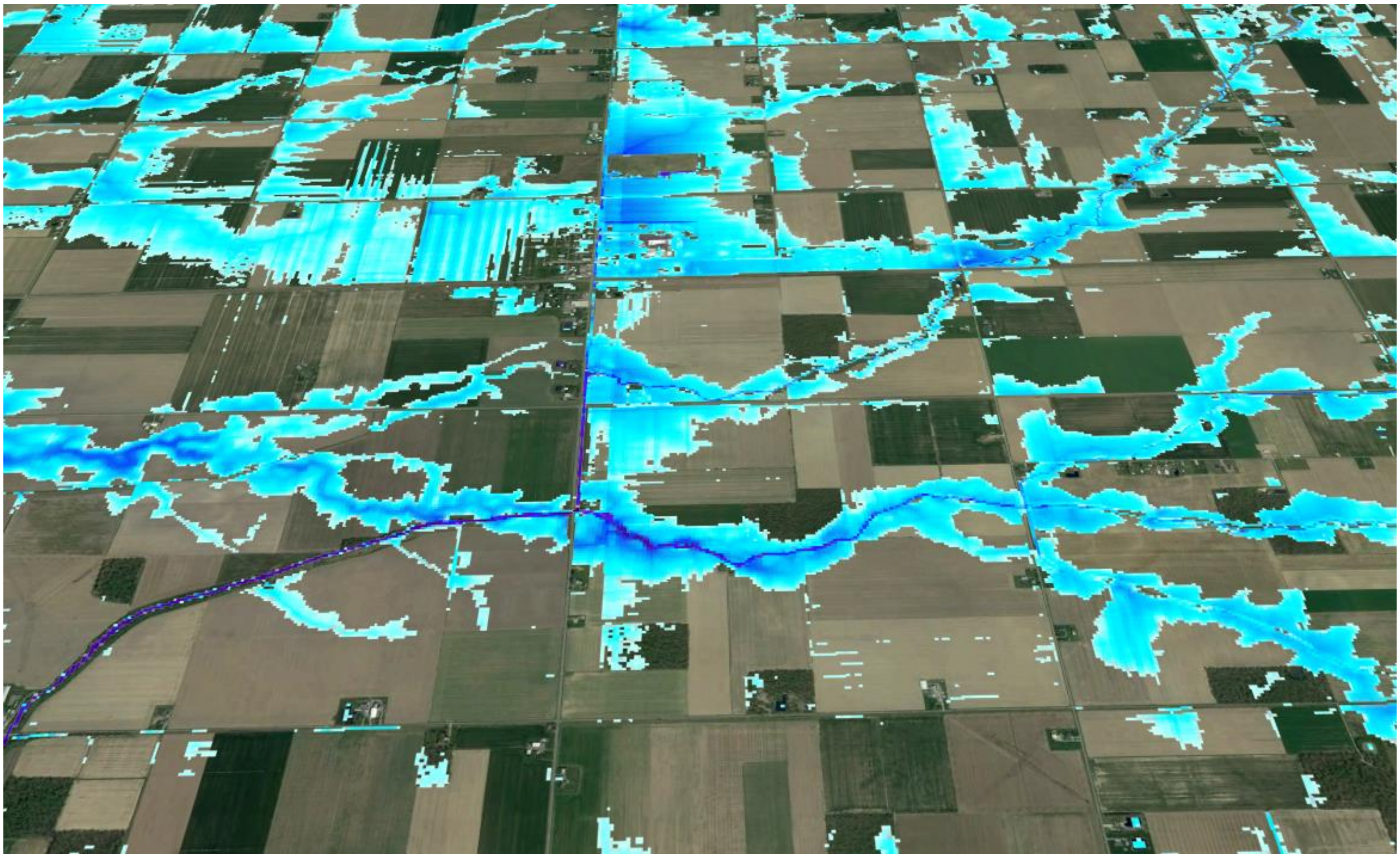

HYDROLOGY STUDY

Powell Creek Solar Project

Putnam County, Ohio

MARCH, 2020

PREPARED FOR:

AVANGRID RENEWABLES

PREPARED BY:

Westwood

Hydrology Study

Powell Creek Solar Project

Putnam County, Ohio

Prepared For:

Avangrid Renewables
1125 NW Couch St., Suite 700
Portland, OR 97209

Prepared By:

Westwood Professional Services
12701 Whitewater Drive, Suite 300
Minnetonka, MN 55343
(952) 937-5150

Project Number: R0026093.00
Date: March 27, 2020

Table of Contents

Exhibits

Appendices

Executive Summary

The purpose of the study is to describe the hydrology of the proposed Powell Creek Solar Project ("the project") and any impacts that the hydrology may play in the design of the solar array.

The project area is located approximately 15 miles southeast of the city of Defiance in Putnam County, Ohio (Exhibit 1). The project site is located on extremely flat slopes. The landscape generally slopes to the west towards Powell Creek. The southern portion of the modeled area slopes to the south towards the Blanchard River. The modeled watershed area encompasses approximately 47 square miles.

FEMA has completed a study to determine flood hazards for the selected location, and the project area is covered by FEMA FIRM panels 39137C0135D and 39137C0155D. The modeled area contains a portion of mapped FEMA Zone A and Zone AE flood hazards with a small area of FEMA Zone A within the project boundary. No pending FEMA data was located that will affect the project area.

The hydrologic modeling in this report was created using FLO-2D modeling software. Because of the complex and distributary nature of flow paths upstream and through the project site, FLO-2D hydrologic/hydraulic modeling software was utilized to determine flow depths and velocities throughout the site.

Overall, the analysis shows low to moderate water depths and low velocities (Exhibits 6 - 7A) across the majority of the site. The project location has a moderate amount of rainfall associated with storm events, an overall curve number of 87 and minimally sloping terrain. During a 100-year storm the flood depths across the majority of the project area are less than 1.5 feet with velocities less than 1 foot/second. Larger flood depths occur near areas of concentrated flow. See Exhibits 6 through 16A for areas within the project with higher flood depths, velocities and scour for the 2, 10, 25, 50 and 100-year, 24-hour storms.

Data Sources

TABLE 1: DATA SOURCES

Task	Format	Source	Use
Elevation	2.5-foot Digital Elevation Model (DEM)	2006 Ohio State Imagery Program (OSIP) Lidar: North	Hydrologic Model Elevations (onsite and offsite)
Crop Data	Shapefile	USDA 2013 Crop Data Layer	Landcover
Soils	Shapefile	USGS SSURGO Dataset	Curve Numbers
Precipitation	PDF File	NOAA Atlas 14	Design Storms
HUC-12 Drainage Boundary	Shapefile	USGS Data Gateway	Define Model Extents
Site Boundary	KMZ	Avangrid Renewables	Define Model Extents
2014 Aerial Photography	ArcGIS Map Service	USDA FSA	Reference

Existing Conditions

The project area is located approximately 15 miles southeast of the city of Defiance in Putnam County, Ohio (Exhibit 1). The project site is located on extremely flat slopes. The landscape generally slopes to the west. The southern portion of the modeled area slopes to the south towards the Blanchard River.

Watershed Hydrology

The modeled watershed area encompasses approximately 47 square miles. The landscape has many areas of concentrated flow due to drainage ditches and part of North and South Powell Creek.

Onsite Conditions

Areas directly adjacent to the creeks contain steeper slopes, but in general the slopes throughout the site are less than 1%. The project area is primarily used for agricultural row crops (Exhibit 4) and has soils generally belong to Hydrologic Soil Group D (Exhibit 3). The main potential hydrologic issue on site is flooding and extended periods of standing water with muddy site conditions due to clay soils.

FEMA Flood Zones

FEMA has completed a study to determine flood hazards for the selected location. The project area is covered by FIRM panels 39137C0135D and 39137C0155D. The project area contains FEMA Zone A flood hazards on the western side (Exhibit 2). The modeled area contains a portion of mapped FEMA Zone A and Zone AE flood hazards with a small area of FEMA Zone A within the project boundary. A FEMA Zone A is a 100-year flood hazard with no defined base flood elevation, and FEMA Zone AE is with defined base flood elevations (Exhibit 2). No pending FEMA data was located that will affect the project area.

Proposed Conditions

The majority of the proposed solar facility will consist of above ground mounted solar modules. Meadow grass will be planted below the modules and will make up a majority of the land cover. A small amount of impervious surface will be added from the gravel access roads and electrical equipment pads. The project should be designed to minimize grading and maintain existing drainage patterns. Any existing drain tile onsite should be protected or replaced in order to provide proper drainage to the site.

Post-Construction Stormwater Management

The project will be subject to the State of Ohio's stormwater discharge permit and the Municipal separate storm sewer systems (MS4) permit. Additionally the project will need to follow the Ohio EPA Guidance of Post-Construction Storm Water Controls (Appendix C) for solar panel arrays. Based on this guidance small amounts of storage will be needed to account for the added impervious areas of roadways, buildings, and inverter pads, along with storage for the panels if the soils are not functionally restored.

The typical solar project's low-impact development technique of converting the land cover from a row crop field to a meadow grass will provide post-construction stormwater management to meet most agency requirements. The proposed meadow grass will act as a vegetated filter providing both runoff treatment and reduction when compared to existing conditions. As the project design advances the post-construction stormwater management should be reviewed in further detail with the County Engineer.

FLO-2D Modeling

FLO-2D is a physical process model that routes rainfall runoff and flood hydrographs over flow surfaces or in channels using the dynamic wave approximation to the momentum equation. FLO-2D offers advantages over 1-D models and unit hydrograph methods by allowing for breakout flows and visualization of flows across a potential site. This is particularly useful on a flat site that receives offsite flows, such as the project site. The primary inputs are a DTM (elevation data), curve numbers and precipitation. Major culverts impacting the site were modeled based on aerial imagery provided by Google Earth.

Because of the complex and distributary nature of flow paths upstream and through the project site, a FLO-2D model with 40' grid cells was utilized to determine flow depths and velocities throughout the site.

Elevation Data

The elevation data input into the FLO-2D model was 2.5-foot DEM data from the Ohio Geographically Referenced Information Program (Exhibit 5), which was incorporated into the DTM using the export to xyz function in Global Mapper. These XYZ files are read directly into FLO-2D.

Watershed Soils and Land Cover

USDA-NRCS SSURGO soil data provides soil types within the project boundary and full coverage of the contributing watershed. Soils in the area are primarily classified as Hydrologic Soil Group D in the project boundary (Exhibit 3). Land cover was obtained from the USDA 2013 Crop Data Layer. Exhibit 4 displays the land cover classes for the entire watershed. Curve numbers were applied to each grid cell in the FLO-2D model based on intersecting the grid with the curve numbers (Exhibit 5).

Precipitation

Precipitation data was downloaded from the NOAA Atlas 14 (Appendix A) and used for the FLO-2D analysis for the 2, 10, 25, 50 and 100-year, 24-hour storm. The rainfall depths of 2.48, 3.53, 4.21, 4.75 and 5.33 inches, respectively, were distributed based on a nested Type II rainfall distribution and input into FLO-2D based on Avangrid requirements for modeling storm events. Using a variety of storm events allows for the results to be bracketed and the worst areas of flooding and erosion to be identified.

Crossing Sizing

Once the final layout of the project area has been determined and prepared, crossing locations should be determined by using the 100-year FLO-2D results and generated drainage streamlines to identify areas of concentrated flow. Based upon field conditions, either a culvert or LWC option will be recommended to help prevent erosion in those locations. Culverts are recommended where an incised channel is crossed or along steep slopes where it is possible to have the optimal amount (1'+) of cover over the culvert crown. Low water crossings are recommended in flat areas of terrain.

Avangrid Drainage Crossing Design Requirements

The following drainage crossing design requirements were received from Avangrid and will be used in future drainage crossing design. Hydraulic sizing of structures including 48” and smaller will be performed using the 25-year 24-hour duration storm event results from the hydrologic analysis. At County and State Right of Way Project engineer shall use the 50-year or 100-year 24-hour duration storm event results for the hydrologic analysis. All culverts are to be the sized 18 inch or larger. Culverts are to be proposed where there is a defined channel or if low-water crossing is not feasible. If access roads are overtopped during any of the storm events noted in section 3.1.2 Project engineer shall use appropriately designed embankment sections with the use of head walls or wing walls. All culvert inlets and outlets should be protected with appropriately designed controls or best management practices to withstand the computed velocity, shear stresses and water depth. All temporary crossings (crane walks and intersections improvements) shall be designed using the above criteria. Proposed bridges and culverts (over 48” diameter) shall be designed to accommodate the 100-year 24-hour duration storm event.

Contractor shall evaluate and analyze each major drainage crossing. Where it is determined that a bridge or large culvert structure is necessary, Contractor shall prepare structural and civil plans using the appropriate design standards, in compliance with agency requirements, whether local and/or state DOT, USACE, etc., for Owner review and comment. Contractor shall review each lease agreement to propose appropriate type of structure at drainage crossings.

Hydraulic sizing of low water crossing structures will be performed using the 25-year 24-hour duration storm event results from the hydrologic analysis. Low-water crossings are to be proposed where there are no defined channels. All low-water crossings should be designed to withstand the computed velocity, shear stresses and water depth with a length derived from the modeling results. Project engineer shall prepare calculations to demonstrate how allowable shear stress was determined.

Flood Analysis Results

Existing Conditions Flood Analysis

The analysis shows low to moderate water depths and low velocities (Exhibits 6 through 16A) across the majority of the site. During a 100-year storm, the flood depths across the majority of the project area are less than 1.5 feet with velocities less than 1 foot/second. See Exhibits 6 through 16A for areas within the project with higher flood depths and velocities. Minimal scour is expected on site (Exhibit 8).

Recommendations

Based on experience on similar projects, the site is suitable for the planned development, and hydrologic concerns can be addressed by either avoiding areas of high flood depths or through detailed engineering design.

Next Steps

1. Final engineering design should account for the flood depths, velocities, and scour presented in Exhibits 6-8 to protect infrastructure.

2. Facilities to be elevated 2’ above the 100-year, 24-hour peak flood elevations.

3. Proposed facilities should avoid FEMA Flood Zones located onsite.

4. Stormwater management should be revisited to ensure the final design meets the local and state requirements.

5. Any drain tile found on site should be protected or replaced in order to provide proper drainage to the site.

6. Crossing locations should be identified

7. Depth at infrastructure locations should be identified.

Included Output Files

1. Shapefile of Flow Depth-100-year Rain Event

2020-03-23_PowellCreek_100yrFlowDepth.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Max Flow Depth (Feet)

2. Shapefile of Velocity-100 year Rain Event

2020-03-23_PowellCreek_100yrVelocity.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Velocity (FPS)

3. Shapefile of Flow Depth-50-year Rain Event

2020-03-23_PowellCreek_50yrFlowDepth.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Max Flow Depth (Feet)

4. Shapefile of Velocity-50 year Rain Event

2020-03-23_PowellCreek_50yrVelocity.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Velocity (FPS)

5. Shapefile of Flow Depth-25-year Rain Event

2020-03-23_PowellCreek_25yrFlowDepth.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Max Flow Depth (Feet)

6. Shapefile of Velocity-25 year Rain Event

2020-03-23_PowellCreek_25yrVelocity.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Velocity (FPS)

7. Shapefile of Flow Depth-10-year Rain Event

2020-03-23_PowellCreek_10yrFlowDepth.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Max Flow Depth (Feet)

8. Shapefile of Velocity-10 year Rain Event

2020-03-23_PowellCreek_10yrVelocity.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Velocity (FPS)

KMZ Legend

Depth (FT)

≤ 0.5′
> 0.5′
1′ +
2′ +
3′ +
4′ +
5′ +
10′ +
≥ 15′

KMZ Legend

Velocity (FPS)

< 1
1 +
2 +
3 +
4 +
5 +
6 +
8 +
10 +
12 +
15 +
≥ 20

9. Shapefile of Flow Depth-2-year Rain Event

2020-03-23_PowellCreek_2yrFlowDepth.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Max Flow Depth (Feet)

10. Shapefile of Velocity-2 year Rain Event

2020-03-23_PowellCreek_2yrVelocity.shp
Attribute "ID" = Grid Cell Number
Attribute "VAR" = Velocity (FPS)

11. KMZ of Flood Depth- 2, 10, 25, 50, 100-year Rain Event

2020-03-24_PowellCreek_FlowDepth.kmz
Overlay in Google Earth for graphical representation
Attribute "VAR" = Max Flow Depth (Feet)

12. KMZ of Velocity- 2, 10, 25, 50, 100-year Rain Event

2020-03-24_PowellCreek_Velocity.kmz
Overlay in Google Earth for graphical representation
Attribute "VAR" = Velocity (FPS)

References Cited

National Engineering Handbook, Part 630 Hydrology. Chapter 9 Hydrologic Soil-Cover Complexes. USDA. NRCS. 210-VI-NEH, December 2004

NOAA, & Service, N. W. AHPS Precipitation analysis. Retrieved February 2020, from http://water.weather.gov/precip/download.php

Ohio Geographically Referenced Information Program. 2.5-ft DEM, Elevation data, retrieved March 2020, from http://gis5.oit.ohio.gov/geodatadownload/

USGS. USGS water resources: About USGS water resources. Retrieved February 2020, from https://water.usgs.gov/GIS/huc.html

USDA 2013 Crop Data Layer, Landcover data, retrieved February 2020, from https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php

This foregoing document was electronically filed with the Public Utilities

Commission of Ohio Docketing Information System on

10/7/2020 10:25:56 AM

in

Case No(s). 20-1084-EL-BGN

Summary: Application Exhibit G - Hydrology Study (Part 1 of 4) electronically filed by Teresa Orahood on behalf of Dylan F. Borchers