.3–26.2)	24.4 (20.1–28.5)	26.0 (20.6–30.9)	28.0 (21.5–33.8)	29.3 (22.1–36.1)
60-day	15.1 (13.6–16.8)	16.9 (15.2–18.8)	19.6 (17.6–21.9)	21.7 (19.4–24.3)	24.5 (21.1–27.6)	26.4 (22.4–30.2)	28.2 (23.2–32.7)	29.9 (23.8–35.3)	31.9 (24.5–38.4)	33.2 (25.1–40.7)

[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

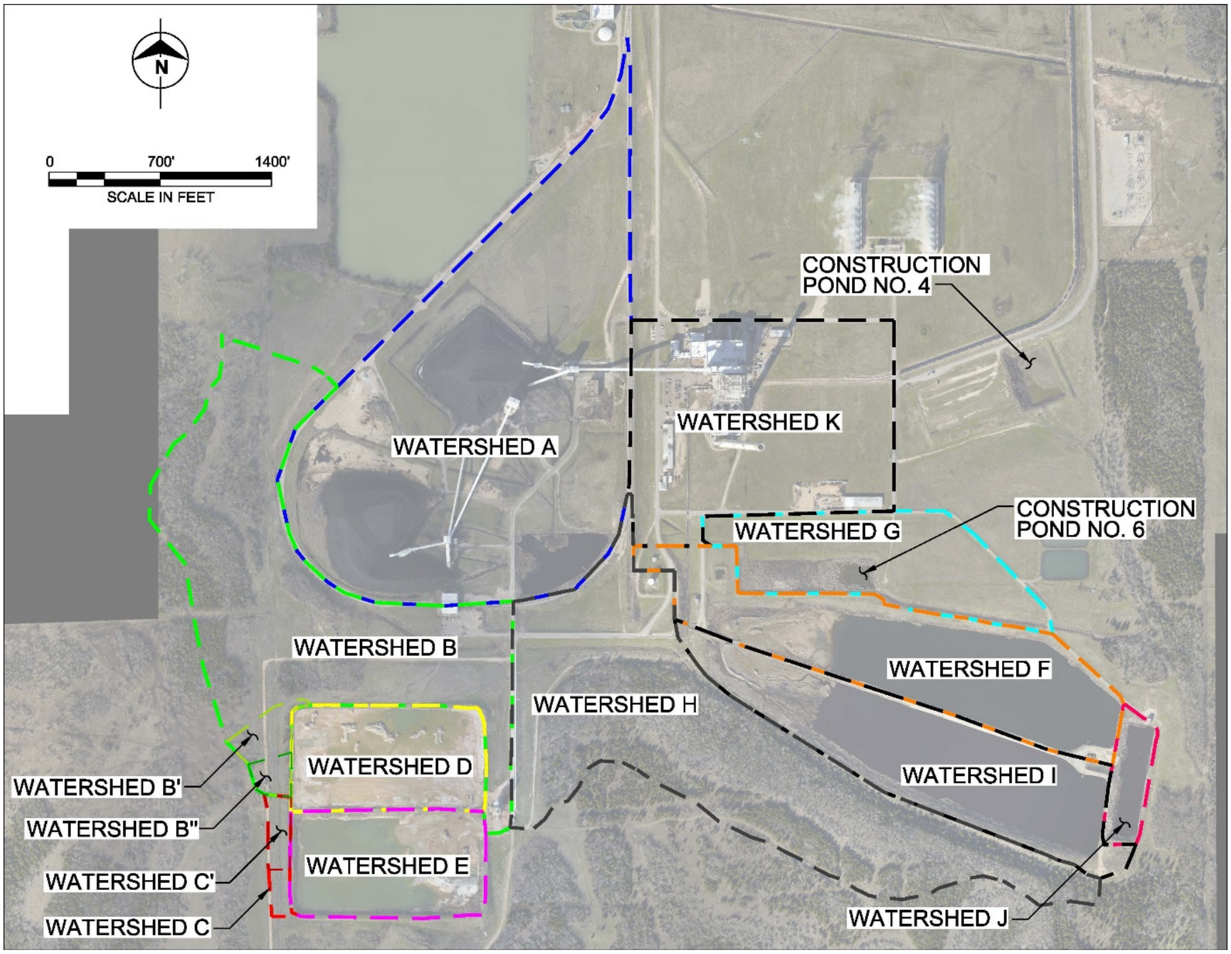
Main Link Categories:
Home | NWC(OHD)

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center (formerly OHD)
1325 East West Highway
Silver Spring, MD 20910
Page Author: HDSC webmaster
Page last modified: August 27, 2014

Map Disclaimer
Disclaimer
Credits
Glossary

Privacy Pol
About
Career Opportunit

Figure 4-3. Plant Watershed Boundaries



5.0 RESULTS

5.1 Summary

The peak flows from Watersheds B', C, and C' were input into Bentley FlowMaster. The results indicated that the peak runoff from the 24-hour 25-year return storm would not overtop the ditches at the locations checked. The volume from the peak flows from Watersheds D and E were modeled in HEC-HMS. The results indicated that the volume of runoff would be contained within the Landfill, until such time the Plant were to pump the water to the Impoundment.

5.2 Operating Plan

To meet the requirements of 40 C.F.R. § 257.81(a)(1) and prevent flow onto the active portion of the Landfill during the peak discharge from the design storm, the Plant should maintain the system of perimeter ditches and berms which to direct stormwater runoff from Landfill.

To meet the requirements of 40 C.F.R. § 257.81(a)(2) and collect and control the water volume of design storm, the Plant should continue to utilize low areas of the Landfill to collect runoff from the Landfill itself. The runoff collected in the low areas of the Landfill should be sent to the Impoundment after the design storm event.

To meet the requirements of 40 C.F.R. § 257.81(b) and discharge in accordance with 40 C.F.R. § 257.3-3, the Plant should continue to utilize the equipment and methods currently used to comply with the OPDES permit.

5.3 Conclusion

The run-on and run-off control system for the Landfill is designed, constructed, operated, and maintained to: (1) prevent flow onto the active portion of the Landfill during the peak discharge from a 24-hour, 25 year storm; and (2) collect and control at least the water volume resulting from a 24-hour, 25 year storm. Runoff from the active portion of the Landfill is handled in accordance with the surface water requirements of 40 C.F.R. § 257.3-3.

6.0 REVIEW AND REVISIONS

The Control Plan will be placed in the Plant's Operating Record in accordance with the CCR Rule. Pursuant to the CCR Rule, if there is a significant change to any information compiled in the Control Plan, the relevant information will be updated and the revised document will be placed in the Plant's Operating Record with notice and public accessibility as required by the CCR Rule. A record of revisions made to this document is included in Section 7.0.

7.0 RECORD OF REVISIONS

Revision Number	Date	Revisions Made	By Whom
0	10/16/2016	Initial Issue	Burns & McDonnell

APPENDIX A – 85009-C-003

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
Project Number : 85009

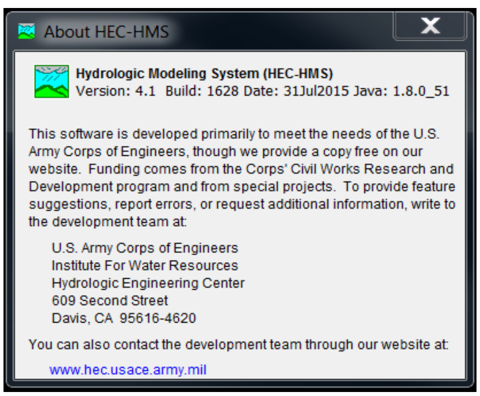
WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-003
ISSUED DATE:	10/16/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	V. Larson

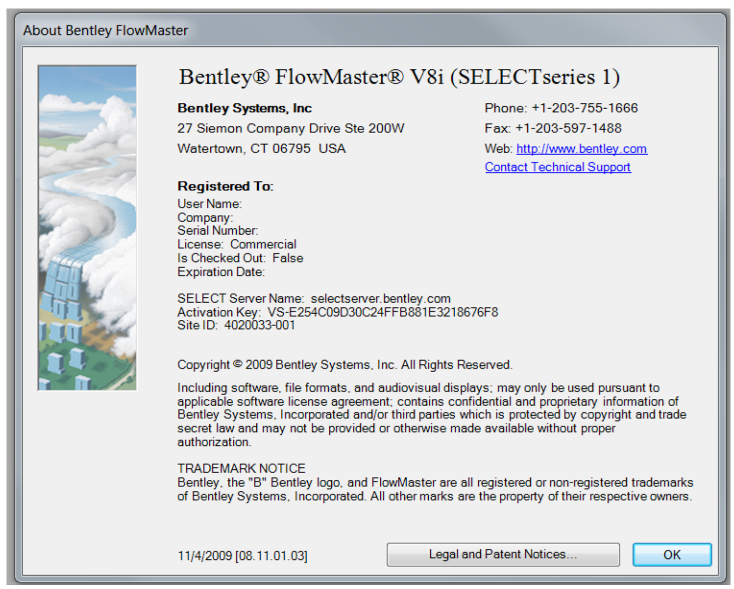
OBJECTIVE: Provide calculations to demonstrate the hydrologic run-on and run-off per 40 C.F.R. Part 257 §257.81.

REFERENCES:

1 Lindeburg, M. (2006). *Civil engineering reference manual for the PE exam.* Belmont, CA: Professional Publications, Inc.
2 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 (2011). NOAA Atlas 14 Volume 6 Version 2.0, Precipitation-Frequency Atlas of the United States, California. NOAA, National Weather Service, Silver Spring, MD.
3 Cox, D., Chu, T., Ruane, R. (February 1979). *Characterization of coal pile drainage* (EPA-600/7-79-051). Washington, DC: US Environment Protection Agency
4 Web soil survey
5 Cronshey, R. et al. (June 1986). *Urban hydrology for small watersheds* (TR-55). Washington, DC: US Department of Agriculture.

SOFTWARE:
1 Hydrologic Modeling System (HEC-HMS)
2 Bentley FlowMaster





MODEL:
1 HUGO_RUN-ON_RUN-OFF
\Clients\ENR\WFEC\85009_CCRStudy\Studies\Tech_Consult\Reports\Run-on and Run-off\HUGO_RUN_ON_RUN_OFF
2 85009 Run-on Run-off.fm8
\Clients\ENR\WFEC\85009_CCRStudy\Studies\Tech_Consult\Reports\Run-on and Run-off\

DESIGN INPUT:
1 Per §257.81 (a) the design storm is a 24-hour 25-year return storm.
2 Site soil classification is D. — Reference 4
3 Curve Numbers as follows:

	CN	
Coal Pile/CCR	73	Reference 3
Meadow - Mowed for Hay	78	Reference 5

4 There is relatively little impervious area, therefore a single CN will be used, and 10% impervious will be conservatively added.
5 Channel velocity is 5 ft/s for calculating Time of Concentration.

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
Project Number : 85009

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-003
ISSUED DATE:	10/16/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	V. Larson

OBJECTIVE: Provide calculations to demonstrate the hydrologic run-on and run-off per 40 C.F.R. Part 257 §257.81.

EQUATIONS:

1 Sheet Flow Travel Time
tsheet = 0.007*(nL)0.8/√(P2)*Sdecimal0.4 — Reference 1, p. 20-3, eq. 20.6
2 Shallow Flow Travel Time
tshallow = L/v — Reference 1, p. 20-3, Section 5
3 Velocity of Shallow Flow
vshallow =16.1345√(Sdecimal) — Reference 1, p. 20-3, eq. 20.7
4 Channel Flow Travel Time
tchannel = L/v — Reference 1, p. 20-3, Section 5
5 Time of Concentration
tc = tsheet + tshallow + tchannel — Reference 1, p. 20-3, eq. 20.5
6 Lag Time
tlag= 0.6*tc — Reference 1, p.20-11, eq. 20.27
7 Soil Water Storage Capacity
S = (1000/CN) -10 — Reference 1, p. 20-19, eq. 20.43
8 Initial Abstraction
Ia = 0.2*S — Reference 1, p. 20-15, eq. 20.38

VARIABLES:

1	tlag	lag time, min
2	L	hydraulic length of the watershed, ft
3	S	soil water storage capacity, in
4	Sdecimal	slope, ft/ft
5	CN	curve number, unit less
6	Ia	initial abstraction, in
7	Ad	total drainage area, ac or mi2
8	AT	total area, ac
9	Q	peak runoff rate, cfs
10	vchannel	channel velocity, ft/s
11	vshallow	shallow velocity, ft/s
12	tc	time of concentration, min
13	tsheet	sheet flow travel time, min
14	tshallow	shallow concentrated flow travel time, min
15	tchannel	channel flow travel time, min
16	P2	2yr 24hr rainfall, in
17	n	Manning's roughness coefficient

PROCEDURE:

1 Use topographic mapping and planimetric features to establish the watersheds boundaries and ground surface cover for the plant.
See Figure 1 for watershed boundaries.
See Table 1 for watershed area and summary of ground surface features.

Table 1

Watershed	B'	B''	C	C'	D	E
Area, sf	159,199	56,414	105,492	67,375	798,171	823,814
Area, ac	3.7	1.3	2.4	1.5	18.3	18.9
Area, mi^2	0.005710	0.002024	0.003784	0.002417	0.028630	0.029550
Surfacing	Grass	Grass	Grass	Grass	CCR	CCR
Curve No.	78.0	78.0	78.0	78.0	73.0	73.0
S	2.8	2.8	2.8	2.8	3.7	3.7
Ia	0.56	0.56	0.56	0.56	0.74	0.74

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
Project Number : 85009

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-003
ISSUED DATE:	10/16/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	V. Larson

OBJECTIVE: Provide calculations to demonstrate the hydrologic run-on and run-off per 40 C.F.R. Part 257 §257.81.

PROCEDURE (continued):

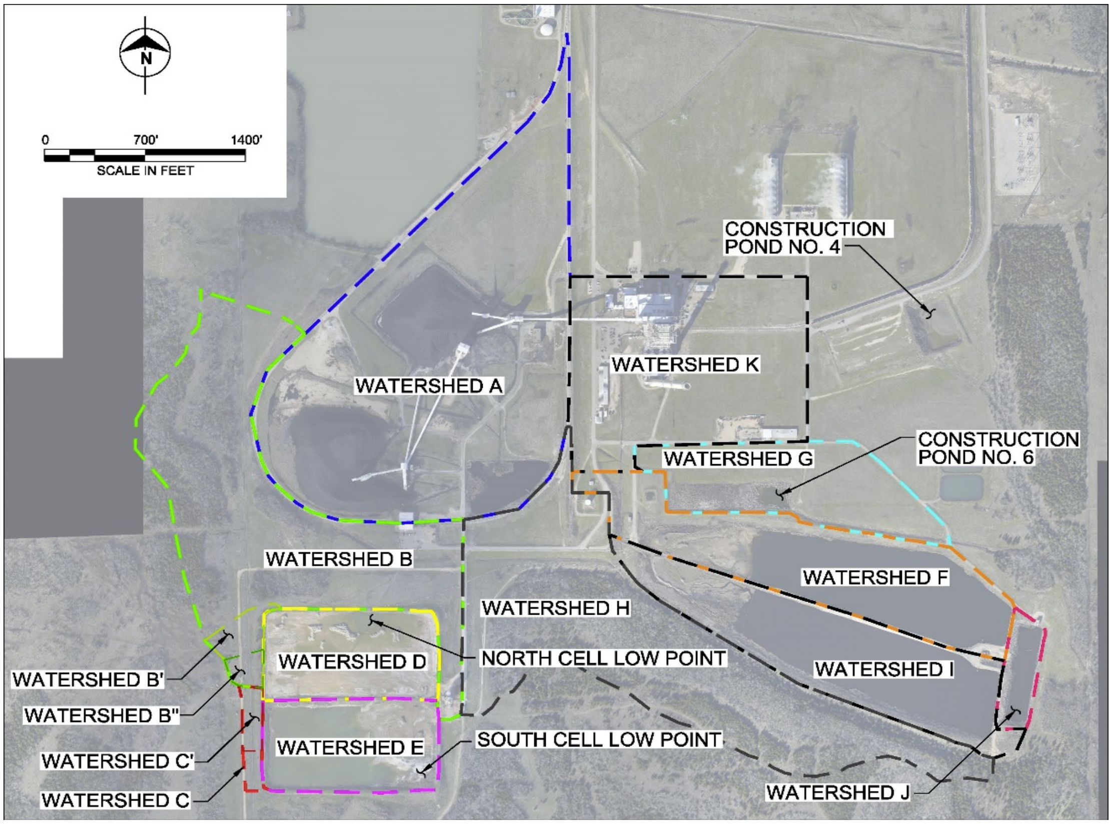


Figure 1 - Watershed Boundaries for Plant

Watershed A drains through the coal pile runoff pond into the impoundments.
Watershed B is diverted around the Coal Pile and CCR Landfill into a ditch that goes through Watershed H.
Watershed B' and B'' are sub-watershed of Watershed B. Peak discharges will be calculated for these sub-watersheds to evaluate the ditch's capacity.
Watershed C drains to the south side of the site.
Watershed C' is a sub-watershed of Watershed C. Peak discharges will be calculated for these sub-watersheds to evaluate the ditch's capacity.
Watershed D is the north half of the CCR Landfill which drains to a low point on the north side of the cell.
Watershed E is the south half of the CCR Landfill which drains to a low point on the east side of the cell.
Watershed F drains through various open ditches and pipes to the impoundments.
Watershed G drains to the north side of the CCR Impoundment.
Watershed H drains to the south side of the CCR Impoundment.
Watershed I consists of the area immediately around the south impoundment.
Watershed J is the Process Waste Pond.
Watershed K drains the plant to Construction Pond 4.
Watersheds A, F, G, H, I, J, and K do not runoff to the CCR Landfill, and therefore they are excluded from further consideration in this calculation.

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-003
ISSUED DATE:	10/16/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	V. Larson

OBJECTIVE: Provide calculations to demonstrate the hydrologic run-on and run-off per 40 C.F.R. Part 257 §257.81.

PROCEDURE (continued):

2 Use topographic features to establish time of concentration.
See Table 2 for summary of time of concentration calculations.

Table 2

	B'	B''	C	C'	D	E	Notes
Sheet							
n	0.150	0.150	0.150	0.150			
L (ft)	150.00	150.00	150.00	150.00			(total < 150ft)
P_2 (in)	4.45	4.45	4.45	4.45			
$S_{decimal}$ (ft/ft)	0.010	0.010	0.017	0.017			
t_{sheet} (hr)	**0.25**	**0.25**	**0.21**	**0.21**			Equation 1
t_{sheet} (min)	**15.16**	**15.16**	**12.36**	**12.36**			Equation 1
Shallow							
L (ft)	157.00	84.00	81.00	81.00			
$S_{decimal}$ (ft/ft)	0.054	0.101	0.068	0.068			
$v_{shallow}$ (fps)	3.75	5.13	4.20	4.20			Equation 3
$t_{shallow}$ (s)	**41.82**	**16.37**	**19.27**	**19.27**			Equation 2
$t_{shallow}$ (m)	**0.70**	**0.27**	**0.32**	**0.32**			Equation 2
Channel							
L (ft)	319.00	0.00	591.00	298.00			
$S_{decimal}$ (ft/ft)	0.0089	0.0044	0.0050	0.0043			
$v_{channel}$ (fps)	5.00	5.00	5.00	5.00			
$t_{channel}$ (s)	**63.80**	**0.00**	**118.20**	**59.60**			Equation 4
$t_{channel}$ (m)	**1.06**	**0.00**	**1.97**	**0.99**			Equation 4
t_c (min)	**16.92**	**15.44**	**14.65**	**13.68**	**0.00**	**0.00**	Equation 5
t_{lag} (min)	**10.15**	**9.26**	**8.79**	**8.21**	**0.00**	**0.00**	Equation 6

*Rain that falls directly on the Landfill immediately converts to runoff, therefore, there is no time of concentration.

3 Set up North Cell Low Point and South Cell Low Point as Reservoir to model the storage capacity for Run Off.
See Table 3 for Elevation Area data.

Table 3

North Cell Low Point		South Cell Low Point	
Elevation	Area	Elevation	Area
ft	ac	ft	ac
510	8.6737	500	10.1896
511	13.9211	501	11.2516
512	15.9307	502	12.0882
513	16.4192	503	12.5744
514	16.7585	504	13.0548
515	17.0966	505	13.5532

4 Set up Meteorological Model
SCS Storm Type 2
25-year - 24 hours Rainfall 7.55 inches

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-003
ISSUED DATE:	10/16/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	V. Larson

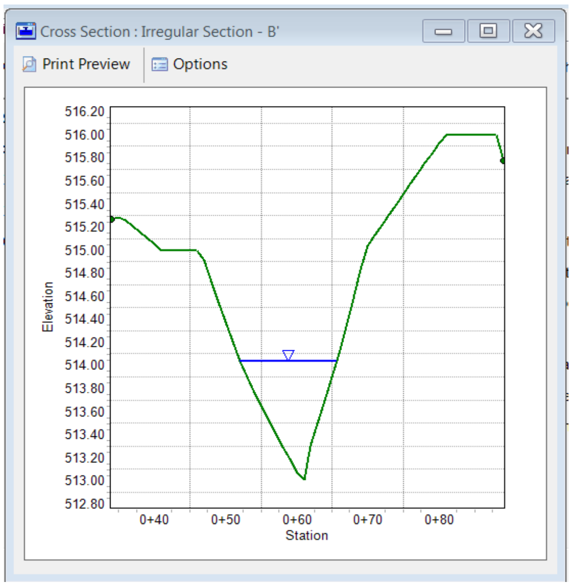
OBJECTIVE: Provide calculations to demonstrate the hydrologic run-on and run-off per 40 C.F.R. Part 257 §257.81.

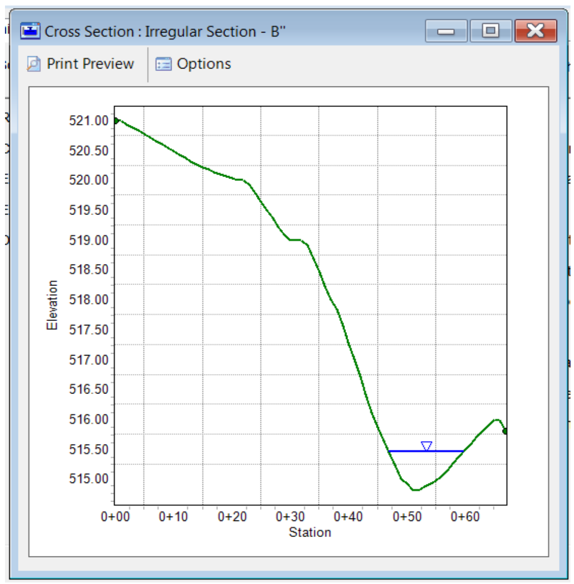
PROCEDURE (continued):

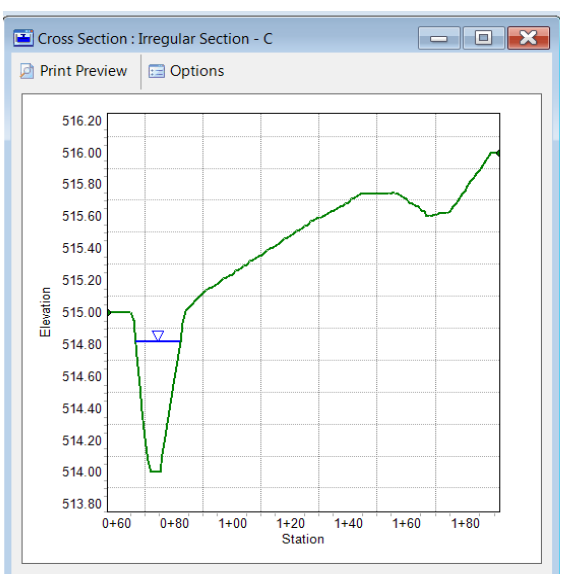
5 Set up Control Specification.
Use 1 minute to be conservative.

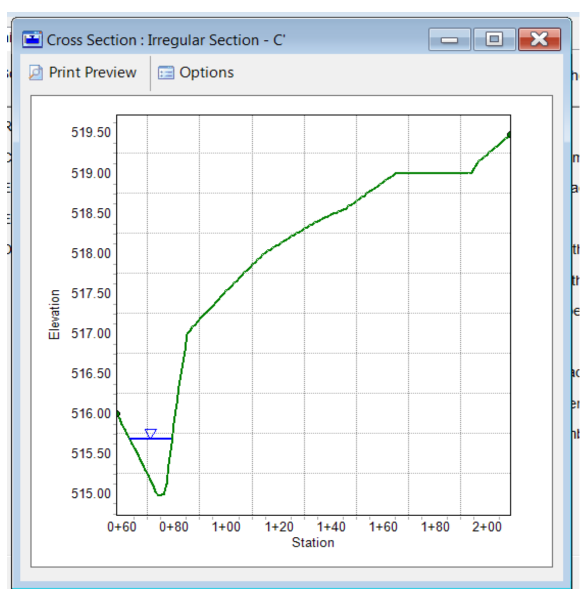
6 Run HEC-HMS.
Graphs of water surface elevation in the North Cell Low Point and South Cell Low Point show the water elevation not over topping.

7 Plug peak discharges for B', B'', C and C' from HEC-HMS into FlowMaster.
FlowMaster shows the ditches have capacity to carry the 25 year 24 hour peak runoff.









CREATE AMAZING.

Burns & McDonnell World Headquarters
9400 Ward Parkway
Kansas City, MO 64114
O 816-333-9400
F 816-333-3690
www.burnsmcd.com