March 08, 2023

To	City of Ukiah		
Copy to	GHD Files		
From	GHD and Northern Hydrology & Engineering	**Tel**	+1 415 283 4970
Subject	City of Ukiah FEMA Map Revision Review	**Project no.**	12589077

MEMORANDUM

1. Review Summary

This memorandum summarizes GHD's and Northern Hydrology & Engineering (NHE) preliminary review of the Mendocino County Map Revision (Orrs, Gibson, Doolin, and Zone AE) Updates, prepared by FEMA Region 9 and resented to the City of Ukiah (the City) on August 16, 2022. This review included the preliminary Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) dated April 29, 2022, and the hydraulic analysis model and data provided by the FEMA's STARR II contractor team on August 2, 2022.

The preliminary FIRM shows proposed changes in the floodplain extent in the City. The preliminary FIRM generally shows additional floodplain areas, especially for Zone A and Zone AE. For example, in FIRM panel 06045C1514, a significant portion of the urban area between Orrs Creek and Gibson Creek is remapped as floodplain Zone AE, as shown in Figures 1 and 2. The changes are partly due to a different hydraulic analysis approach in this floodplain area. The hydraulic analysis for the effective FIRM was based on one-dimensional (1-D) creek modeling. The new hydraulic analysis for the preliminary FIRM included 1-D modeling and limited two-dimensional (2-D) floodplain modeling to provide additional resolution to the floodplain flooding. These updates of floodplain extents in the preliminary FIRM may trigger new flood insurance requirements in the area.

GHD and NHE completed a preliminary review of the hydraulic analysis and identified a significant technical or scientific inaccuracy with the hydraulic modeling approach for Orrs Creek, Gibson Creek and adjoining floodplain; and several areas where additional clarification is needed to better understand the overall analysis's approach, accuracy, and precision. The hydraulic model setup, assumptions, and execution for Orrs Creek, Gibson Creek, and the interconnected floodplain between these two creeks have resulted in inaccurate and physically impossible differences in base flood elevations between the creeks and adjoining the floodplain. The resulting preliminary floodplain's base flood elevations are unrealistically high and significantly expand the City's Special Flood Hazard Area (SFHA). We recommend the City appeal the preliminary FEMA findings with the intention of having a more accurate and realistically defined floodplain extent and depth.

This technical review provides comments on the preliminary FIS, FIRM, hydraulic analysis, and supporting data provided by STARR II. The first part of this memo summarizes the technical and/or scientific inaccuracy of the hydraulic modeling approach for Orrs and Gibson Creek. The second section summarizes other minor analysis issues where additional clarifying information would be useful.

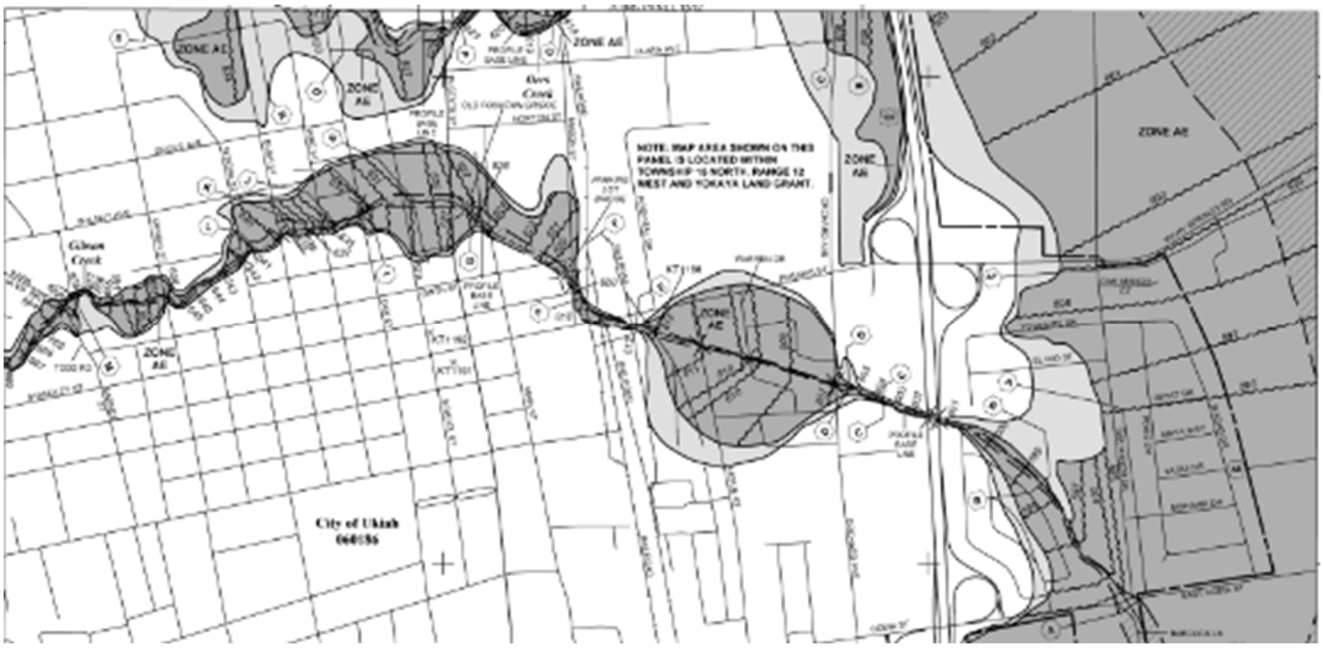


Figure 1. Effective FIRM Panel 06045C1514F (June 2, 2011)

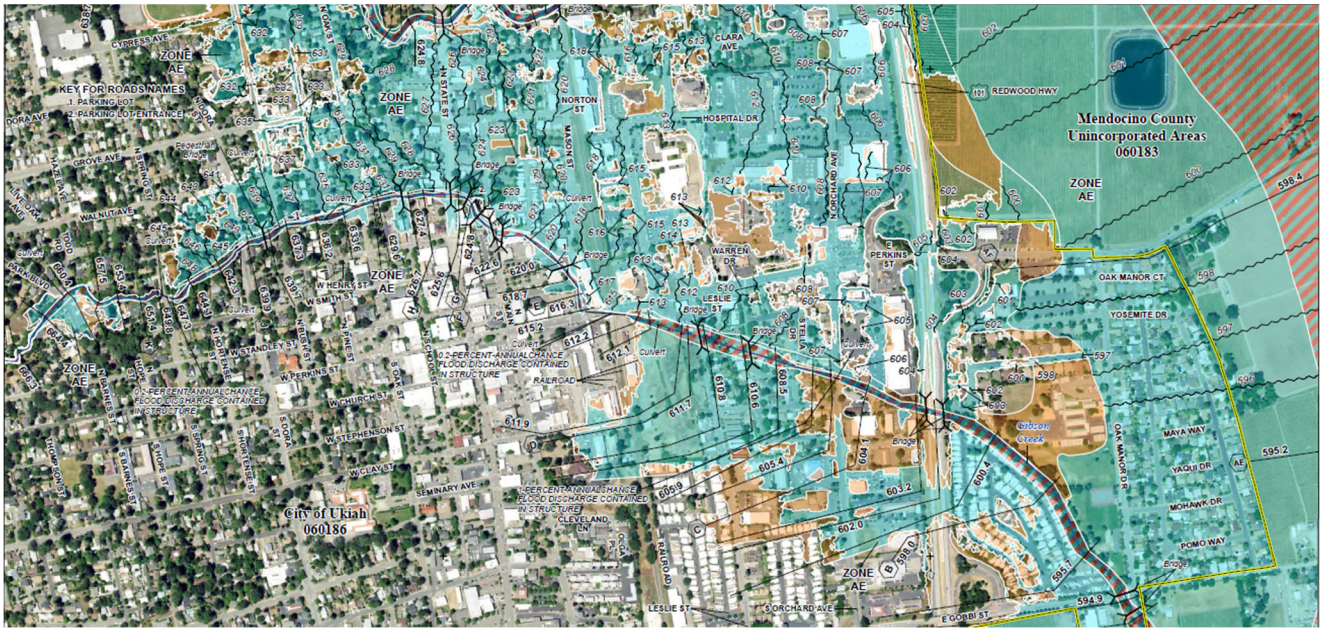


Figure 2. Preliminary FIRM Panel 06045C1514G (April 29, 2022)

2. Technical and Scientific Inaccuracy of Modeling Approach and Mapping Discrepancies

The impetus for this review of the preliminary FIRM update concerned the large expansion of the SFHA along and between Orrs Creek and Gibson Creeks (Figures 1 and 2) within the City (Tim Eriksen, City of Ukiah City Engineer, personal communication). Based on comments and feedback from a long-time local engineer (Ron Franz) who has completed hundreds of Elevation Certificates in the City limits, flooding in these expanded SFHA areas has not occurred, even during the December 2005 flood event (Ron Franz, personal communication). For reference, the 30 December 2005 flood event on the Russian River near Ukiah (USGS station: 11461000) observed peak flow was 22,600 cfs and exceeded the 1% annual exceedance flow (100-yr event) of 22,100 cfs estimated by the USGS (Gotvald et al. 2012) for this station.

The STARR II Hydraulic Report (dated March 2021) describes the general modeling approach and assumptions used for Orrs Creek and Gibson Creek. Initially, separate HEC-RAS 1-D hydraulic models were constructed for both Orrs Creek and Gibson Creek similar to the effective FIS. However, concerns regarding comingling of floodplain flows between Orrs and Gibson Creeks led STARR II to develop a separate HEC-RAS 2-D model of the floodplain area between these creeks and the Russian River to the east, and conduct a HEC-RAS 1-D/2-D analysis. Figure 3 shows the extent of the 2-D model domain. The following comments apply to the HEC-RAS 1-D/2-D model configuration, assumptions, and analysis of Orrs Creek and Gibson Creek conducted by STARR II.

The STARR II 1-D/2-D analysis consisted of developing three separate HEC-RAS models. For Orrs Creek, the 1-D model cross-sections terminated along the right channel top of bank and these cross-section ends were connected by a series of lateral structures. A similar approach was used for Gibson Creek, but the cross-sections were terminated and connected by lateral structures along the left bank. The 2-D floodplain mesh was trimmed to align with the lateral structures (ends of the cross-sections) along Orrs and Gibson Creeks. HEC-RAS allows the 2-D floodplain mesh to be connected to the 1-D lateral structures, creating a 1-D/2-D hydraulic model that dynamically simulates the flow exchange between the channel and floodplain. In other words, the model can continuously simulate flows leaving the channel and flowing onto the floodplain or leaving the floodplain and reentering the channel based on topography and flow conditions. However, STARR II did not link the 1-D and 2-D models and instead attempted to conduct the 1-D and 2-D analysis separately. Although this approach can work in theory, it appears that the assumptions and analysis of the STARR II 1-D/2-D modeling approach was not accurately conducted, which resulted in unrealistic and physically impossible flow conditions and water surface elevations between Orrs Creek and Gibson Creek (1-D model) and the adjoining floodplain (2-D model).

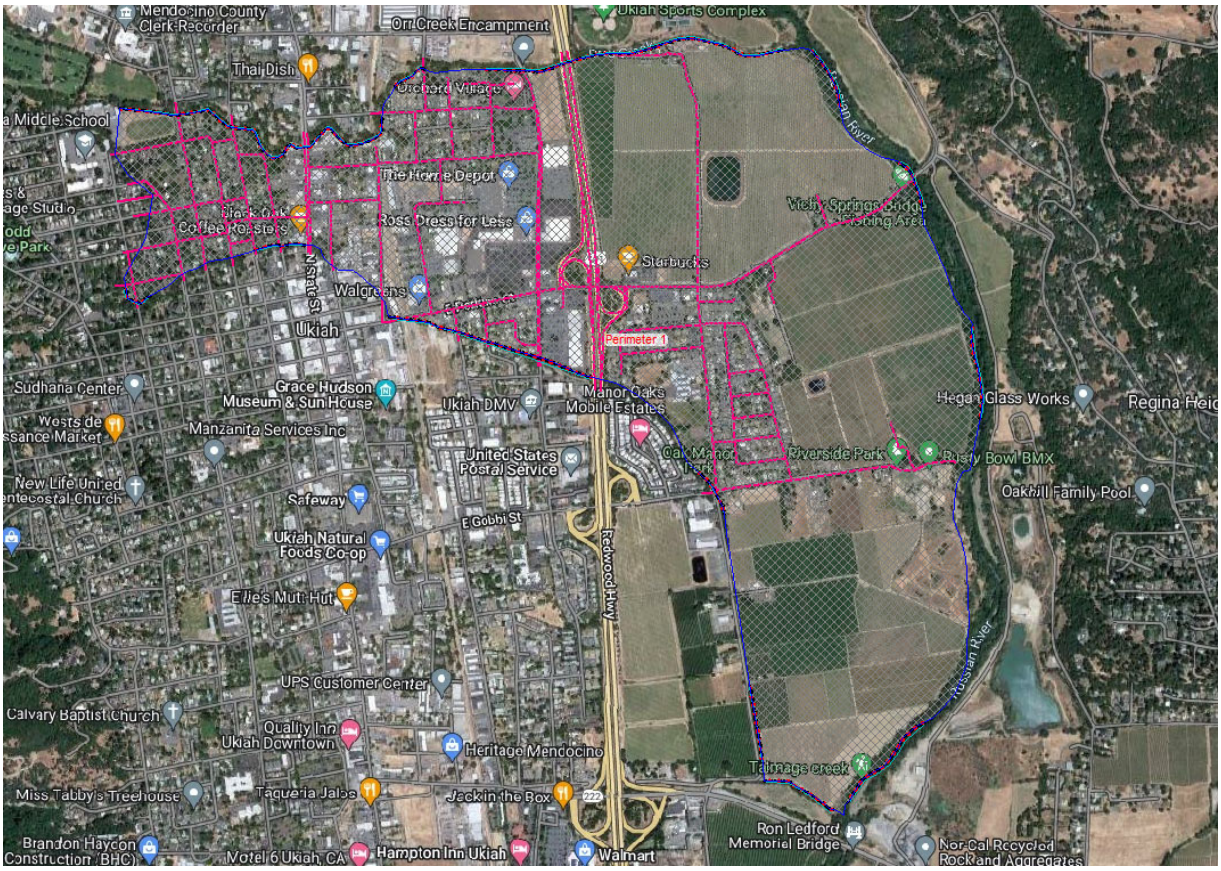


Figure 3. 2-D model domain for the Orrs Creek/Gibson Creek intermingled floodplain flow

Based on the STARR II report, the 1-D models of Orrs and Gibson Creeks were initially run and the flows going over the lateral structures were removed from the 1-D model and used as inflow boundary conditions for the 2-D model. However, flows from the 2-D model were not allowed to leave the 2-D mesh and reenter the 1-D models except near HWY 101 on Orrs Creek and between the railroad grade and HWY 101 on Gibson Creek. In other words, throughout the City west of HWY 101 and the railroad, floodplain base flood elevations are artificially elevated due to flows not being allowed to leave the 2-D model and reenter the 1-D model (creek channels). The STARR II modeling approach and assumptions have created inaccurate and physically impossible base flood elevations which can be seen in the preliminary FIRM map and supporting data.

A review of the preliminary FIRM map and the spatial files provided by FEMA for the Base Flood Elevations within the floodplain reveal differences between the channel and floodplain water surface elevations, with floodplain water levels being higher and in some locations significantly higher than creek levels along much of the upper reaches of Orrs and Gibson Creeks. This difference occurs in locations where the 1-D channel is assumed to be contributing flow to the floodplain, which is physically impossible. An example of this is highlighted in Figures 4 and 5 for Orrs Creek Station 7019.798 and the adjacent floodplain-defined water surface elevation. The 2-D floodplain model has a boundary condition line distributing 240 cfs flow from the creek (1-D model) to the floodplain at this location. However, the 1-D model water surface elevation at this cross-section (625.48 ft.) is over 2.5 ft. lower than the water surface elevation in the adjacent 2-D model floodplain (628.0 ft.). Given the difference in water levels, this is a location where floodplain flow should be re-entering Orrs Creek, not leaving Orrs Creek. However, the model setup and assumptions prevent flow from re-entering the channel at this location.

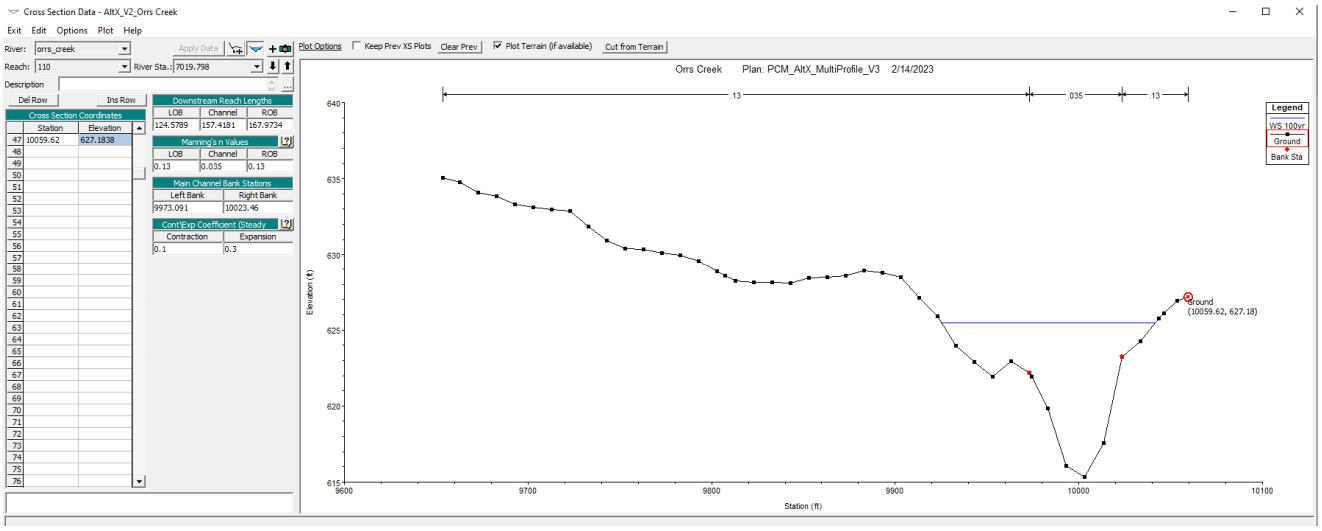


Figure 4. Orrs Creek Station 7019.798 (arrows point to this station in Figure 5)

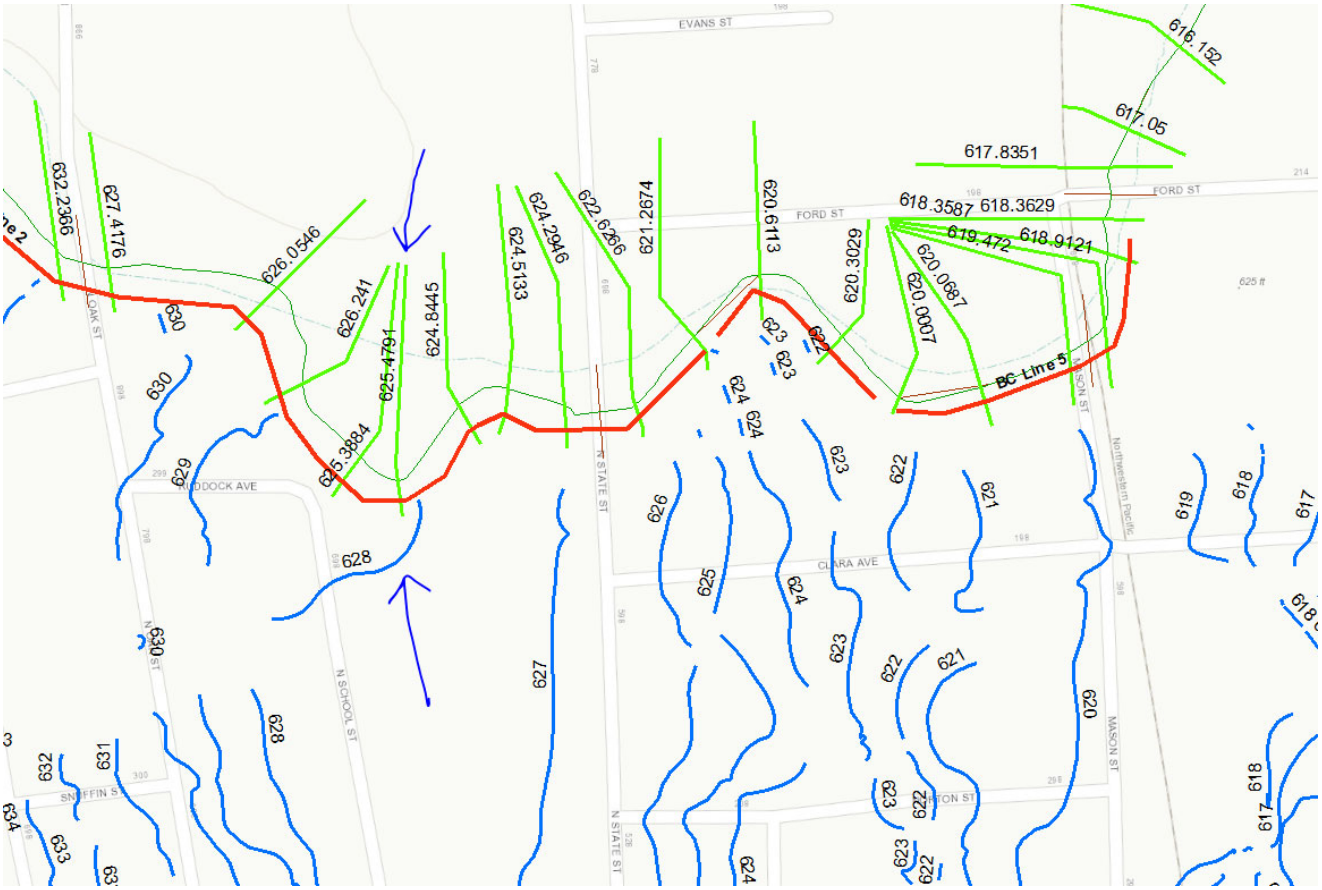


Figure 5. FEMA defined Base Flood Elevations for the floodplain and adjacent Orrs Creek Cross Sections (Blue lines = floodplain BFE, Green lines = Cross-section location and WSE)

The above example for Orrs Creek is at a single location. However, this unrealistic difference in water levels between the floodplain and creek channels occurs along much of the length of Orrs Creek and Gibson Creek. Figure 6 displays the 100-year flood water surface elevation profiles for Orrs Creek (1-D model), the adjacent floodplain levels from the 2-D model, and the right-bank lateral structure elevations. There are two locations where creek levels are higher than the ground and floodplain water levels, and flows would leave the channel (1-D model) and enter the floodplain (2-D model). However, there are significantly more locations where floodplain flows are higher than the ground and creek levels and floodplain flows would want to reenter the channel at these locations. It should be noted that this condition occurs immediately downstream of the locations where flow leaves the channel, which tends to be at creek crossings. Unfortunately, the STARR II modeling assumptions and analysis do not allow floodplain flows from the 2-D model to reenter the creek (1-D model) along this section of Orrs Creek, which is unrealistically elevating floodplain depths and base flood elevations by artificially keeping flow in the floodplain. These differences in creek and floodplain water surface elevations can be seen along both reaches of Orrs Creek and Gibson Creek. Only east of the railroad grade near HWY 101, where floodplain flows are allowed to leave the 2-D model and reenter the 1-D model, do floodplain and creek water surface elevations realistically coincide.

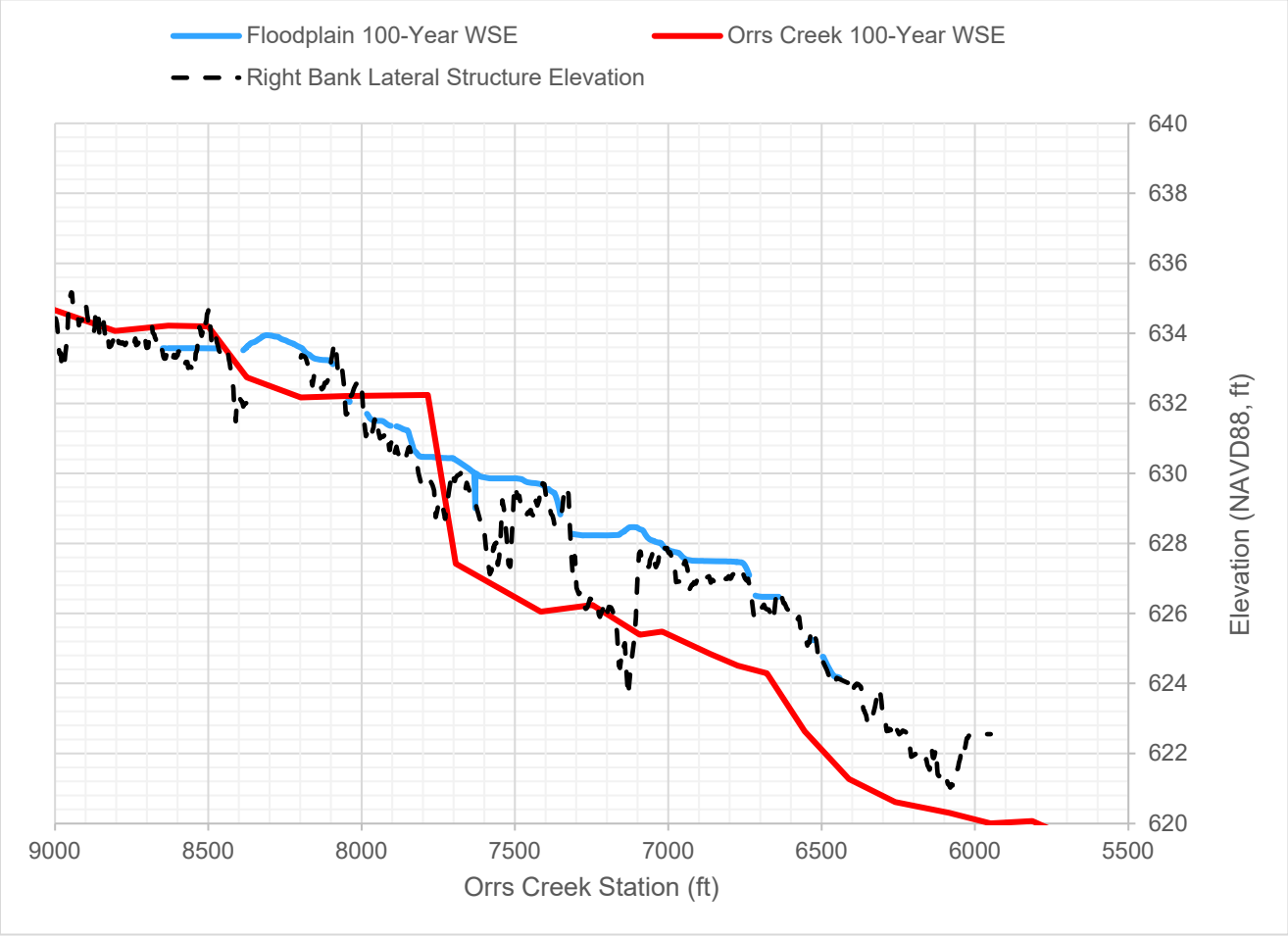


Figure 6. Orrs Creek 100-Year water surface elevation (WSE) Profile with Lateral Structure elevation and adjacent Floodplain 100-Year WSE

Another critical issue is that flows can only leave the 2-D model and renter Orrs Creek (1-D model) along a small section of lateral structure near HWY 101. However, flows can reenter Gibson Creek along a significantly longer section of lateral structure between the railroad and HWY 101. This modeling assumption appears to be artificially elevating floodplain water surface elevations along the lower reach of Gibson Creek near HWY 101 as more water is forced to return to Gibson Creek than would have occurred if upstream floodplain flows were allowed to leave the 2-D model and reenter the creek channels (1-D models), especially Orrs Creek. This assumption is also causing water to overtop HWY 101, which according to local observations did not occur during the December 2005 flood event (Ron Franz, personal communication).

As a final point, the hydraulic analysis did not include an update to the watershed hydrology. The 1-D/2-D modeling approach forced the rebalancing of flow between Orrs Creek, Gibson Creek, and the floodplain between the two creeks. Table 2 shows the flow comparison between the effective FIS and preliminary FIS. While Orrs Creek has a slight increase in flow, Gibson Creek has over 200 cfs flow reduction, further indicating potential inaccuracies of the forced flow rebalancing between the 1-D and 2-D models.

Table 2. 100 Year Flow Between Effective and Preliminary FIS

Stream	Effective FIS	Preliminary FIS
Gibson Creek	954 cfs	725 cfs
Orrs Creek	2,940 cfs	2,985 cfs
Doolin Creek	2,160 cfs	2,160 cfs

As mentioned previously, the STARR II 1-D/2-D modeling approach, assumptions and analysis was not accurately conducted for Orrs Creek and Gibson Creek, which resulted in unrealistic and physically impossible flow conditions and water surface elevations between Orrs Creek and Gibson Creek (1-D model) and the adjoining floodplain (2-D model). These modeling issues have led to overestimated floodplain depths and based flood elevations, that have caused the significant expansion of the SFHA for Orrs Creek and Gibson Creek.

3. Additional Review Comments

3.1 Hydraulic Analysis Comments

Orrs, Gibson, and Doolin Creek are represented by three separate 1-D HEC-RAS hydraulic models. The below section summarizes additional comments based on further review of the three models.

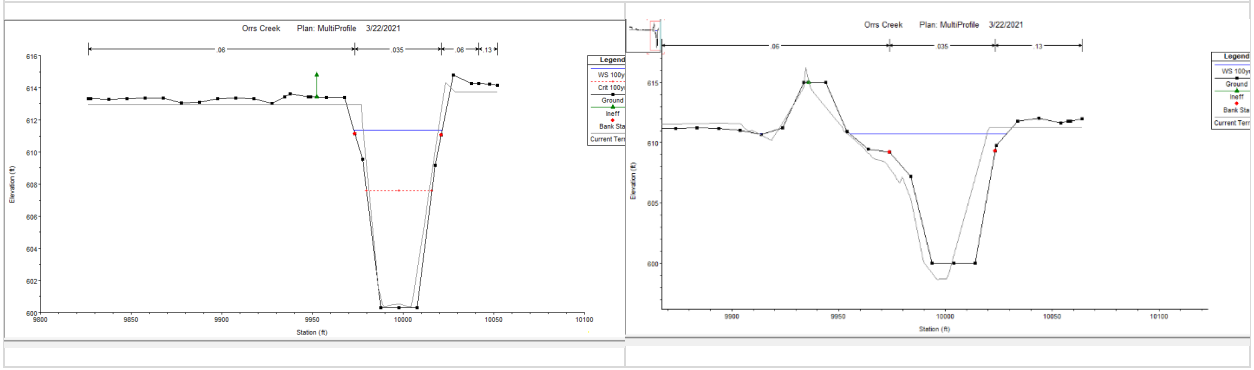
Orrs, Gibson, and Doolin Creek Model Comments

1. Provide additional information on how the models are calibrated or verified for their accuracy.
2. The model domains for Orrs, Gibson, and Doolin Creeks extend to the confluence with the Russian River. The portion of the creeks between Hwy. 101 and the Russian River is within the Russian River floodplain and it seems that the Russian River would have a hydraulic impact on all three Creek profiles in this area. However, a normal depth downstream boundary condition was used for Orrs, Gibson, and Doolin Creek, so it is not clear if consideration was given to the effect of the Russian River on the creek profiles. We would recommend that a coincident peak analysis be completed to justify the normal depth boundary condition.

3. The models were run with a subcritical flow regime, however, there are several places where the model defaulted to critical depth because a subcritical solution could not be found. The channels may have areas with supercritical flow that are not accurately captured by running with a subcritical flow regime. While we understand that model runs in a subcritical flow regime usually yields a more conservative water surface elevation estimate, we would recommend that the models be run in mixed flow and a comparison be made with the subcritical flow.

4. Cross-sections were extracted from a 10-ft grid LiDAR and only in limited instances updated with survey data. 10-ft grid LIDAR may not be sufficient to capture the channel geometries and may impact channel capacity. In order to determine whether the cross-section geometry used in the HEC-RAS model accurately reflects the existing conditions of the channels, the cross-section geometry was compared to survey information gathered by GHD for other projects. GHD is currently working on the Orrs Rd. crossing project which required a survey of the channel and overbank areas. The channel survey data was compared to the FEMA HEC-RAS model. Particular attention was paid to the overall conveyance area, thalweg elevations and top-of-bank elevations. In general, the survey information was consistent with the HEC-RAS model geometry. Examples of the comparison are shown below:

Table 2. HEC-RAS model geometry at Orrs Rd. Crossing with Survey terrain for comparison



It is our understanding that FEMA surveyed all structures along Orr, Gibson, and Doolin creeks. There are many structures within the urban area of the City of Ukiah, resulting in a fairly accurate representation of the channel in these areas.

5. Based on the hydraulic profile for the Doolin Creek, it appears that many of the bridges and culverts along the channel are constrictions and control the upstream hydraulic profile as shown in Figure 4. All these structures are overtopped during the 100-yr flow, so the elevation of the bridge deck/roadway and the structure opening may have significant impacts on the hydraulic profile upstream of the structure. Per the Hydraulic Report, these structures were all surveyed, but we wanted to highlight this observation in case there is any uncertainty in the geometry of the structures.

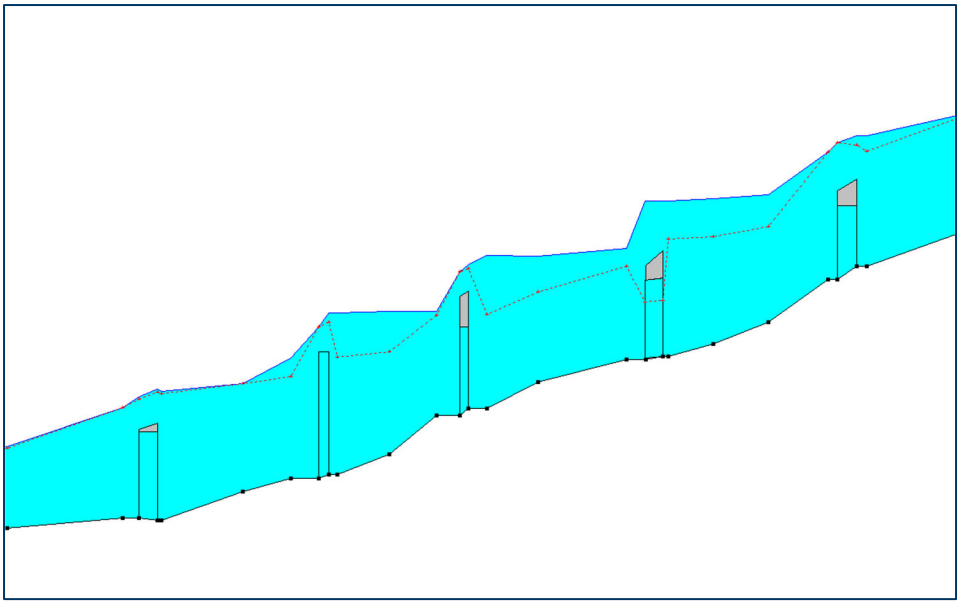


Figure 7. Hydraulic profile (100-yr) of a section of Doolin Creek showing bridges/culverts controlling HGL

6. The Orrs Creek 1-D HEC-RAS model has two cross-sections with contraction and expansion coefficients set at 0.6 and 0.8 respectively. The accompanying report does not include a justification for these values, which should be included as the higher values would force more flow from the 1-D model into the 2-D model domain.
7. The 2-D model uses normal depth boundary conditions at the downstream extents. The normal depth assumption may be artificially lowering the hydraulic grade line through the model area. It would be more appropriate to use the Russian River's 100-year water surface elevations (WSE) depending on the outcome of a coincident peak analysis.

3.2 Flood Insurance Rate Map Comments

As a standard of practice, a workmap should be provided that shows the effective floodplain and floodway and the revised floodplain and floodway included in the Hydraulic Report. An example is provided below.

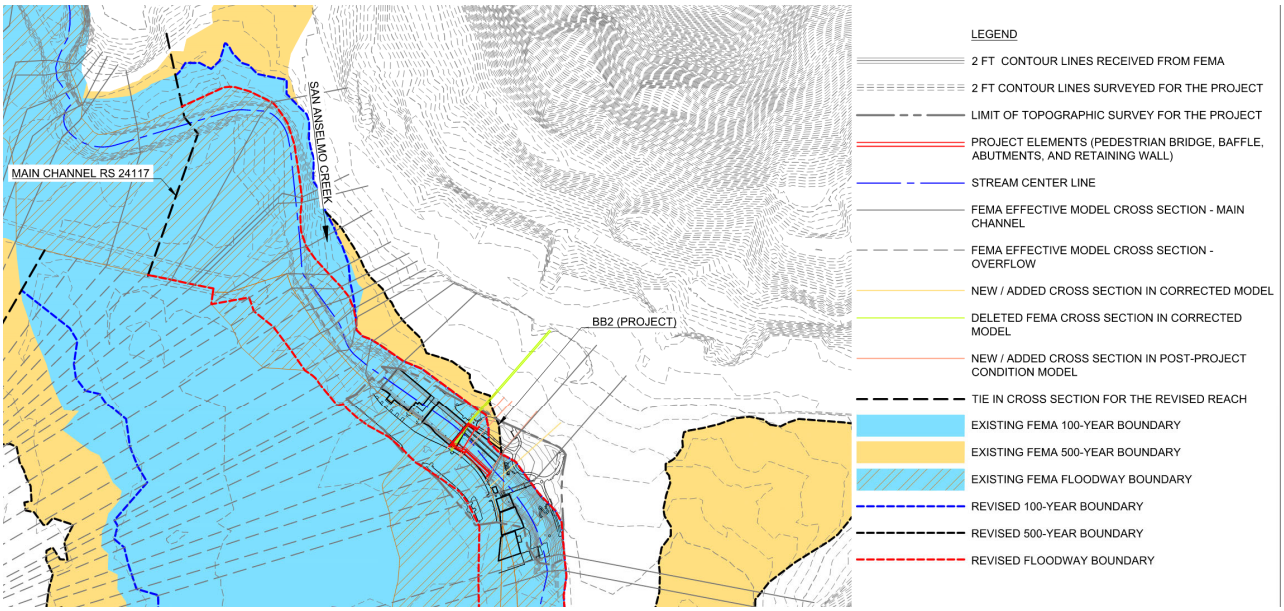


Figure 3. Workmap Example

The workmap is an important tool for the review team to identify areas of change in the floodplain and floodway boundary. The review team would like to request this additional information from FEMA's STARR II contractor team for review.

4. Summary

The Preliminary FEMA submittal for the City of Ukiah is missing several key pieces which would help to better understand the model development, assumptions, and subsequent findings:

- Workmap
- Survey Workplan

In addition, the assumptions and hydraulic analysis for Orrs Creek, Gibson Creek, and the floodplain between Orrs and Gibson Creek have led to physically impossible discrepancies in water surface elevations between the creeks and floodplain and resulted in unrealistically high proposed base flood elevations along the creeks and floodplain. Furthermore, these high base flood elevations have significantly expanded the SFHA in this area.

The separation of the two creeks (1-D models) and the intermediate floodplain (2-D model) has resulted in errors in assumptions and execution and should be re-evaluated based on a single hydraulic model incorporating Gibson Creek, Orrs Creek, and the intermediate floodplain in a true HEC-RAS 1D/2D coupled model, at a minimum.

Based on the above findings, we recommend the City of Ukiah formally appeal the Preliminary FEMA findings.

5. References

Gotvald, A.J., Barth, N.A., Veilleux, A.G. and C. Parrett. 2012. Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113,