APPENDIX I

Drainage Study
JVR Energy Park
Part 1

DRAINAGE STUDY

JVR Energy Park

San Diego County, California

Grading Permit No: PDS2019-LDGRMJ-30240

PREPARED FOR

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1 DECLARATION OF RESPONSIBLE CHARGE

I hereby declare that I am the Civil Engineer of work for this report, that I have exercised responsible charge over the preparation of this report as defined in section 6703 of the business and professions code, and that the report is consistent with current project concept.

I understand that the check of this report by the County of San Diego is confined to review only and does not relieve me, as engineer of work, of my responsibilities for the report.

08/11/2020

David M. Bossu, RCE No. 78103 *Date*

Kimley»Horn

2 INTRODUCTION

JVR Energy Park, LLC is currently developing a Solar photovoltaic (PV) facility, JVR Energy Park, in the south of San Diego county. This report will be a part of a larger Environmental Impact Report (EIR) prepared for the project. The report has been prepared in accordance with the San Diego County (SDC) Hydrology Manual guidelines.

This Drainage Study (the report), will work to analyze the hydrologic characteristics of the existing watershed and the hydrologic and hydraulic impact of the proposed PV facilities on the watershed. Watershed hydrologic run-off calculations were performed for the 100-year storm event using the San Diego County Unit Hydrograph Program (SDUH). An analysis of the 100-year flood level was conducted using the Army Corps of Engineers Hydrologic Engineering Centers River Analysis System (HEC-RAS) software.

Model inputs and results are discussed throughout this report. The goal of the report is to deliver a comprehensive study of the watershed which features its existing and post-development hydrologic characteristics.

3 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The proposed site is located within the Jacumba Valley; An unincorporated area in south-east San Diego County, near the US-Mexico Border. The project abuts the US-Mexico border on its southern side and is 3.8 miles west of the San Diego/ Imperial County border, located at Latitude 32°37'30" N, Longitude 116°10'33" W. See Figure 1 in Appendix A for Vicinity Map.

The site's developed area will span approximately 646 acres and lies at the near end of an approximate 111 square-mile (71,040 acre) watershed. The watershed contributing to the site, flows from south to north, with approximately two-thirds (2/3) of the watershed being located in Mexico.

3.2 SITE DESCRIPTION

The project will consist of a 90MW Solar generation facility. This facility will provide electricity that will be utilized in the public utility grid.

Onsite improvements will consist of inverter skids, all weather access roads, and photovoltaic (PV) modules. General impervious area for solar facilities is very low. Generally, the only impervious area will come from the addition of PV piles, inverter skids, battery skids, and additional substation area.

The solar facility will utilize PV modules to convert energy in the form of light, into electricity by way of the "photovoltaic effect". These modules will be mounted on a tracker mounting system. Tracker mounting systems have the ability to dynamically track the sun as it moves across the sky during the day. The racking systems are generally mounted 5-ft to 7-ft above finished grade. However, this range can vary dependent on the expected depth of the 100-year flood. Maximum mounting height is typically 8-ft. The tracker systems are supported by steel piles that are driven into the surrounding ground. These piles make up a very small percentage of the total area the modules will encompass. The PV modules require a few key supporting pieces of infrastructure, including combiner boxes, inverters, gen-tie lines, and substation. These structures will be detailed in the accompanying construction documents and are designed to handle the 100-year flood as outlined in this report. The hydrologic conditions that will be influenced by said improvements will be outlined in the following sections.

3.3 RAINFALL

Rainfall data for the proposed project were found using the isopluvial maps within the San Diego County Hydrology Manual (SDCHM). The vales for the 100-year event are as follows.

100-year 6-hour Rainfall (P_6) = 3.0 inches

100-year 24-hour Rainfall (P_{24}) = 5.0 inches

The isopluvial maps for the 6-hour and 24-hour events can be found in Appendix D.

4 EXISTING DRAINAGE (PRE-DEVELOPMENT CONDITION)

4.1 METHODOLOGY

The proposed site lies at the end of a 111 square-mile watershed. The site is bordered by lowland hills to the east and west, the US-Mexico border to the south, and mountainous canyons to the north. Approximately two-thirds (2/3) of the watershed resides within Mexico. Much of the watersheds existing land consists of rural undeveloped land scattered through lowland hills in the south and north. The watershed boundary was delineated using the *Streamstats Application* along with analysis of the Topographic contours. Streamstats is an online interactive program developed by the United States Geologic Survey (USGS).

The San Diego County Unit Hydrograph Peak Discharge Program (SDUH) was used to estimate off-site flows.

The 111 square-mile watershed was broken into four distinct sub basins; the south, west, east, and mid basins (See Appendices A & B). Subasins are defined by the drainage areas contributing to offsite streams that eventually make it onsite. Basin #2 (West) contains the drainage area from *Boundary Creek.* Basin #3 (East) contains the drainage area for runoff traveling from the east that concentrates along Highway 8 and Old Highway 80. Basin #1 (South) contains the drainage area that is contributing from south of the US Border. This flow will concentrate and then sheet flow across the southern portion of the site. Basin #4 (Mid) contains the west and north drainage areas, along with additional on-site drainage area.

The SDUH program utilizes Corps Lag time in its calculations. Corps Lag times were calculated using SDCHM Section 4.1.5.2. See Appendix B for Lag Time Calculations. Other program inputs are described in the following sections. The calculated Corp Lag was used as an input in the SDUH Program. The peak discharge generated for the SDUH on-site/offsite analysis was ***26,000 CFS.*** See *Figure 7 & 8* for associated on-site flood depths.

4.2 EXISTING TOPOGRAPHY

The proposed site is located in the south-eastern portion of unincorporated San Diego county. The site will reside in a large valley, bordered by hills to the west and east. On-site elevations range from 2750-ft to 2800-ft. Elevations of the contributing watershed range from 2710-ft to 4500-ft. Site drainage flows from south to north. An existing topographic map is shown on Figure 2.

Flows from storm event are shallowly concentrated within the valley that our site will reside in, and then further concentrated into a steam to the north of our site. This stream terminates into the Salton Sea.

4.3 EXISTING HYDROLOGIC SOIL GROUPS

Existing hydrologic soil groups across the site and watershed are used to determine the expected amount of runoff for the given storm event. Hydrologic soil groups are categorized by A, B, C, and D. Each group is representative of a soil's potential for run-off. The hydrologic soil groups for the proposed site were determined using Web Soil Survey (WSS). WSS is a national public data base for soils data. Soils data was not available in the most remote eastern area of the watershed, as well as those areas located within Mexico. Hydrologic soil groups (HSG) were assigned to these areas using information from the adjacent hydrologic soil groups that were provided, as well as the use of aerial photography. Aerial photography provides general marks on shifts in landscape. Coupled with HSG from adjacent areas, reasonable assumptions can be made on the HSG for the

unknown areas. See Figure 3 for watershed HSG's. A breakdown of the watershed HSG values is provided below.

Table 1

Watershed Hydrologic Soil Groups

Hydrologic Soil Group	Area (Square-Miles)	Percentage of Area
A	32.17	28.9%
B	0.97	0.9%
C	5.48	4.9%
D	72.61	65.3%
Total	**111.23**	**100.0%**

4.4 EXISTING LAND USE AND LAND COVER

Existing Land use areas were based on Geographic Information System (GIS) Shapefiles provided by San Diego Counties *SanGIS* website. In conjunction with the land use areas, land cover data was used from the National Land Cover Database (NLCD). See Figures 5 and 6 for existing land cover and land use maps respectively.

Major existing land cover types onsite include desert shrub/scrub, field crops, herbaceous grassland, and woody wetlands to the north. land cover data for areas in Mexico were not available and were assumed as shrub/scrub.

Major existing land usage consists of field crops, spaced rural residential, and vacant undeveloped land. The proposed site is bordered by single family detached units to the west, site retail and commercial to the north-east, and the Jacumba Valley Airport to the east. The majority of surrounding land consists of vacant undeveloped land, open space, and barren land. While data within Mexico is not available, based on aerial photography, land use and land cover remain similar; consisting of small rural residential lots and barren undeveloped land.

4.5 CURVE NUMBER

Curve numbers for the watershed were produced using SDCHM Table 4-2 for curve numbers. These tables rely on a combination of land use/land cover parameters and hydrologic soil group information. Curve numbers were applied to every land cover and HSG combination. These curve numbers were then modified using the Precipitation Zone Number (PZN) Conditions specified in SDCHM section 4.2.4. ArcGIS ArcMap software was used to create a weighted average by area for the curve numbers.

4.6 HYDROLOGIC RESULTS

The SDUH program model produced in this report, shows an estimated runoff of 26,000 cfs for northern study point. See Table 2 for existing hydrologic results. The Peak Q values in Table 2 were used in the hydraulic analysis using HEC-RAS.

Table 2

Existing Condition Peak Flows; 100-Year 24-Hour Storm (Figure 7)

Basin	Existing results per SDCHM (Unit Hydrology Method) using SDUH program				
	Area (Mi^2)	Weighted CN	Lag Time (hours)	Peak Q_{100} (cfs)	Peak V_{100} (fps)
Basin #1 (South)	82	83	2.81	24,661	7.1
Basin #2 (West)	19.5	68	2.75	4,181	5.1
Basin #3 (East)	6.9	70	1.49	2,521	5.29
Basin #4 (Mid)	104.2	79	3.14	25,740	14.7
Watershed Outlet	111	79	3.35	26,164	10.2

Source: See Appendix B for Lag Time Calculations
Notes: CN = Curve Number; V100 for Basin #1, Basin #2, and Basin #3 were calculated as Flow Distance / Lag Time. V100 for Basin #4 and Watershed Outlet were found using HEC-RAS cross-sections.

5 PROPOSED DRAINAGE (POST-DEVELOPMENT CONDITION)

The impacts of solar facilities on the hydrologic process and methods to quantify any impact have not been widely documented in the civil engineering industry. A study published in the Journal of Hydrologic Engineering researched the hydrologic impacts of utility scale solar generating facilities. The study utilized a model to simulate runoff from pre- and post-solar panel conditions. The study showed that the solar panels themselves have very little impact on runoff volumes or rates (Cook and McCuen, 2013). Increases in runoff were found from other well-documented causes such as increased imperviousness or significant reduction in vegetal cover.

The proposed site will add a few pieces of infrastructure, including steel piles (for tracker system), access roads, combiner boxes, inverters, gen-tie lines, and substation. It is anticipated that these additional items will cause minimal impact to the site hydraulics and hydrology. See section 5.4 for discussion.

Drainage patterns will be maintained from the pre- to post condition. See Section 5.2.

5.1 METHODOLOGY

See Section 4.1 for Methodology.

5.2 PROPOSED TOPOGRAPHY/GRADING

Onsite grading will be sparse and minimal. Grading onsite will not change the overall drainage pattern of the site. See grading plan for onsite grading.

5.3 PROPOSED HYDROLOGIC SOIL GROUPS

See Section 4.3 for watershed Hydrologic Soil Groups

5.4 PROPOSED LANDUSE/LAND COVER

Increases in imperviousness for the project will be minimal. Onsite access roads will be compacted native or gravel similar to existing conditions. The site has very little vegetation and only minor grading is expected with no changes to the existing site drainage patterns. The proposed project will produce approximately 1.9 acres (0.0030 square-miles) of impervious area. This impervious area is added to existing barren/crop land that is pervious. For the purpose of this calculation, impervious areas were assumed to be the PV Tracker pile area, inverter skids, battery skids, and additional substation pads. The proposed all weather access roads were assumed be pervious. Proposed hydraulic obstructions include fencing, tracker piles, and landscaping.

The additional impervious area represents 0.0027% of the watershed that is contributing to the stream passing through the proposed site. This increase in impervious area constitutes a small enough area to confidently assume that the additional impervious area for the solar site will have minimal to no impact on the existing watershed hydrologically.

5.5 CURVE NUMBER

On-site increases in impervious has no calculable impact on CN values, see section 5.3. Therefore, CN values have not be modified for the proposed drainage condition. See section 4.4 for details on determining CN values.

5.6 HYDROLOGIC RESULTS

Table 3

Proposed Condition Peak Flows; 100-Year 24-Hour Storm (Figure 8)

The SDUH program model produced in this report, shows an estimated runoff of 26,000 cfs for watershed outlet. See Table 3 for post-condition hydrologic results. The Peak Q values in Table 3 were used in the hydraulic analysis using HEC-RAS.

Basin	Proposed results per SDCHM (Unit Hydrology Method) using SDUH program				
	Area (Mi^2)	Weighted CN	Lag Time (hours)	Peak Q_{100} (cfs)	Peak V_{100} (fps)
Basin #1 (South)	82	83	2.81	24,661	7.1
Basin #2 (West)	19.5	68	2.75	4,181	5.1
Basin #3 (East)	6.9	70	1.49	2,521	5.29
Basin #4 (Mid)	104.2	79	3.14	25,740	14.7
Watershed Outlet	111	79	3.35	26,164	10.2

Source: See Appendix B for Lag Time Calculations
Notes: CN = Curve Number

6 HYDROLOGIC IMPACTS AND MITIGATION

It is expected that proposed site features that could potentially obstruct the flow of runoff through the site will produce very little impact (Cook and McCuen, 2013). Trackers piles comprise a small enough cross-sectional area as to expect they would not obstruct flow in any significant manner.

Because on-site features will be elevated off the ground, storm water runoff will be conveyed through the site as it was in the existing condition. No proposed drainage structures will be constructed as part of the scope of this project. The proposed site will not utilize channels or underground piping to convey runoff. Proposed equipment will be constructed above the 100-year flood plain, allowing runoff to sheet flow across the site. Current tracker design will utilize flood sensors to automatically switch modules into "stow" mode in the case of severe site flooding. This "stow" mode rotates the modules to a more horizontal position, lifting their leading edge to a higher position.

Fencing will also encompass the site. Because of the potential effects of debris blockage on fencing perpendicular to flow, special fencing will be proposed along these sections. The two types of fencing discussed with San Diego county include *Breakaway Fencing* and *Flow-Through Fencing.* Per discussion with the County of San Diego, either of these fencing options would be viable for the Project. *Breakaway Fencing* would not require any additional modeling, while the use of *Flow-Through Fencing* would require the use of the obstruction function within HEC-RAS to properly model the fence. This analysis assumes *Breakaway Fencing* will be utilized. This type of fencing is County approved and will mitigate the effects of high flows and blockages caught by the fencing.

7 100-YEAR FLOOD INUNDATION

The existing flood zone designation of the proposed site was characterized as *Zone D,* per the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) 06073C2350F. This designation is considered "Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk". An analysis of the flood plain for the proposed site will be used to both inform the county of the changes to an existing watershed, as well as provide professional guidance on the potential risks to the proposed site features located within the floodplain.

The 100-year-24-hour storm event was analyzed for the proposed site using the watershed limits that contribute to the stream running through the proposed site and into a concentrated stream to the north. The analysis was run with HEC-RAS software using publicly available data. The inundation depths for the 100-year storm are shown in Figures 7 and 8. AutoCAD Civil 3D was used to translate HEC-RAS results into a 3D Water surface elevation (WSE) inundation surface.

The peak Q values described in Table 2 were used to hydraulically model the on-site runoff. The on-site HEC-RAS model was analyzed using three (3) separate streams. See Appendix C for stream map detailing locations of HEC-RAS streams. *Stream 1* was used to model the 4,181 cfs peak flow from Basin #2 (West). *Stream 2* was used to model the 2,521 cfs peak flow from Basin #3 (East). The mainline stream was used to model the flow through the center of the site. For flow passing through Old Highway 80, the two culverts were modeled within HEC-RAS. The *Mainline* was used to model the peak flow from Basin #1 (South) through the site and to the north. See Appendix C for the *Mainline* River tables. A normal depth estimate was used as a boundary condition.

7.1 HEC-RAS RESULTS

A review of the HEC-RAS results shows that the panel locations on the proposed site can expect 5ft max flood depths concentrated primarily along Old Highway 80 and average flood depth of 2-ft to 3-ft across the site. Flows from the south will be conveyed north through existing culverts in Old Highway 80. The HEC-RAS analysis shows that the 100-year flood, will overtop the highway and sheet flow across. See Appendix C for culvert section and profile.

Just north of the site, flows will concentrate into a much deeper and faster flowing stream. This flow will be conveyed under Highway 8 through existing under passages. Depths of flow in this zone are expected to surpass 6-ft in depth.

A pier scour analysis was also performed using the Federal Highway Administration Hydraulic Engineering Circular No. 18 (FHWA HEC 18). Maximum onsite scour will reach approximately 1.3-ft to 2.0-ft. Calculation examples for typical scour potential are found in Appendix D.

Measures will need to be taken to elevate proposed site features above the expected inundation level. Protective measures will also need to be in place to protect the site from potential erosion and pile scour. Enhanced gravel roads and rock-lined areas within places of concentrated flow will protect against erosion. Pier embedment depths will need to be increased across the site to adequately deal with the potential effects pile scour. Structural considerations for the effect of pier scour will be evaluated in the final structural design phase.

8 CONCLUSIONS

1) Existing flow patterns and depths will be preserved onsite. Runoff is affected by rainfall intensity, soil type, land cover, site imperviousness, and site topography.

    a. Rainfall intensity, duration, and distribution are not affected by onsite improvements and therefore will remain constant for pre- and post-conditions.
    b. Soils within the watershed and within the site will not be changed as a result of any onsite work. Therefore, hydrologic conditions will not vary with such.
    c. Current land cover for the proposed site consists of field crops and barren undeveloped land. As a result of the proposed site, much of the underlaying soil will remain undisturbed, with the exception of minimal changes due to onsite construction.
    d. Solar farms naturally add very little impervious area due to their design. The only impervious area onsite will include tracker piles, inverter skids, battery skids, and additional substation area. Even with the addition of various impervious elements, those said elements tend to be spaced out across the site at large intervals. This results in an imperviousness value that is not much different than that of the pre-developed condition.
    e. There will be minimal onsite grading for the proposed project. Therefore, current drainage patterns will maintain their current courses.

2) As discussed in section 5 of the report, there will not be an increase in surface runoff onsite due to minimal amounts of impervious area being added. Existing drainage systems onsite consist of two culverts that pass runoff under Old Highway 80. Because onsite peak flow and flow patterns will be maintained, the integrity of the culverts will not be compromised due to onsite improvements.

3) The existing flood zone designation of the proposed site was characterized as *Zone D,* per the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) 06073C2350F. This designation is considered “Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk”. A summary of the flood depths of this analysis can be found in Figure 8. As demonstrated in Figure 8, and in section 5 of the report, there will not be an increase in runoff or change in flow pattern. Therefore, the proposed site will not affect nearby residences to any additional flood risk from the 100-year storm. In addition, because the post condition peak runoff is the same as in the pre-condition, existing structures within or around the site will not be placed in any additional risk.

4) The site does not contain any levees or dams and is not located near any levees or dams. Therefore, the site will not impose any additional risk to people or structures near the site due to a potential dam or levee failure.

5) There will not be any proposed onsite improvements to convey the 100-year storm. Stormwater runoff will flow overland across the proposed site just as it does in the pre-developed state. PV panels will be elevated above the 100-year inundation flood limit, eliminating the need to concentrate onsite flow into specially design channels to handle large flood events.

6) Onsite flood depths will reach a maximum of 5-ft with an average depth of 2-ft to 3-ft across the site. These depths will increase downstream of the site, as the valley constricts into a narrow canyon stream. It is expected that flows within this stream will reach more that 6-ft in depth.

7) Pre-construction erosion control will be implemented to reduce erosion caused during construction while soils are less stable. Local scour at individual piles will need to be addressed by increasing the minimum embedment depth of piles based on their placement with the inundation zone. Structural considerations for the effect of pier scour will be evaluated in the final structural design phase. Graded areas are to be reseeded, reducing erosion potential.

8) Using the results and conclusion within this report, proper precautions will need to be taken to protect the PV arrays and onsite improvements from the potential of flooding. Onsite electrical equipment within the 100-year inundation limits will need to be constructed above or outside the 100-year inundation depth.

9) The proposed improvements and grading will not increase the volume and/or velocity of surface flows to the detriment of downstream/adjacent landowners and/or facilities.