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Leo Lew
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MEMORANDUM FROM COUNTY ENGINEER

DATE: **MARCH 31, 2021**

TO: **PINAL COUNTY STAFF AND LAND DEVELOPERS**

FROM: **CHRISTOPHER WANAMAKER, P.E., CFM, CPM, PINAL COUNTY ENGINEER**

SUBJECT: **DRAINAGE DESIGN REQUIREMENTS; UTILITY-SCALE PHOTOVOLTAIC (PV) SOLAR AND WIND POWER GENERATING FACILITIES**

Background:

At a high level, the main drainage issue associated with solar panel arrays is the concentration of stormwater runoff at the solar panel drip line, which can act like an un-guttered roof that channelizes and accelerates stormwater flow onto and across the ground surface (Greene, 2020). Solar panel arrays also have the effect of creating discontinuous flow paths where a continuous path once existed through the site (Barnard, 2017). This discontinuity of flow alters hydrologic processes which can decrease soil infiltration and increase erosion and runoff.

A 2013 study published in *the Journal of Hydrologic Engineering* utilized various hydrologic modeling techniques to specifically look at the impacts that solar panels have on runoff. The study concluded that the solar panels themselves did not have a significant effect on the direct runoff volumes, peaks, or times to peak. However, the study noted that if the ground cover under the panels is gravel or bare ground, owing to design decisions, or lack of maintenance, the peak discharge may increase significantly requiring the need for stormwater management measures (Cook, 2013). In other words, the combined effect of all improvements and changes to land cover could result in increases in runoff. It should be noted that this 2013 study did not include field or experimental verification.

In addition, construction activities on the site as well as the inclusion of new impervious surfaces, alter soil characteristics and vegetative cover densities. These combined effects result in the need for permanent stormwater management measures (Sharp, 2019). Similar challenges exist for wind power facilities.

In conclusion, the cumulative effect of multiple-panel solar installations is that there is a small, but non-negligible, increase in runoff over the pre-developed condition. Thus, stormwater mitigation measures are still needed to offset this impact to drainage.

Regulatory Framework

The current regulatory framework and design criteria in Pinal County is lacking provisions that address the unique and specific drainage characteristics of utility-scale photovoltaic (PV) and wind power generating facilities.

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The current Pinal County Drainage Ordinance (PCDO), number 100798-DO, became effective on November 7th, 1998 and the current Pinal County Drainage Design Manual, Volumes I & II (PCDM) was put into effect in August 2004. Neither the PCDO nor the PCDM have specific provisions that pertain to solar and wind power generating facilities.

The Current Drainage Ordinance details retention requirements in Section 602 as follows:

> *The entire drainage detention and runoff conveyance system shall be designed to eliminate or minimize storm water runoff effects and convey the runoff through the development with minimum detrimental effects to the development or to any other property. No system shall be approved if the effect may cause an increase in the peak discharge or velocity of runoff or change the point of entry of drainage onto other property during the 2, 10- and 100-year runoff event. No system shall be approved that impedes runoff from adjoining upstream properties.*

With regard to drainage, solar and wind energy projects are significantly different than typical commercial developments that the current Drainage Ordinance was intended to govern. Characteristics of solar and wind energy facilities that warrant a change in drainage requirements include the following: 1) most sites are located in rural and remote areas, 2) most sites include minimal post-development impervious coverage, and 3) most site designers and owners often desire to limit grading while maintaining existing drainage patterns of the developed land.

In addition to this, both the PCDO and PCDM are in the process of being revised and updated. The new PCDO has gone through part of the public involvement process as of this writing and is expected to be adopted by the end of 2022. There is no specific schedule for the update to the PCDM at this time. These new regulatory and guidance documents will have provisions that address utility-scale photovoltaic (PV) and wind power generating facilities.

Policy:

In recognition of the fact that most utility-scale photovoltaic (PV) and wind power generating facilities often have a low impact to drainage, Pinal County desires to limit the need to mass-grade sites such as these. Therefore, applicants for projects such as these **may apply for a waiver** requesting to use the regulatory provisions of the June 2017 Version of the Draft Drainage Ordinance in lieu of strict application of the current PCDO. The language in the Draft Drainage Ordinance is below:

> *Section 6.1.C.3: The Drainage Administrator may reduce the retention requirements for utility scale solar or wind power generating facilities which utilize raised reflecting or photo-voltaic panels or vertically oriented windmills as the primary means of generating energy provided that the applicant can demonstrate that the inverters, panels or towers will not have an adverse impact on drainage patterns and that the overall post-construction impervious ground cover (including access roads, pedestals, & ground mounted electrical equipment) is less than 10% of the entire site.*
>
> *The reduction in retention from the standard 100-year, 2-hour criterion for utility scale solar and wind power generating facilities may be to a minimum of retaining the difference in runoff generated from a pre versus post condition providing that the applicant can demonstrate that post construction flow rate leaving the site is less than or equal to the existing flow rate for the 2-year, 10-year, and 100-year storms and that the requirements of the Pinal County Stormwater Ordinance are still being met.*

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Design Criteria

In accordance with the PCDO, the retention system shall be designed to receive and retain the volume of runoff generated by the 100-year storm having a duration of 2 hours (100-year, 2-hour storm) falling over the entire development site including all rights-of-way, excluding off-site flow conveyance areas.

Section 2.2.1.4 of Volume II of the PCDM states:

> For purposes of determining on-site retention requirements utilizing the Rational Method, the following equation can be used:
>
> $$V = \frac{CPA}{12}$$
>
> Where:
>
> V = Storage Volume (ft^3 or acre-ft)
> C = Watershed Runoff Coefficient (unit-less)
> P = 100-Year, 2-Hour Precipitation (inches)
> A = Drainage Area (sqft or acres)

Design Methodology

If a waiver is granted, retention for the pre-versus-post condition may be provided. For the purpose of determining the pre-versus-post runoff condition, many methods exist to estimate the increase in runoff caused by the installation of solar and wind power generating components over land. Some example methods include decreasing the watershed's time of concentration, altering the time-area relation affecting the generation of hydrographs on the site, increasing the runoff coefficient, or by reducing/limiting the initial abstraction. Other valid hydrologic modeling techniques may be valid as well.

However, in general and in lieu of any other supporting information, the preferred method to account for changes in runoff is to simply increase the Watershed Runoff Coefficient (C-Value) over the pre-developed condition by 5 to 10% based on the overall density of the panel arrays and the increased percentage of imperviousness on the site due to the combination of all site improvements.

Retention Scheme

In light of the desire to limit the grading work necessary to construct a solar or wind power generating facility, retention may be provided in a number of different methods which could include:

A. Designated basins constructed for the purpose of retaining runoff onsite
B. Strategically retaining runoff throughout the site upstream of access roads and/or perimeter landscaping berms
C. Constructing curbs/berms throughout the site to store runoff under the panels (refer to Figure 1 on the following page).
D. Installing infiltration trenches throughout the site. Infiltration trenches are typically 1 to 2 feet wide, up to 4 feet deep, and filled with large (3" D_{50} or larger), screened aggregates.

In any case the retention storage depth should not exceed 1ft when utilizing any above grade methods to contain runoff and the bottom edge of any panel must be at least 1ft higher than the 100-year water surface elevation in any basin or retention area.

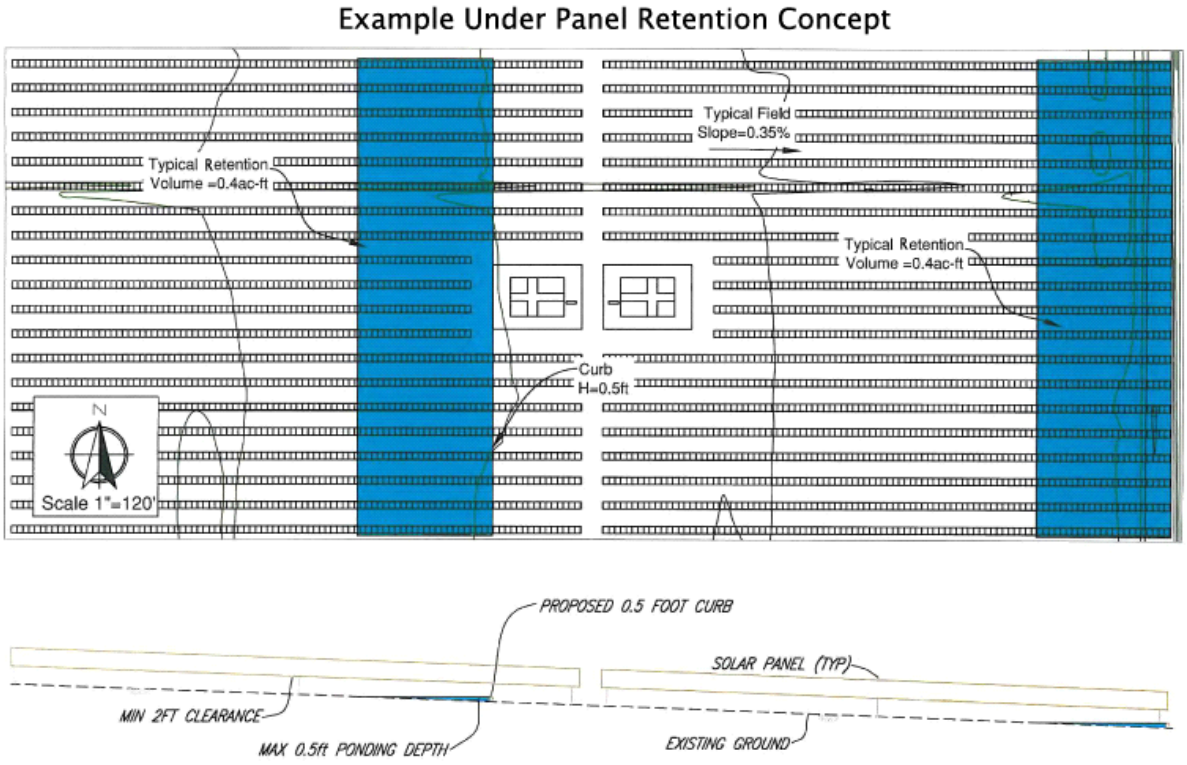

Figure 1: Example Under Panel Retention Concept

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