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MEMORANDUM

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Subject: Upper Grande Ronde River IFIM – Hydraulic Model Calibration Memorandum

Executive Summary

The purpose of this study is to develop instream flow targets for ESA-listed Chinook and summer steelhead for juvenile rearing, spawning, and migration life stages in the Upper Grande Ronde River using the IFIM study methodology. The goal of the hydraulic model calibration memorandum is to report model calibration metrics in support of developing the depth and velocity components of habitat suitability analysis. This memorandum is an excerpt from the Upper Grande Ronde Instream Flow Incremental Method Study Report and is not intended to include all background information. Model calibration comparing simulated model results to observed data collected in the field meets the majority of the calibration benchmarks provided by the best available science, demonstrating adequate calibration performance for the intent of this study.

Model Calibration

Hydraulic model calibration is a critical step to determine confidence in simulated hydraulic properties (depth and velocity) used in habitat suitability analysis. The calibration process involves iteratively adjusting model parameters to match observations most closely, while preserving hydraulic modeling best practices and available science. The calibration process is repeated until model calibration metrics are met, the point of diminishing returns is achieved, and/or simulated accuracy is approximately equal to the resolution and accuracy of the input data. The following section details the calibration objectives.

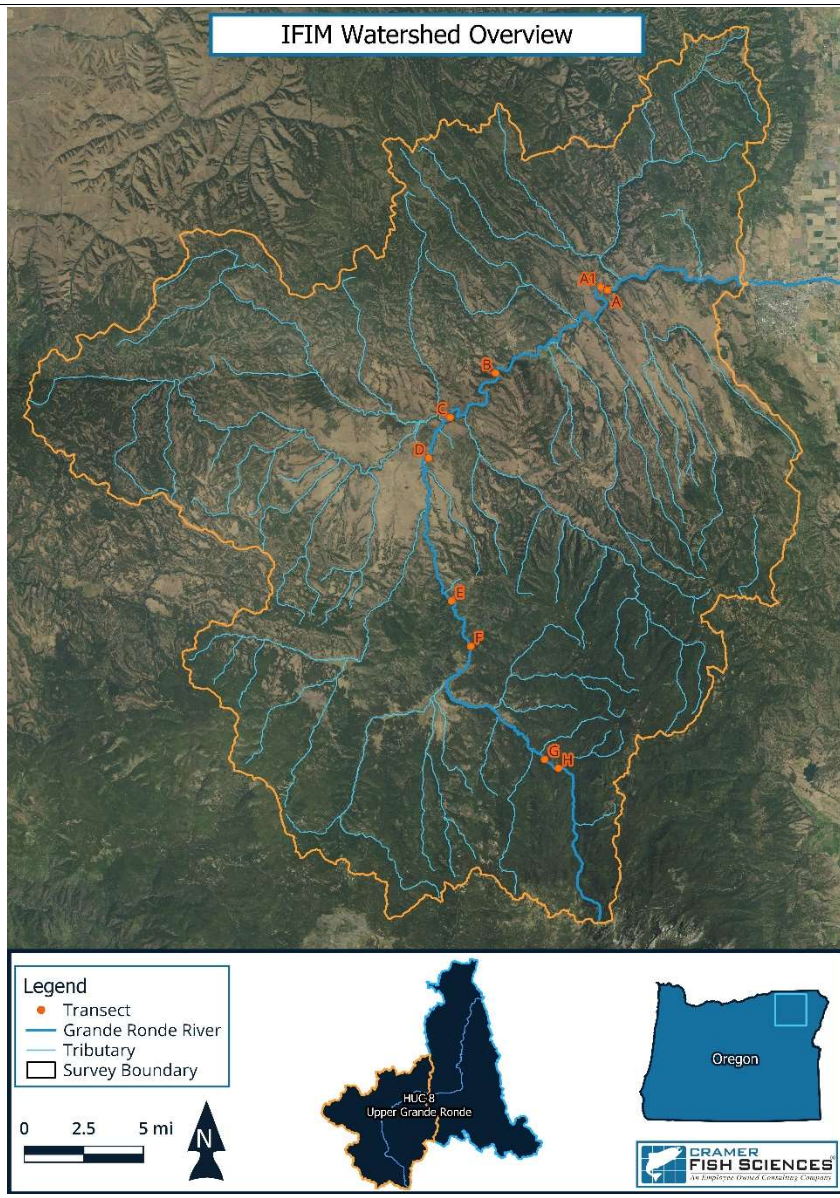

Figure 1. Upper Grande Ronde River IFIM transect locations.

The first calibration objective is to meet calibration metrics, which were established based on previous benchmarks from Pasternack (2011) and are summarized below:

- Depth and velocity R^2 between 0.4 and 0.8
- Depth and velocity mean and median percent error less than 30%
- Slope of linear regression line for depth and velocity greater than 0.9
- Zero intercept of linear regression line for depth and velocity less than 5% of max value.
- Depth and velocity error histogram equally distributed around zero.

These calibration metrics represent the best available science for hydraulic model calibration specific to instream flow studies and have been used successfully on previous projects (Seattle City Light 2023, Seattle City Light 2023a, and Wright et al. 2016). However, calibration metrics must be achievable given the resolution, accuracy, and precision of the input and observation data. Input and observation data relevant to setting the threshold for model calibration are listed below:

- Accuracy of LiDAR topobathymetric data (NV5 2021): The submerged median difference between LiDAR and check point was -0.08 feet with a 95% confidence interval of 0.32 feet (n = 779). The median error for wetted edge points was -0.003 feet with a confidence interval of 0.27 feet (n = 200). Average 95% confidence interval for relevant points is 0.31 feet.
- Temporal accuracy of LiDAR surface: Observed calibration data was acquired in 2023, but the LiDAR was flown in 2020. Natural topobathymetric changes in the Grande Ronde River are expected to occur. The mean error for all surveyed elevation points compared to the 2021 LiDAR was 0.11 feet and 0.09 feet assessed at the 95% confidence interval. However, detected change varied by transect (Table 1).

Table 1. Summary of mean error between LiDAR (2021) and RTK surveyed elevation at each transect.

Transect	Mean Error [ft]
A	0.00
A1	-0.14
B	-0.02
C	0.33
D1	0.23
D2	0.04
E	0.23
F	-0.01
G	0.23
H	0.04

- Accuracy of velocity measurements: Velocity measurements represent depth-averaged conditions of velocity, which vary over time due to turbulence. Examining the standard deviation of velocity measurements indicates the degree of variability within individual measurements. The average standard deviation of velocity measurements is 0.13 ft/s, with a maximum of 1.36 ft/s. Standard deviation is reported by the instrumentation used to collect the data.

The above elements represent an upper threshold for model calibration, which is limited by the resolution, accuracy, and precision of both input and observed data. In summary, calibration to depth with accuracy beyond a mean error of 0.10 ft and calibration to velocity to greater accuracy than a mean error of 0.13 ft/s is unlikely to be achievable due to resolution, accuracy, and precision of input and observed data. These thresholds represent average condition, transects with greater topobathymetric change are likely to have less stringent accuracy thresholds.

Results

The hydraulic model was iteratively calibrated based on performance relative to selected metrics in order to optimize model results. Model iteration included changes to parameters such as hydraulic roughness, solution equation, time step, model geometry, and others. The performance metrics were tracked to identify the point of diminishing returns. Table 2 and Figure 2 - Figure 5 demonstrate the calibration metrics of the selected model configuration. In general, the calibration to depth observations performed better than velocity, which is consistent with previous studies. Additionally, calibration to higher discharge events typically performed better than lower discharge values, this is due to both inherent model factors and data collection factors. During low flow conditions the proportion of interstitial flow increases, which is not resolved by the model. Additionally, velocity measurements are more likely to be influenced by substrate that is smaller than the resolution of the topobathymetric data. As flow is diverted around individual substrate the complex flow pattern, eddies, and turbulence impact measurement quality.

Table 2. Summary of mean error between LiDAR (2021) and RTK surveyed elevation at each transect.

	Velocity					Depth					
Discharge	**R^2**	**Slope**	**y-Intercept (ft/s)**	**Mean Error (ft/s)**	**Percent Bias (%)**	**R^2**	**Slope**	**y-Intercept (ft)**	**Mean Error (ft)**	**Percent Bias (%)**	**Number of Obs.**
Low	0.31	0.44	1.10	0.18	35.3	0.69	0.86	-0.06	-0.13	-27.6	342
Moderate	0.39	0.57	0.41	0.25	21.9	0.53	0.88	0.04	-0.05	-6.9	345
High	0.40	0.53	0.78	-0.14	-6.5	0.69	1.01	0.13	0.15	11.4	454
Combined	**0.57**	**0.58**	**0.65**	**0.07**	**5.2**	**0.78**	**1.10**	**-0.09**	**0.00**	**0.2**	**1141**

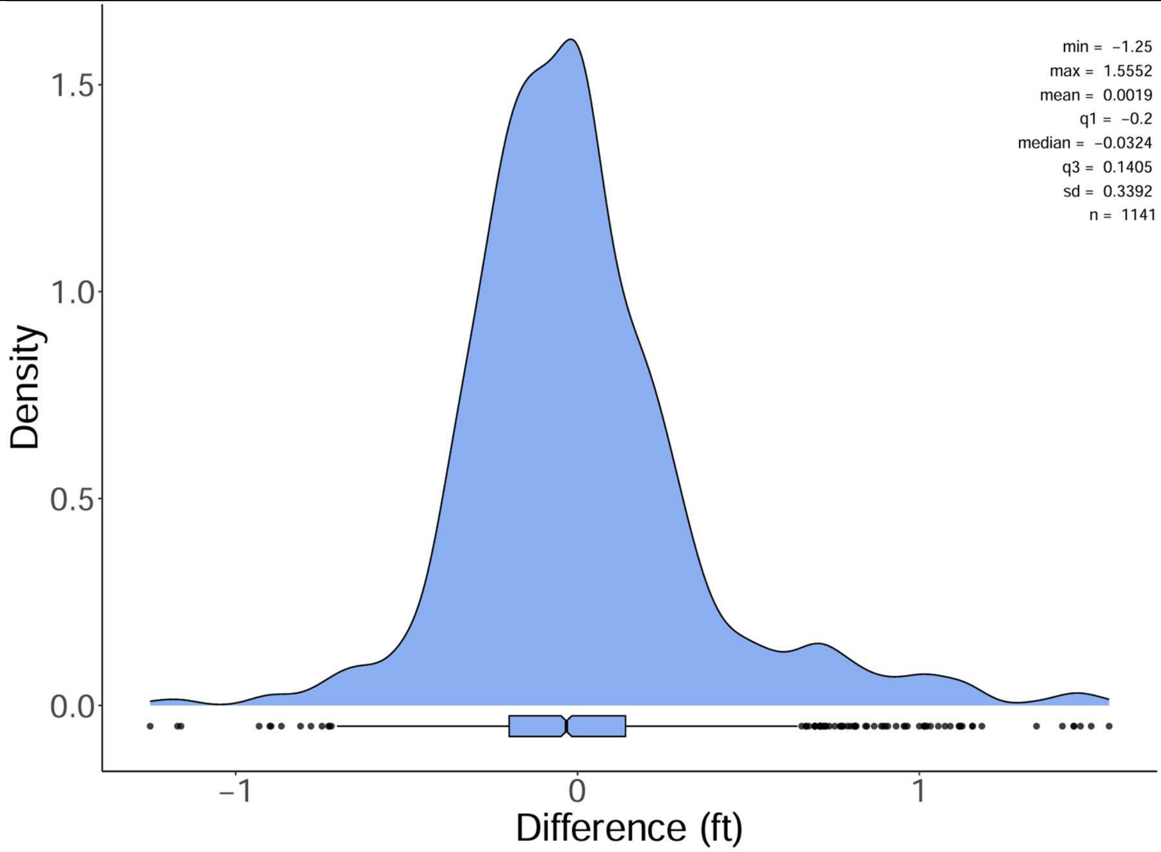

Figure 2 Density plot of depth residual for all three calibration discharges.

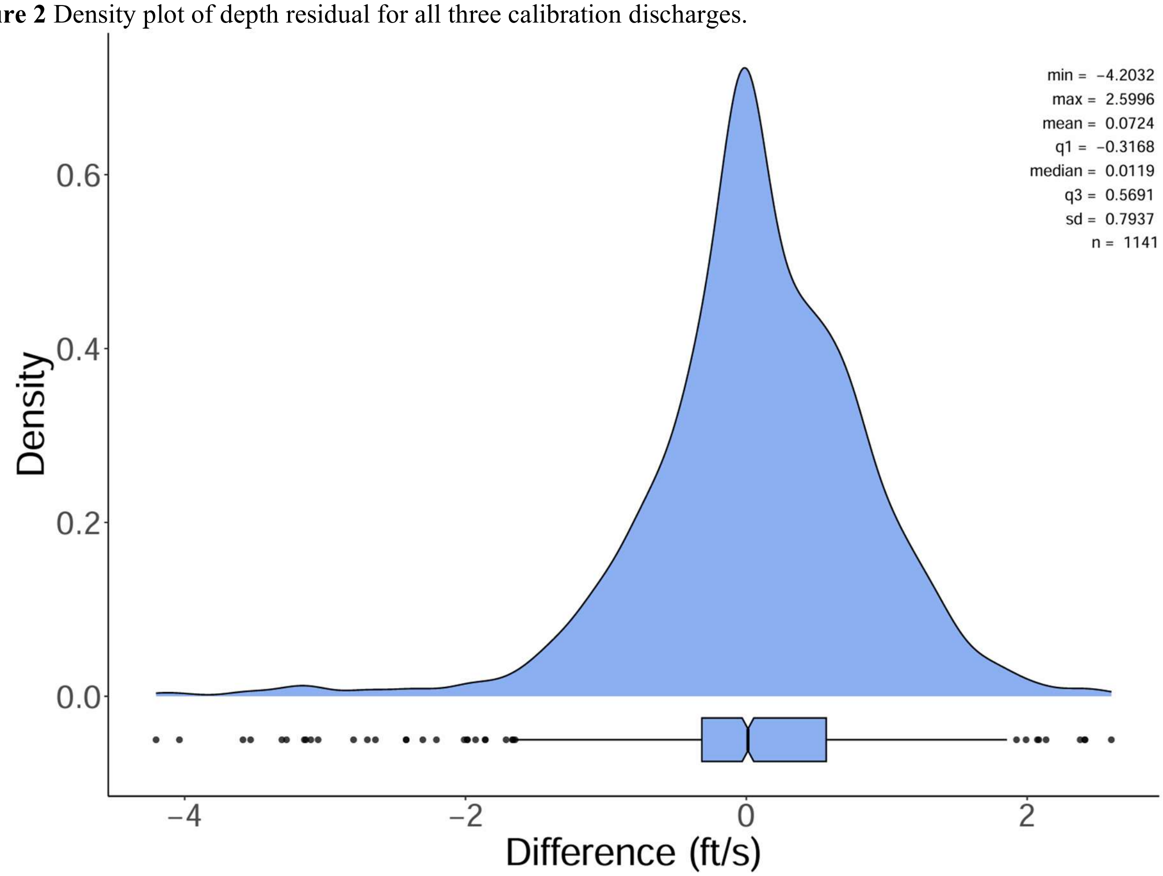

Figure 3 Density plot of velocity residual for all three calibration discharges.

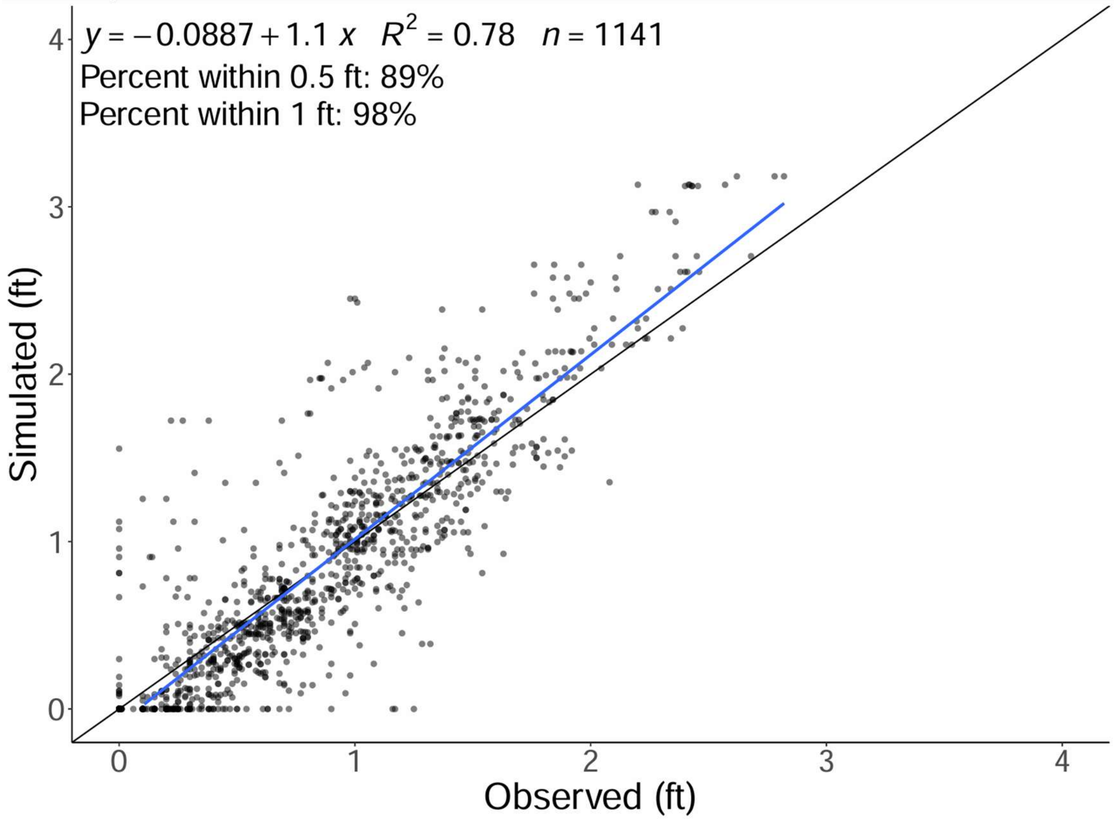

Figure 4 Linear regression plot comparing observed and simulated depth for all three calibration discharges.

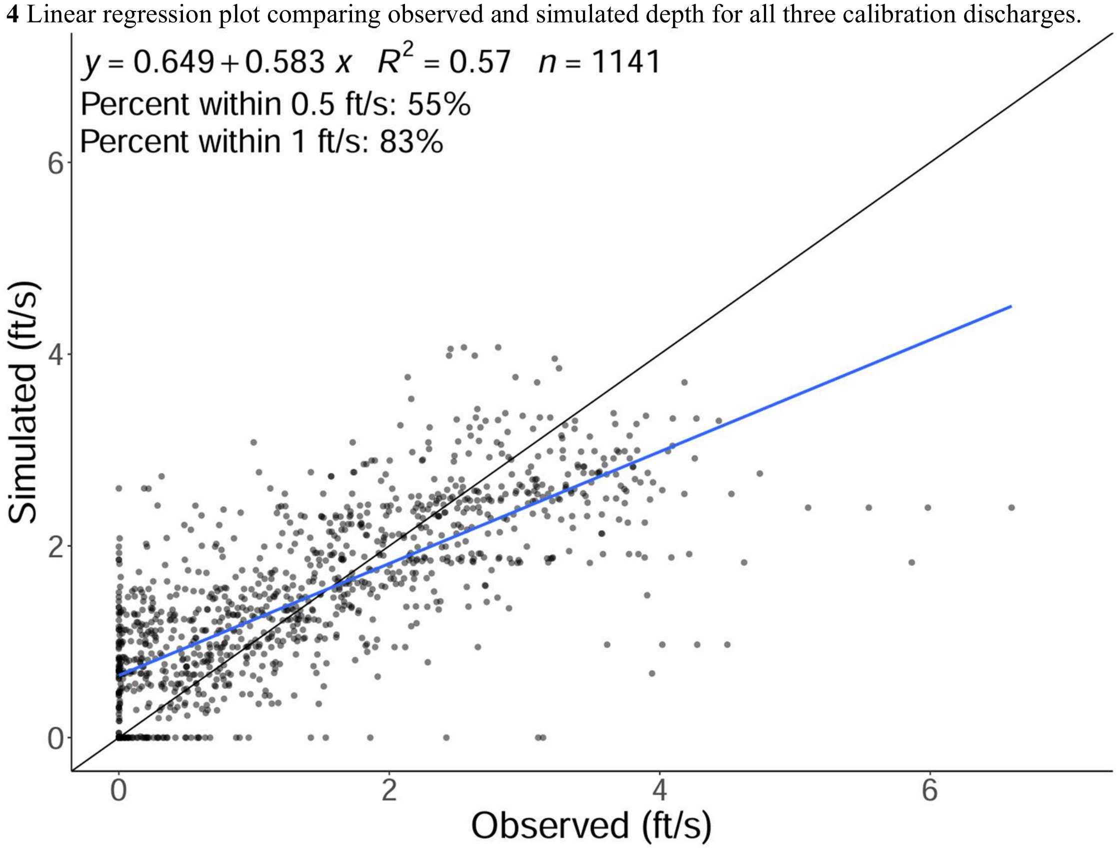

Figure 5 Linear regression plot comparing observed and simulated velocity for all three calibration discharges.

Conclusion

In summary, calibration to depth and velocity observations met calibration criteria in most cases for R^2, percent bias, and histogram distribution. Additionally, calibration objectives were met for depth, but not for velocity for linear regression slope and y-intercept. Calibration performance was determined to be adequate given the input data limitations and intent of the project. Time since LiDAR acquisition and LiDAR resolution are likely to be the most significant factors contributing to model accuracy.

Limitations

Hydraulic modeling performed for the Upper Grande Ronde River follows the best available science, but assumptions and limitations still apply, both to hydraulic models in general and the Upper Grande Ronde model in particular. The following includes some primary assumptions and limitations relevant to this project:

- HEC-RAS 2D utilizes and assumes a rigid bed during model simulations (i.e. the bed does not deform under flow conditions). This assumption is not always appropriate for high flow conditions, as sediment transport, erosion, and deposition occur in natural systems.
- HEC-RAS 2D presents hydraulic properties based on a solution of the Shallow Water equations that assumes depth-averaged conditions, and therefore this model maintains the limitations and assumptions inherent to a depth-averaged solution.
- LiDAR flown in 2020 was used as the model terrain and to derive model parameters, therefore the hydraulic model closely resembles conditions at the time of LiDAR acquisition. Rivers are inherently dynamic and change over time, so the intended uses and required resolution of hydraulic model outputs need to consider input resolution and time of acquisition. The hydraulic conditions in this study should be considered a representation of a system in dynamic equilibrium, rather than an explicitly accurate representation at each location.
- The HEC-RAS 2D model input does not include temporally varied parameters such as vegetation condition, ice condition, large wood location, aquatic vegetation, and others. These assumptions are required due to data availability and model utility, however temporally varied factors may impact model results.

References

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