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Outline of scope of work/deliverables for GIS contract

The Forest Practices Board (Board) has accepted two Anadromous Fish Floor (AFF) proposals for comparison and analysis in order to help inform the appropriate metric for the permanent water typing rule. The anadromous fish floor is defined as measurable physical stream characteristics downstream from which anadromous fish habitat is presumed and where protocol surveying to identify fish habitat is generally not applied. The AFF acts as a 'floor' concept when determining waters used by anadromous fish in western Washington.

The primary objectives of the GIS spatial analysis include: (1) relating channel gradients, obstacle and barriers, [1] and channel widths to known anadromous fish distributions in selected Washington state watersheds/streams, (2) assessing the sensitivity of the results to the parameters used in the analyses, and (3) summarizing the results of the analyses to inform the Water Typing Rule Committee on AFF options.

The GIS spatial analysis is being overseen by the AFF Workgroup, which recommends contracting GIS expertise to help conduct the analysis. Washington State DNR will administer the contract. The results of the GIS spatial analysis will be used to address the questions of interest described in the AFF Workplan – see Attachment 1.

The scope of work of the GIS spatial analysis contract is comprised of 5 general tasks:

1. Participate in meetings, conference calls, give presentations
2. Use available high-quality lidar to build virtual watershed datasets in NetMap
3. Run GIS analyses
4. Conduct sensitivity analysis on GIS model
5. Write up methods and help draft final reports

Subtasks include:

1. Participate in meetings, conference calls, give presentations

- Meet with Project Team/Workgroup 2 times, a workshop after NetMap and presentation of the
- Participate in weekly conference calls with Project Team/Workgroup
- Give 2 presentations (Workgroup, Water Typing Rules Committee)
- Travel to meetings and presentations

2. Use available lidar to build virtual watershed datasets in NetMap

- Build virtual watershed datasets and conduct the comparison analysis in the following watersheds: [2]

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[1] One of the proposals includes obstacles as a part of its AFF definition, both proposals include barriers.

[2] (from one of the PIs on the project): One way to do the analysis that I think will be very cost effective would be to only measure subbasins that have anadromous data in them. For example, instead of doing the entire Skagit basin, we could do each individual subbasin that we have data for. If stream lengths from the confluence of each subbasin with the mainstem Skagit River to Puget Sound become important, we could measure those on maps and add them to the lengths calculated for each upstream reach.

There are 87 Coho distribution points in the Skagit LFA dataset. For arguments sake, say each subbasin is 10 square kilometers. We could use the same math for the Forest Service dataset, which contains ~190 potentially useful points.

- Skookum Creek (near Shelton, WA)
- Mill Creek (near Shelton, WA)
- Sub-basins in the Skagit/Samish watershed
- Selected basins/streams in the Olympic National Forest (data from and Forest Service stream survey project)

- Using lidar DEMs, build virtual watershed datasets in NetMap that will include a synthetic stream layer containing all necessary attributes to accurately measure channel gradient and vertical drop structures and estimate channel width. The synthetic stream layer will have a spatial resolution equivalent to the DEM resolution (1-2 meters). This will allow channel gradients and vertical drops to be calculated over any length greater than ~2 m. The synthetic stream layer will contain attributes necessary to address the study objectives, including stream segment length (variable and fixed), elevation, drainage area, channel gradient (over any length scale), vertical drops (any length scale), channel bankfull width and depth (regression based), floodplain width, tributary junctions, and the streamwise length between each reach and the basin outlet.

  i) Assemble and mosaic lidar DEMs for selected watersheds. Iteratively digitize artificial 'culverts' to enforce flow across roads, fill depressions, compute flow direction and flow accumulation rasters, create synthetic stream network, review for 'captured' flow, and repeat until all errors in flow accumulation have been fixed.

  ii) Divide the synthetic network into segments of approximately constant gradient over variable channel lengths, as outlined by Cavalli et al (2008) and Tompalski et al. (2017) (Figure 1). Apply this method across all selected study watersheds.

  iii) Divide the synthetic network into stream segments based on fixed lengths, as determined by the Project Team.

  iv) Compute attributes outlined above for each reach in the fixed-reach-length and variable-reach-length stream networks.

- Provide the synthetic stream networks, including attributes, for all selected watersheds to allow any user to conduct similar or different AFF or end-of-fish analyses following the completion of the GIS portion of the project.

3. Run GIS analyses

Summarize results on maps and in table formats designed in conjunction with the Project Team, including results from the three westsise watersheds done as part of the WFPA PHB spatial analysis (Stillman Creek, Kalama River, Jones Creek).

(A) Work with Project Team to set model parameters including:

- Gradient – minimum reach length, both variable – based on channel width and set length (e.g. 30m), and fixed – slope-change consistency threshold
- Permanent Natural Barrier criteria – height (if it is a step), width, gradient, length
- Stream width

This should give us an upper bound, because we may not need to do all the subbasins with available data (or if we choose to use a random sample of basins). Perhaps Dan/Lee could give us an estimate for each 10 km2 basin, and for each 50 km2 basin, etc.

(B) Create maps of the selected watersheds with the following locations plotted:

- Documented end of anadromy points (Coho & other species) (Anadromy points provided by Project Team)
- Estimated end of fish habitat (Fish points provided by Project Team)
- Permanent Natural Barriers – both field identified and modeled (field identified barrier points provided by Project Team, or imported from available datasets), including barriers that meet the WDFW definition of permanent natural barriers [3]
- Downstream-most reaches that exceed 5%, 7%, 10%, 12% and 16% on each stream that contains an end of fish habitat distribution point and/or an end of anadromous habitat point.
- Landowner Anadromous Overlay points for each stream with an end of fish distribution point and/or an end of anadromous habitat point.

(C) Build and populate database/spreadsheet that includes at a minimum the following information:

For each end of habitat point (for both anadromy and other fish)

- Reach description, both upstream and downstream of point, (based on field data, if available, and modeled info) – gradient, bankfull width and depth, step height (if present), floodplain (if present), channel confinement
- Steepest downstream reach gradient
- Steepest upstream reach gradient (to next barrier)
- Distance to nearest barrier, both upstream and downstream
- Distance, positive or negative, to downstream-most reach in stream that exceeds 5%, 7%, and 10% gradient
- Distance, positive or negative, to landowner end of anadromous overlay point
- Distance, positive or negative, between AFF point and approved F/N Break.

(D) Help develop field protocols for model validation

- Design field sampling protocols to assess model accuracy (with Project Team)
    - Channel gradient
    - Stream width
    - Barrier identification
- Assist in providing guidance, as necessary, to field data collection work done by Project Team
- Help summarize with Project Team potential error in model estimates based on QA/QC findings

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[3] **The current WDFW natural fish barrier definition**

Natural barriers, that would exclude most adult salmonids, are defined as:

- a waterfall > 3.7 vertical meters in height,
- a stream reach having a sustained gradient exceeding 20% for 160 or more meters (continuous), or,
- a channel having a sustained gradient >16% for a distance of 160 meters and having a width <0.6 meters in Western Washington or <0.9 meters in Eastern Washington as measured at the scour line

While it is recognized that different species have various jumping and swimming abilities, for example, bull trout are often found above 30% gradient (Cannings and Ptolemy 1998) and cutthroat trout have been found in gradients up to 33% (Jauquet 2002), for purposes of this manual, the 20% gradient threshold has been accepted as the upper limit for most adult salmonids.

4. Help design and conduct sensitivity analysis on GIS model accuracy

- Address the following questions through a sensitivity analysis:
    - How do different minimum reach lengths affect estimates of channel gradient?
    - How does application of variable versus fixed reach lengths affect the distributions of estimated channel gradients and stream length between modeled AFF and known anadromy?
    - How do different definitions of barriers change the distributions of stream gradients and channel lengths observed in the GIS analyses?
    - How do different threshold values for the minimum change in gradient that trigger a reach break affect distribution of channel gradients?
- Summarize findings of sensitivity analysis into a report

5. Write up methods and help draft final reports

- Summarize GIS methods in final report
- Help summarize with Project Team the GIS analysis and findings in final report

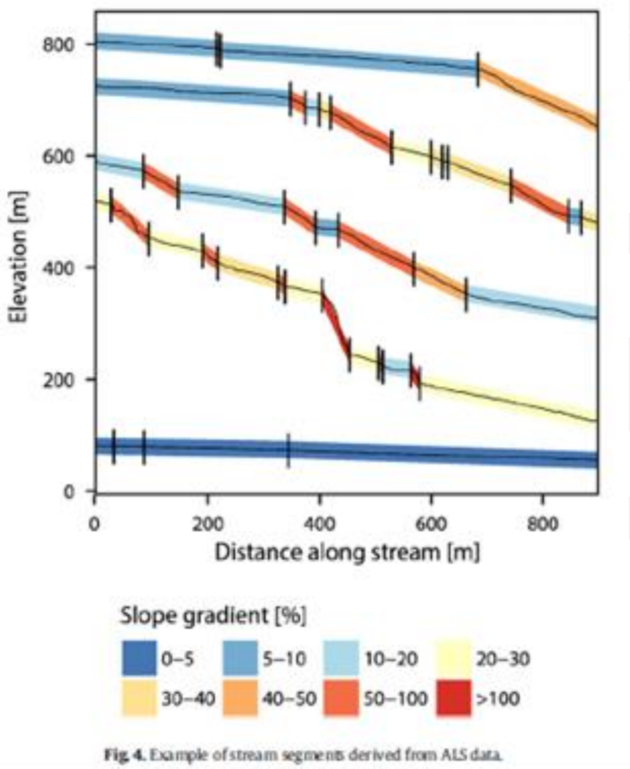

Figure 1. An example of channel segmentation of varying length having homogeneous channel gradients (Tompalski et al. 2017). Appropriate gradient breaks will be defined during consultation with project collaborators.

<u>Citations</u>

Cavalli, M., Tarolli, P., Marchi, L., and Fontana, G. D., 2008, The effectiveness of airborne LiDAR data in the recognition of channel-bed morphology: Catena, v. 73, p. 249-260.

Tompalski, P., Coops, N. C., White, J. C., Wulder, M. A., and Yuill, A., 2017, Characterizing streams and riparian areas with airborne laser scanning data: Remote Sensing of Environment, v. 192, p. 73-86.