Date: **January 25, 2019**

To: **Eric Simmons and Patrick Clancey, FEMA Region IX**

From: **Seth Ahrens and Pani Ramalingam, STARR II**

Subject: **Recommended Path Forward for the Carson River PMR CTP Project**

This memorandum summarizes STARR II's recommended path forward for completing the Carson River PMR CTP project. The CTP is the Carson Water Subconservancy District (District). The District's contractor is HDR.

There are technical issues related to the 2D floodway modeling approach, the levee modeling approach, the hydrology methodology, and a few miscellaneous topics that need to be resolved. These issues are discussed below.

Floodway Modeling Approach

HDR's approach to mapping the floodway was the following:

- Build a steady-state 1D model of the study streams to develop a first cut of the floodway. This floodway covers the lower half or so of the model domain and a small section of the East Fork. The new floodway in the lower half of the domain extends further upstream than the effective floodway.

  The limits of the floodway were placed by HDR because

  > "many areas of the Carson Valley floodplain have highly bifurcated flowpaths, where the general concept of a conveyance-based floodway breaks down. For this reason, HDR was involved in conversations with Douglas County's floodplain managers and engineers, who decided that a floodway determination was only relevant in areas of the floodplain where the flowpath is contiguous across the entire valley. With the exception of one short reach on the East Fork, where there is an existing floodway, the East Fork and West Fork will not include floodways. Douglas County intends to keep track of the cumulative rise in this area using this regional model."

- Apply Method 4 in the 1D model so the first cut of the floodway is based on equal conveyance losses. HDR did not try to replicate the widths of the effective floodway.

- Place the floodway extents from the 1D model in the 2D model.

- Run the 2D model and revise the floodway extents as needed to generate valid floodway surcharges throughout the 2D domain.

- No FDT was developed.

- HDR noted in its TSDN that the floodway results should be considered preliminary and that they would like to meet with FEMA and its PTS contractor to outline a process and appropriate products for the floodway submittal.

The Region had two questions for HQ about the floodway approach that HDR used. These questions were:

- Do the floodway limits from the 2D model need to be put back into the 1D modeling to verify the surcharges in the 1D modeling are acceptable?

- Is a new FDT required for the 2D floodway?

The responses from HQ, sent to Patrick Clancey by Christina Lindemer on July 26, 2018, were that the floodway limits from the 2D model did not need to be placed in the 1D model since the floodway extents on the work map were derived from the 2D modeling. Regarding a new FDT, the response was that a new FDT is required, and it needs to be based on the results of the 2D modeling. To create the data to be included in the FDT, cross sections would need to be cut across the 2D domain that coincide with the BFE contour lines. Additional details may be found in Section 6.0 of FEMA's Floodway Guidance.

STARR II recommends that FEMA complete the following steps to wrap up the floodway for this project:

- Confirm with the District and Douglas County that a floodway, as mapped by HDR, is still desired. Notes from the meeting with HDR and STARR II on January 25, 2018 suggested that while the County was interested in a floodway in this area at the beginning of the project, interest may have waned as the technical challenges associated with the floodway have revealed themselves. Bob Bezek was invited to this meeting but was not able to attend.

- If a floodway is desired, confirm where in the model domain the floodway should be established. The current upstream end of the floodway on the Carson River is somewhat arbitrary. See Figure 1 at the end of this document for more information.

- Inform HDR that the process they followed for creating the floodway is acceptable. Let them know a FDT would need to be created using the 2D model. FEMA or STARR II would create this FDT if HDR does not.

Modeling Approach Around Levees

HDR noted in its TSDN that

> "[d]ue to the large number of agricultural berms and natural channel levees in the floodplain, the floodplain boundary was modeled and mapped in an "as is" condition without special treatment of non levee embankment features."

During the meeting between HDR and STARR II on January 25, 2018, HDR noted that they required guidance from FEMA regarding how to model and map these agricultural berms and channel levees.

STARR II has assessed the embankments in the model domain and recommends the following steps for addressing them:

- There are 10 levees/levee-like structures in the study area for which a Natural Valley analysis should be performed. All 10 are located along the East Fork of the Carson River. Three of these structures are shown on the effective FIRM panels. The remaining seven structures were

identified from the terrain and HDR's 1% AEP event simulation. Figure 2 shows the locations of these levees/levee-like structures.

- Eight different Natural Valley simulations should be completed. The first simulation would remove structures 1, 2, and 3 on Figure 2 from the model. Each remaining simulation would remove one of structures 4 through 10 from the model.

- The 1% AEP floodplains from the 9 simulations (one baseline simulation and 8 Natural Valley simulations) can be combined to build a composite 1% AEP floodplain. This composite floodplain should be shown on the work maps.

- There are non-levee features (i.e., embankments) throughout the model domain, such as the Highway 395 embankment. According to Section 7.0 of FEMA's *Guidance for Flood Risk Analysis and Mapping – Levees* (February 2018), such features "exist independent of a levee system but still may inadvertently impact floodway conveyance." In addition, Section 7.2 of the Guidance says "[t]he flood hazard on the landward side of most non-levee features will be analyzed and mapped as not providing 1-percent-annual-chance flood hazard reduction."

  There are a number of non-levee features in the model domain. Creating enough simulations to remove them one-by-one from the model could be burdensome. STARR II would like to meet with the Region to identify the non-levee features that should be included in future Natural Valley analyses.

Hydrologic Methodology

While developing the approach for addressing the levees/levee-like structures, STARR II discovered an issue with the hydrologic analysis.

HDR applied the following approach to establish the hydrology for the 1% and 0.2% AEP events:

- There are two USGS gages, one along the East Fork and one along the West Fork. Following a statistical analysis of the gage data, the results were combined with "historic 'pattern' hydrographs" from HEC-1 to develop balanced hydrographs at the gage locations for the 1% and 0.2% AEP events. These hydrographs provided the input hydrographs for the upstream end of the model. The combined volume of the two gage hydrographs is 61,436 acre-feet (ac-ft).

- The TSDN noted a flow volume at the downstream end of 128,053 ac-ft. No justification for this volume was presented.

- The difference in volume between the hydrographs at the upstream end and the volume at the downstream end is 66,617 ac-ft. HDR identified a series of 18 tributary inflow locations on both the east and west sides of Carson Valley where flow could enter the study area. HDR then distributed the 66,617 ac-ft across these 18 locations using a technique based on the drainage area feeding each inflow location and a "review of historic storm events in the region" that concluded that tributaries on the west side of the valley contribute approximately 8 times the volume as those on the east side. The volume at each inflow location was converted to a hydrograph using the shapes of the East Fork and West Fork gage hydrographs as "pattern hydrographs."

- In the TSDN, regarding these 18 tributary inflow hydrographs, HDR wrote

> "[n]one of the estimated hydrographs is a statistically relevant frequency event or derived from any accepted hydrologic methodology or analysis. HDR developed these tributary inflows *only* to add volume to the model to match hydrographs at the known downstream location."

HDR must provide documentation

Section 4.0 in FEMA's General Hydrologic Considerations (February 2018) states that "[d]ischarge values used to determine water-surface elevations shown on the FIRMs must be based on hydrologic or statistical models identified in FEMA's acceptable models list."

HDR's hydrology methodology conflicts with this guidance. Although STARR II has concluded that the upstream inflow hydrographs are reasonable (as described in the first bullet in this section, since the analysis was based on USGS Bulletin 17B), the process to develop the 18 inflow hydrographs is not justifiable since it is not supported by an acceptable hydrologic or statistical analysis.

STARR II recommends HDR do the following to address the shortcomings in the hydrologic analysis:

- Use hydrologic and/or statistical models to support the inflow hydrographs for the tributary watersheds. The hydrologic analysis should be verified with any available information. HDR must provide justification to support the selection of their hydrologic analysis and demonstrate that the computed discharges are reasonable.

- HRD should include all significant tributary inflows in this assessment. Please establish flow hand-off points to the hydraulic model that are realistic. In the submitted HEC-RAS model, some inflow hydrographs are missing. Two examples are Buckeye Creek (on FIRM panel 32005C0253H), and Sierra Canyon Creek (on FIRM panel 32005C0065G). Inflow hydrographs will need to be developed for these creeks and others where the hydrographs are missing.

- HDR should include the valley floor (i.e., the 2D model domain) in the hydrologic modeling if the volume of rain that falls on the domain is determined to be significant.

- HDR must provide documentation to explain how proposed flow rates in Douglas County align with the new study for Carson City.

Miscellaneous Comments

STARR II noticed a few other things when taking a closer look at the levees/levee-like structures in the HEC-RAS model domain.

- There are some locations where the bare earth LiDAR captures clusters of structures (e.g., houses). Overall, a rough guess is that 5% of the structures were not removed from the bare earth points during the LiDAR post-processing. It typically is not the modeling contractor's responsibility to correct the LiDAR it receives for a study. Nonetheless, some structures are present in the LiDAR, they have been captured in the 2D model mesh, and they may be affecting the modeling results. STARR II would like to review this issue with the Region when we meet to discuss the non-levee features, as noted above.

- According to the TSDN, the LiDAR used in this study was captured in September 2012, when the area's creek and rivers were experiencing drought conditions. Bathymetry data and ground survey data were not collected to supplement the LiDAR.

  For the most part, the LiDAR picked up the channel geometry in detail. However, along the West Fork, between channel cross sections 44791 and 46727, there appear to be some issues with how the channel geometry is depicted in the DEM. Specifically, it appears that the LiDAR may not have penetrated the vegetation in the channel, which has led to the channel's being undersized in the model.

Figure 1 – Revised 100-year floodplain (dark blue), effective floodway (pink), and revised floodway (light blue). On the East Fork, the effective and revised floodways extents are similar.

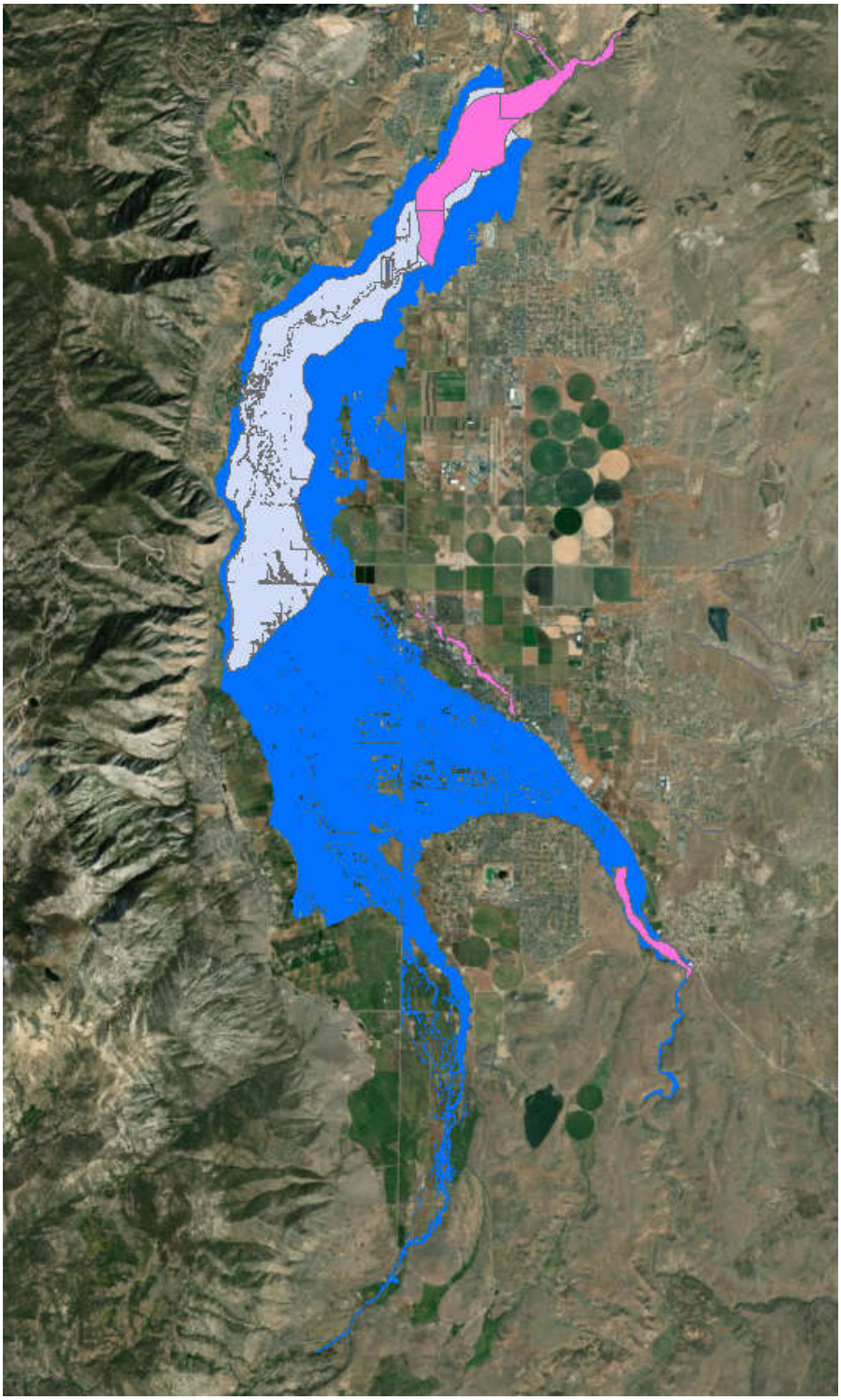

Figure 2 – Ten levee-like structures where a Natural Valley analysis may need to be completed.