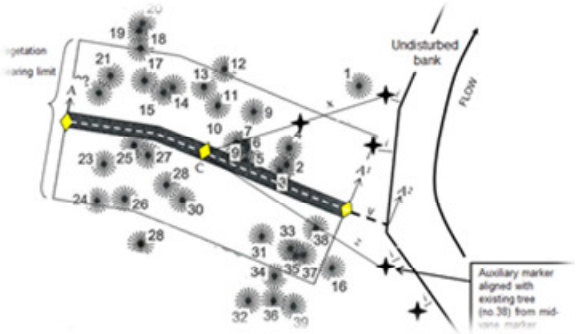
Technical Memorandum

EcoAssets Land and Water Resources Consultants

Crystal River Ranch White River Shoreline
Assessment and Staff/Crest Gage Siting



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TECHNICAL MEMORANDUM

EcoAssets
Land and Water
Resources Consultants

Drafted November 9, 2012 Review / Edit February 9, 2013

To: Crystal River Ranch Executive Board

From: Lawrence Dominguez, Owner, Senior Aquatic Ecologist

RE: River Shoreline Assessment and Staff/Crest Gauge Recommendations

Summary

Crystal River Ranch (CRR) is investing in long-term monitoring and management of shoreline stability for wellhead protection and preserving as much community property as possible. CRR sought to:

a. Create baseline information for long-term monitoring of rock-vane performance and,

b. estimate the rate of natural erosion and condition of rock-vanes in the erosion control project reach.

To attain these goals, EcoAssets Land and Water Resources provided professional environmental consulting services (Agreement for Services Contract Number EALWR 2012-01) to Crystal River Ranch (CRR) for the following tasks:

1. Conduct a qualitative shoreline assessment of the south bank White River containing 14 rock-vanes.

2. Provide recommendations for a long-term monitoring protocol of bank erosion.

3. Provide recommendations for streamflow gage siting and support for securing funds for stream gauge purchase and installation.

Several other tasks were performed to support the findings and recommendations including: review of previous studies and monitoring protocol, consultation with regional natural resource specialists, and review of state and federal stream monitoring programs.

Some standard and many project-specific monitoring/assessment protocols derived from standard methods that have been applied in the region were utilized by EcoAssets for the CRR work. Stream shoreline assessment methods vary from expensive hi-resolution satellite-imagery or modeling-based approaches with ground-based measurement controls to citizen-based

qualitative evaluations with photo monitoring. CRR and EcoAssets concurred that the goals for this assessment and recommendations should be defensible, repeatable, and cost-effective to serve long-term CRR shoreline planning and management objectives. The baselines assessment information will also assist in the permit closure process with Pierce County Planning / Land Services and Washington State Department of Fish and Wildlife in the 2014 - 2016 time frame.

Functional Indicator Ratings were used to provide a standard qualitative assessment of rock-vane function status. These are narrative descriptions based on a 5 point function rating scale. As of this report, all rock-vanes are fully intact and functional. Banks should be monitored for further changes. Benchmarked by the existing rock-vane toe and heel stakes, EcoAssets recommends a network of metal stakes be established to monitor annual and/or major storm event erosion. The number of stakes and orientation of the stake network will vary at each rock-vane site depending on the rock-vane orientation and area of likely erosion, as determined by current trends. Erosion information in auxiliary sites between rock-vane clusters is recommended and will also be helpful in describing the total reach characteristics. Another recommendation is to tag identify trees which is an inexpensive and useful way to document erosion rates.

In addition, if the Crystal Village community undertook a similar marker network on the other side of the river, or at least an initial reconnaissance survey, and participated in establishing and tracking cross channel measurements, it would be valuable for understanding the reach–level issues of erosion.

The USGS and WA Department of Ecology manage stream flow gaging stations in the area. However, the locations are several miles downstream or within tributaries that don't necessarily inform CRR's reach-specific flow and flood height characteristics. Maintaining flood-flow information from the CRR reach could be critical for shoreline project design or modifications in the future. The USDA Forest Service 74 Road, aka Crystal River Ranch Road bridge, provides an ideal location for a long term gaging station. Area telemetric and manual stage height stations were identified. Water Resources professionals from state and federal agencies were contacted and all showed willingness to provide technical support for formalizing and planning the next steps of streamflow gage placement.

BASELINE ASSESSMENT
Shoreline/Rock-Vane Assessment

CRR's 14 rock-vanes have the fundamental purpose of providing long-term protection of the CRR well-head area, road and utility infrastructure, and other community properties. On October 6, 2012, Larry Dominguez, Sr. Ecologist of EcoAssets, conducted a rapid assessment of 2,000 ft of the White River shoreline containing the rock-vanes. CRR board members Wendy Scholl and Curt Simonson participated in the reconnaissance-level survey and in discussions about monitoring approaches, value of current information, identification of risk areas, and trends to look for in monitoring. The overall objectives of the field work were to 1) complete a baseline assessment of 14 inland buried rock-vanes on the southwestern bank of the White River to provide information for the long term functional monitoring of rock-vanes and, 2) recommend siting of a stream gauge. Table 1 and Table 2 contain the rating definitions and field-based ratings respectively for the rock-vanes assessed.

Stream structures evaluated have included various rock and log structures for bank protection or habitat restoration and have been based on failure ratings, level of function or habitat values (see Roper et al. 1998, Brown 2000, Whiteway et al. 2010). These and other evaluations assess the structure's functionality as part of the active channel. For analytic purposes the rock-vanes are clustered in areas with similar bank characteristics which likely will have similar erosion risks (Figure 1).

Vane Cluster 1	Rock-Vane 1
Vane Cluster 2	Rock-Vanes 2, 3, and 4
Vane Cluster 3	Rock-Vanes 5, 6, and 7
Vane Cluster 4	Rock-Vanes 8, 9, 10, 11, and 12
Vane Cluster 5	Rock-Vanes 13 and 14

Despite CRR's rock-vanes being buried landward of the ordinary high water mark, potential for future erosion remains due to the meandering nature of the White River and evidence of historic channel locations beyond the Ordinary High Water Mark.

Description of the Shoreline Area Associated with Buried Rock-Vanes

The Crystal River Ranch Project is located between State Highway 410 Mile posts 46.5 to 48. The geology of the White River basin is composed of volcanic and sedimentary rocks, a drift plain with glacial till and outwash material, alluvium, and mudflow deposits with various overlying soil. The Osceola Mudflow, a lahar triggered by the collapse of the northeast side of Mount Rainier about 5,700 years ago (Crandell 1971) was a substantial geologic event that contributed to the current floodplain sediment composition. As characteristic of most of the upper White River drainage, the CRR reach went through a period of incising after this deposition and is now aggrading (increase in land elevation due to the deposition of sediment) because of sediment loads from retreating glaciers. The material that filled the river valley along with pyroclastic rocks associated with Mount Rainier eruptions are unstable and tend to erode. Modern day forest management has contributed to increased bed-load volume. A US Forest Service Watershed Analysis determined that from the mid-1950s up to 1970 the aggradation from these practices contributed to a doubling of the channel width about 2 miles upstream of CRR. Channel widening in the CRR reach was about 1 ft/yr between 1940 and 2001 based on aerial photography analysis and from 2001 to 2007 an estimate at one cross section suggested the widening rate increased to 6.5 ft/yr (Pace 2009)[1].

Channel width increase has resulted in a braided channel causing regular thalweg (deepest part of the channel) shifts within the active river channel. Some gravel deposition areas are forming vegetated islands that are stabilizing some sections of the mid-channel. An effect of that stabilization however is that river flows have been directed to shoreline areas that are highly erodible. As a consequence large sections of the streambank experience erosion of the base of a landform i.e. toe erosion creating steep and undercut banks.

The river channel appears responsive to wood debris accumulation. Island formation and thalweg shifts are due to wood accumulations. Wood debris accumulates at some sharp bends or land protrusions into the active channel. In some situations the wood debris accumulation is settling out sediment and trapping other wood, in other instances the irregularity of the wood is exacerbating the erosive ability of the flow by directing flows directly to the bank or inducing scour at the toe.

[1] The investigator observed similar widening patterns in other sections but did not take measurements.

Vegetation growth on steep bank faces, even if not actively eroding, appears sparse. This is likely due to the loosely consolidated, non-fertile bank sediment in addition to the soil loss from freeze-thaw cycles during winter periods. Woody vegetation is establishing along bank toes where sediment is accruing in low energy areas and where no major scouring occurs during flood stages

Assessment and Proposed Monitoring Parameters

EcoAssets proposes using a 1 through 5 qualitative rating for three parameters (Table 1):

Functional rating scale

Impact to habitat element

Rock-vane exposure trend

Establish a marker network to conduct measurements from reference points to the top of the undisturbed bank, and channel cross sections will serve as additional baseline information for long-term monitoring.

Functional ratings include definitions that can be used for long-term qualitative assessment. Definitions are for a range of conditions and, if necessary, additional information can be added to the definitions as observations note other issues of concern in the early years of monitoring (Table 1). There are several potential benefits for assigning ratings. The ratings provide a standard qualitative description of the structure condition and its function. Tracking the ratings could eventually help specify a threshold rating for function and be used to determine whether or not repairs need to be made. Definition-based ratings also can guide resource workers with minimal geomorphology or hydrology backgrounds in making reasonable current condition estimates.

Rock-vane Functionality Ratings

The following three examples are suggested actions for ratings and suggest potential actions based on the rating:

1. Rock-vanes with a function rating of 1 should be monitored for further changes and if the condition does not worsen they can be considered stable.

3. Rock-vanes with a function rating of 3 should be more closely monitored and possibly repaired. For bank erosion, additional vegetation plantings may be considered to protect the banks.

5. Rock-vanes with a function rating of 5 are damaged or at imminent risk of damage and should be repaired depending on the functional impairment.

Use of **2.** and **3.** and/or half-point ratings capture intermediate conditions. A photo journal of these ratings can be created to serve as a field guide for future assessments.

Impact to Habitat Element Rating

Habitat elements are fish habitat features within the river reach regardless of the presence of rock-vanes. Examples of such elements include velocity refuge, pools, debris accumulations, gravel sources, and cover habitat. These elements make varying contributions to fish productivity but nonetheless provide for the diversity of habitats in rivers. Current conditions of buried rock-vanes do not contribute to habitat elements but those elements may be present in the area of the rock-vanes. Once portions of rock-vanes become exposed, they may in fact add habitat elements to the river that would otherwise be absent. Therefore the rating sequence assumes that as some rock-vanes are exposed they will contribute to habitat elements but extensive exposure of the rock-vanes, in combination with a continued trend of high velocity flows, could lead to rock-vane loss and/or degraded habitat elements (Table 1).

Rock-vane Exposure as Proxy to Erosion Trends

Qualitative assessment of bank erosion trends will provide the early warning signals of the potential for rock-vane exposure or conversely in the long-term, identify situations where sediment accrual in previously eroding rock-vane areas are now reducing energy.

EcoAssets suggests a more quantitative evaluation could be used to document erosion trends over time such as the Bank Erosion Hazard Index (BEHI). The BEHI was developed by Wildland Hydro to calculate a hazard rating score (http://www.wildlandhydrology.com/html/RiverStability.htm). The BEHI is a method for developing quantitative prediction of streambank erosion rates. The BEHI was used by CRR (Pace 2009) to describe erosion hazard in the buried rock-vane reach. This is a viable evaluation that can be applied at rock-vane sites at an average every 5 years. Large storm events that create excessive erosion could trigger more frequent use, or areas with longer-term stability or evidence of accretion may not require an evaluation. We recommend that professionals familiar with the terminology and metrics of geomorphology conduct the evaluations. Although it may seem that

the forms require only measurements, experience in river ecology and channel dynamics and ability to discern subtle channel trends is valuable in adjusting the hazards scores.

Erosion Monitoring Technique

The main objective of erosion monitoring is to identify long-term erosion trends and qualitatively assess rock-vane functionality. Metal or wood stake or natural (trees) markers that are geo-referenced to benchmarks will be installed and maintained. The most appropriate benchmark is the rock-vane heel stake marker since that is the furthest setback from the river bank. Each rock-vane offers opportunities to use varying combinations of trees, markers tied to the rock-vane location and/or markers to be placed. Rock-vanes within clusters can share reference markers.

It is not essential to estimate soil volume loss or characterize streambank morphology, or to setup a complex grid system or survey-grade marker network to capture useful information. EcoAssets proposes the following general guidance for erosion monitoring at each rock-vane (site variations may require more or less markers). The process is as follows:

1. Determine the location of the rock-vane heel and identify the metal post marker as the principal reference marker for the rock-vane site (it is typically furthest away from the stream and would be the marker least likely to be removed by erosion).

2. Measure the distance from the rock-vane heel marker to the rock-vane toe marker. Record the azimuth.

3. Trees or additional posts can be used as markers along the shoreline. Record their distance and streamward azimuth from the rock-vane heel and toe markers. For markers lost to erosion, monitors will be able to triangulate with 2 tape measures to marker locations during assessments. The precise locations of lost markers do not need to be pinpointed because with their loss there will be a new distance from the reference marker to top of undisturbed bank and a new marker can be established close to the bank. Maintaining a marker close to the bank allows for more rapid measurements during periods of minimal erosion. The monitor records distances in a spreadsheet format provided with this memo.

4. Auxiliary sites should be established on the opposite side of the river. At a minimum it would be helpful to mark trees along the bank with the distance from undisturbed bank.

5. Data from the assessments can be kept in spreadsheet format and periodically summary reports could describe current trends by rock-vane, cluster, or river reach.

Figures 2 and 3 demonstrate example arrangements of markers and use of trees. Figure 4 is an example image of tree marker documentation that could be used in complement with rock-vane monitoring. Eventually, a photo guide of many conditions can assist resource workers that are qualitatively rating the rock-vane function and erosion trends. Appendix A presents this concept.

Channel Cross Section Recommendations

EcoAssets recommends that up to 8 channel cross-sections be established slightly upstream, downstream, and within the project area to establish width/depth ratio (Figure 5 for concept location and spacing). Width/depth ratio is a key variable for assessing departure from a stable reference condition. Increases in W/D ratio generally are associated with accelerated streambank erosion rates, excess deposition/aggradation processes, and over-widening. Cross section endpoints should be placed landward of the bankfull width (the maximum width of a stream) and include a reading at the bankfull width. The bankfull width is essentially the point along the bank where, during high flows, water exits the channel. A laser range finder or for more accuracy, a tape measure stretched from one bank to the other at 90° to the general course of the river, will provide the measurements to record bankfull heights. Bankfull height, the measurement from the stream bottom to the horizontally projected bankfull width elevation, should be taken at changes in topography or bathymetry in a frequency that captures the general streambed cross-section profile. A 1,000 foot spacing of cross sections based on mid-channel lineal distance can provide cross-sectional profiles for future comparison. Some cross sections from the 2008 surveys can be maintained since they could provide a 5-yr. monitoring interval (if surveys occurred in 2013). The cross-section spacing and locations would be adequate for use in hydraulic modeling should that be necessary for project design or effects analysis in the future. If opposite bank benchmarks established such as driven in the ground rebar flagged stakes, they should be negotiated with landowners first since many of the cross section measurement markers will be on private or communal property.

The overall survey can be tied to highway benchmarks for accuracy. In 2008 the Washington Department of Transportation created seven cross-sections over a 1.2 mile length of the White River for a hydraulic modeling project (data cited in CDM 2009). These cross sections (referenced by WA Dept. of Trans State Route Mile Post (SRMP), Highway 410 Road Miles 46.8, 47, 47.2, 47.4, 47.6, 47.8, and 48) are spaced about 1050 ft apart and within the buried rock-vane reach. The cross section's spacing initiate systematically from SRMPs on Highway

410 so their spacing is somewhat irregular on the CRR side of the White River. All the cross sections can serve as viable baseline cross section data. However, a more systematic spacing originating from the CRR side of the river may serve the long-term investment of the project better. Some cross sections may be positioned appropriately amidst buried rock-vanes, such as existing Section 47.2. EcoAssets and associates are capable of conducting these surveys.

A Note on Photo Point Monitoring

Photo point monitoring is essential when documenting baseline markers and trees and in capturing the overall site characteristics of a particular reach. Should a time series of photos be desired for a particular reach or property, take the picture from the same place every time. A measuring rod to provide scale can be positioned and included in the photos. Take the previous year's image into the field when desiring to take another image of the site and frame the new image the same way as the old one. Hard prints of images on acid-free paper are recommended in addition to digital copies. Photo point monitoring can also be used to monitor relative vegetation recovery and growth. Instead of measuring individual plants by the dozens or hundreds, a measuring rod can be placed in the photo every 2 – 4 years and the heights of the plant community can be documented qualitatively. Typically, annual growth is visible when comparing shrub vegetation growth within the first few years until plant height has slowed or height limits have been reached. Trees can be monitored for growth and survival until the main branches are above deer and elk browse height and it becomes evident that they will survive.

Stream Gage Need and Site Assessment

Despite the recent bank stabilization measures future management actions are likely necessary in response to changing river channel conditions. Discharge and flood elevation information will be helpful to inform assessments and permitting for such actions. In addition to providing local river flow characteristics, installing and maintaining a stream gage also indicates a pro-active stewardship of the river reach in response to regulatory agency concerns about continued reactive or emergency measure shoreline actions which could potentially affect the river.

There are active USGS-managed streamflow gages in the White River and tributaries upstream of Mud Mountain Dam (Figure 6). They are:

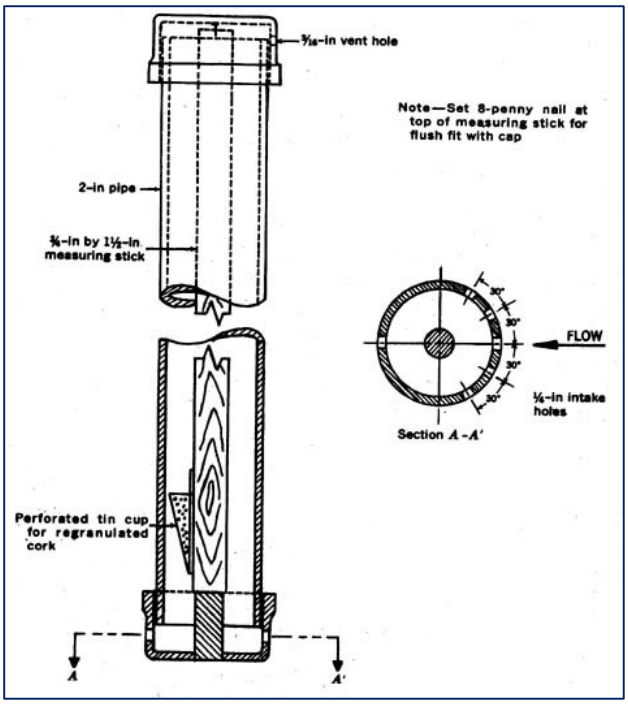
Location	Station Number
Greenwater River at Greenwater, WA	12097500
White River below Clearwater River	12097850
Clearwater River near Buckley, WA	12097820
Huckleberry Creek, upstream of CRR	12096865
White River near Buckley, WA	12098500

Based on the need for more localized and accurate flow measurements for long-term CCR reach management, a stream gage at Crystal River Road crossing is recommended for installation (Figure 7). The site fits many traditional requirements of gage siting including:

- Channel characteristics relative to a fixed and permanent relation between stage (water level above river bed) and discharge (water volume). Although there is a moveable bed, the reach is somewhat uniform.
- No possibility of backwater influence
- Good discharge measurements can be made from a cross-section defined by the bridge
- Stage gage can be properly placed with respect to the part of the channel controlling the stage-discharge relation (underbridge area)
- Suitable structure for safe high-flow discharge measurements
- Low to no possibility of flow bypass in floodplain channels
- Availability of power or telephone lines for real-time data transmission or data recorders
- Accessibility by road during flood stages

CRR may wish to pursue one of several types of stations that include: telemetry, stand-alone or manual stage height gages. A telemetry station transmits data in real-time or programmed hours. Stand- alone stations log data several times an hour and are downloaded in the field periodically, typically monthly. Manual stage-height stations do not contain a continuous record and consist of a series of periodic gage readings related to a series of instream flow measurements. Gage readings can be from a standard staff gage, wire weight gage, or from a reference point (a

location over the wetted area width of the cross-sectional area where a measurement can be made to the water surface). The correlations between these gage readings and the instream flow measurements are used to develop a rating table for the site.



Another low cost option is the Crest-stage gage (right) that obtains the elevation of the flood crest. This economical, reliable, and easily installed gage is the minimum recommendation for CRR reach management. A vertical piece of 2 inch galvanized or plastic conduit pipe with a wood staff held in a fixed position with relation to a datum reference would be appropriate. The USGS is aware of survey monuments in the area so that the gage can be tied to regional datum (standard position that measurements are obtained). The bottom cap has six intake holes located so as to keep the non-hydrostatic drawdown or superelevation (climbing up the staff or pipe wall) inside the pipe to a minimum. Tests have shown this arrangement of intake holes to be effective with velocities up to 10 feet per second, and at angles up to 30 degrees with the direction of flow.

The bottom cap contains re-granulated cork. As the water rises inside the pipe the cork floats on the water surface. When the water reaches its peak and starts to recede, the cork adheres to the staff inside the pipe, thereby retaining the crest stage of the flood. The gage height of a peak is obtained by measuring the interval on the staff between the reference point and the floodmark. EcoAssets and associates are capable of selecting, purchasing, installing and calibrating the preferred system.

Fastening or drilling of a staff gage on, or placement near the USDA Forest Service 74 Road would require consultation with County and Forest Service road managers.

Costs

A staff gauge and associated crest-stage gage can cost up to $200.00 for materials and can be installed in about 3 hours by a team and surveyed into monuments within an additional 2 - 4 hours. 4 – 6 hours of material assemblage and construction is needed prior to the installation.

Telemetry stations can cost between $10,000 – 12,000 to purchase and install and may require up to $6,000 of annual staff time and site visits on 6-week cycle for importing and managing data. Crest gages, which can record peak flow events, in combination with a staff gauge can cost between $900 – 1,300 to install and may require field visits several times over the first 2 years to develop a rating table at the site. A rating table is developed by taking discharge measurements at various flood events while correlating the height of the water to the flow. When an acceptable level of confidence is achieved in the flood height-discharge correlation, the discharge can be estimated simply by reading the staff gauge. Changes in channel shape from flood events may require that the flood height-discharge correlation be re-established if the changes in the channel shape were significant enough to impact the channel capacity at the measurement site.

EcoAssets recommends placement of staff and crest-stage gauges and accomplish flood event monitoring for a period of 2 years. This information can be used to compare with the active gaging stations in the area to determine if long-term monitoring goals can be satisfied by staff and crest-gage monitoring.

Several resource agency personnel have agreed to participate in dialogue and advise Crystal River Ranch Board members or resource workers in decisions for gage management, methods, and provide technical expertise. EcoAssets is capable of creating technical justification for the purchase and installation of stream gage and to assist in pursuing funds and developing partnerships for establishing the stream gage. Resource professionals with jurisdiction or interest in White River management that have been contacted are:

Public Agency and NGO Personnel Available to Assist in Pursuing Stream Gage Funding

Chuck Springer, Hydrologist	WA Department of Ecology	360-407-6997
Ken Frazzel, Field Office Chief	US Geological Survey	253-552-1670
Brent Bower, Hydrologist	National Weather Service, NOAA	206-526-6095 ext 228
Andy Bryden, South Zone Hydrologist	US Forest Service, Mt. Baker Snoqualmie District	360-677-2214
Karen Chang, Fishery Biologist	US Forest Service – Snoqualmie Ranger District	425-888-1421

Jim Franzel, District Ranger	US Forest Service – Snoqualmie Ranger District	360-825-6585
Kristen Williamson, Program Manager	South Puget Sound Salmon Enhancement Group	360-412-0808

Conclusion

With these measures in place, CRR demonstrates pro-active management and conservation in their shoreline areas. These types of efforts build trust and credibility with resource agency managers in part because the information provides a greater understanding of the river system and removes much of the guesswork out determining historic or baseline conditions. Even minimal efforts in tracking erosion rates with simple methods will provide information about the river reach as a whole. This will lead to responsible long-term river management decisions where the natural resources and its users mutually benefit. EcoAssets and associates would be pleased to work with CRR in any of these areas in moving forward.

References and Resources

Carter, R.W. and J. Davidian. 1968. General procedure for gaging streams. Chapter A6 Book 3 Applications of Hydraulics. 20p.

CDM. 2009. Floodplain Assessment Technical Memo – Crystal River Ranch Stream Bank Stabilization Project. Attachment 10. Prepared by Paul Fendt, P.E. 11 p.

Cederholm, C.J., L.G. Dominguez, and T.W. Bumstead, 1997, "Rehabilitating Stream Channels And Fish Habitat Using Large Woody Debris," Pages 8-1 to 8-28 in P.A. Slaney and D. Zaldokas, Fish Habitat Rehabilitation Procedures for the Watershed Restoration Program, Technical Circular No. 9. British Columbia Ministry of Environment, Vancouver, B.C.

Crandell, D. R., 1971, Postglacial Lahars From Mount Rainier Volcano, Washington: USGS Professional Paper 677, 75 p.

Dominguez, L.G. and C.J. Cederholm, 1999, "Rehabilitating Stream Channels Using Large Woody Debris With Considerations For Salmonid Life History And Fluvial Geomorphic Processes," pages 545-564 in E. Eric Knudsen, C.R. Steward, D.D. MacDonald, J.E. Williams, and D.W. Reiser, editors, Sustainable Fisheries Management: Pacific Salmon, CRC Press, Lewis Publishers, New York, NY. 724p.

Frissel, C. A., and Nawa, R. K. 1992. Incidence and causes of physical failure of artificial habitat structures in streams of western Oregon and Washington. North American Journal of Fisheries Management, 12(1): 182-197.

Galli, J. "Rapid Stream Assessment Technique." Available at: http://www.stormwatercenter.net/monitor-ing%20and%20assessment/rsat/smrc%20rsat.pdf. Accessed 25 October 2006.

Pace Engineering Services. 2009. White River Integrated Streambank Protection Guidelines (ISPG) Process. Prepared by R. Lawrence, Fluvial Geomorphologist, Oregon City, OR.

Roper, B. B., Konnoff, D., Heller, D., and Wieman, K. 1998. Durability of Pacific Northwest instream structures following floods. North American Journal of Fisheries Management, 18(3): 686–693.

Thome, C.R. Stream Reconnaissance Handbook: Geomorphological investigation and analysis of river channels. Wiley and Sons. New York, NY.

United States Department of Transportation. 2006. Assessing Stream Channel Stability at Bridges in Physiographic Regions. Turner-Fairbank Highway Research Center, McLean, VA.Publication No.FHWA-HRT-05-072.

Whiteway, S. L., P.M. Biron, A. Zimmermann, O. Venter, and J.W.A. Grant. Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Canadian Journal of Fisheries and Aquatic Science 67: 831–841.

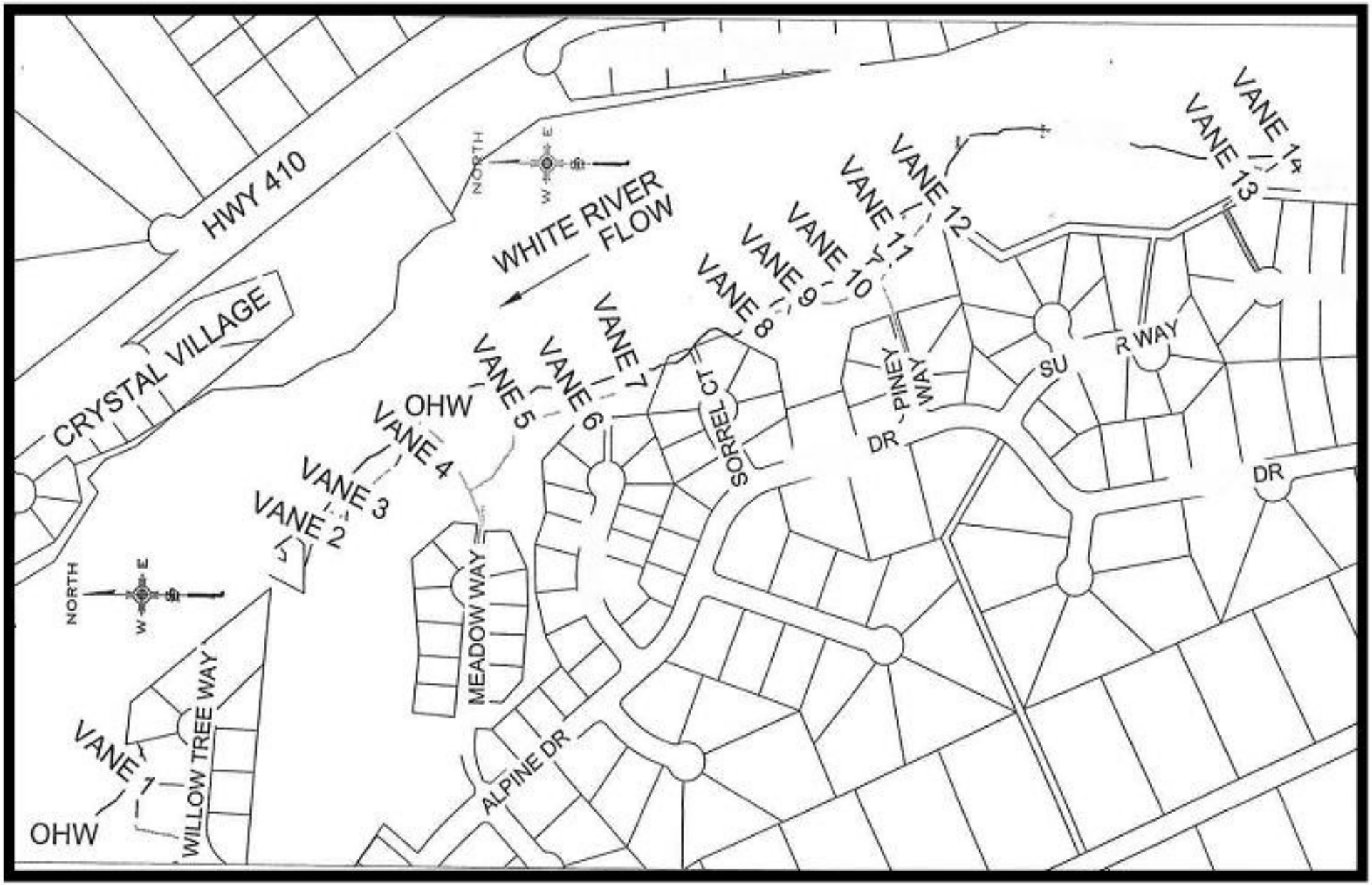


Figure 1. Rock-vane locations on southwest bank of White River. Groupings; 1; 2-4; 5-7; 8-12; 13,14.

Table 1. Functional Rating, Impact to Habitat, and Rock-vane Exposure Trend Ratings for long-term monitoring

Functional Rating[a] (medium to high flow observations)	Definition	Impact to Habitat Elements[b] rating (medium to low flow observations)	Definition	Vane Exposure[c] via Erosion Trends	Definition: The current trend of bank erosion as it relates to rock vane function
1	Rock vane remains completely buried	1	Rock vane completely buried; Any habitat elements are from natural system, evidence of sediment aggradation and new vegetation growth. Woody debris deposition but not scouring.	1	During average to low flows thalwag > 20 ft' from toe of bank, no active slope toe erosion. Vegetation establishing on bank or at toe and/or localized wood deposits causing sediment aggradation or low energy pockets along channel margin. No near term threat of thalwag shifting to vane except for avulsion.
2	Portion of rock vane slightly exposed, active stream channel is not adjacent to rock vane and no immediate threat of average floods to activate channel adjacent to rock vane	2	Some rock vane exposure resulting in scour pool development and/or woody debris deposition	2	During average to low flows thalwag < 20 ft from toe of bank, no active slope toe erosion. Vegetation establishing on bank or sediment aggrading or low energy pockets along channel margin. No near term threat of thalwag shifting to vane except for avulsion
3	<10 % of rock vane length exposed, active stream channel adjacent to vane during last flood event and trend towards active channel remaining adjacent for foreseeable future	3	< 25 % of rock vane length exposed, neglible impact to habitat elements	3	Thalwag may or may not be near bank toe and neglible loss of undisturbed bank. Threat of active channel to shift towards vane in moderate flooding
4	< 25 % of rock vane length exposed with highly erosive flows at toe and indications that high energy impact will continue in foreseeable future.	4	Some rock vane exposure with high energy flows defeflecting back into channel resulting in scour pool development and/or wood racking	4	Actively eroding bank with thalwag at or near bank toe at all flows. Significant width and length loss of undisturbed bank with trend to continue. Bank not over steepened.
5	>25 % of rock vane length exposed and connected to surface waters at all flows; highly erosive action during flood stages	5	> 50 % of rock vane length exposed and unraveling during high flow periods, evidence of high scouring, high energy impact area providing minimal habitat elements	5	Actively eroding bank with thalwag at or near bank toe at all flows. Significant width and length loss of undisturbed bank with trend to continue. Over steepened bank.

a) 1 = good; functional and low risk to loss of function: 5 = poor; at or approaching dysfunction and/or high risk of failure. Mid-step ratings (± 0.5) can be used if the rating category is trending toward negative impacts then add .5, if the rating category is trending towards a good/functional rating then subtract .5.

b) Habitat Elements: Velocity refuge or scour pools (adult staging areas), debris (wood racking) or carcass retention, settling out of gravel (indicates flow reduction), migratory adult holding pool. The project rock vanes are not designed to provide a habitat element but their roughness factors may contribute to forming habitat features.

c) This is not a risk assessment that would typically address the likelihood of failure and potential effects. Rather, this qualitative rating is intended to give an indication of the likelihood of buried rock vanes to be exposed directly to surface flows to further inform the functional rating.

Table 2. Rock-Vane Qualitative Assessment: Rock-vane Function, Habitat Risk, and Bank Erosion Trend Rating

Version October 20, 2012

Rock Vane Qualitative Vane Function, Habitat Impact, and Bank Erosion Risk RatingsTrend

Developed by EcoAssets for a qualitative assessment and long-term monitoring of vane performance on the Crystal River Ranch reach of the White River, Pierce County, WA.

		Vane1			Vane 2			Vane3			Vane4			Vane5			Vane6			Vane7		
YR	Mo	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend
2012	Oct	1	1	3	1	1	3.5	1	1	2.5	1	1	3.5	1	1	3	1	1	3	1	1	3.5
2013																						
2104																						
2015																						
2016																						
2017																						
2018																						
2019																						
2020																						
2021																						
2022																						

		Vane8			Vane9			Vane10			Vane11			Vane12			Vane13			Vane14		
YR	Mo	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend	Vane Function	Habitat Risk	Bank Erosion Trend
2012	Oct	1	1	3.5	1	1	3.5	1	1	1	1	1	2	1	1	3	1	1	2	1	1	2
2013																						
2104																						
2015																						
2016																						
2017																						
2018																						
2019																						
2020																						
2021																						
2022																						

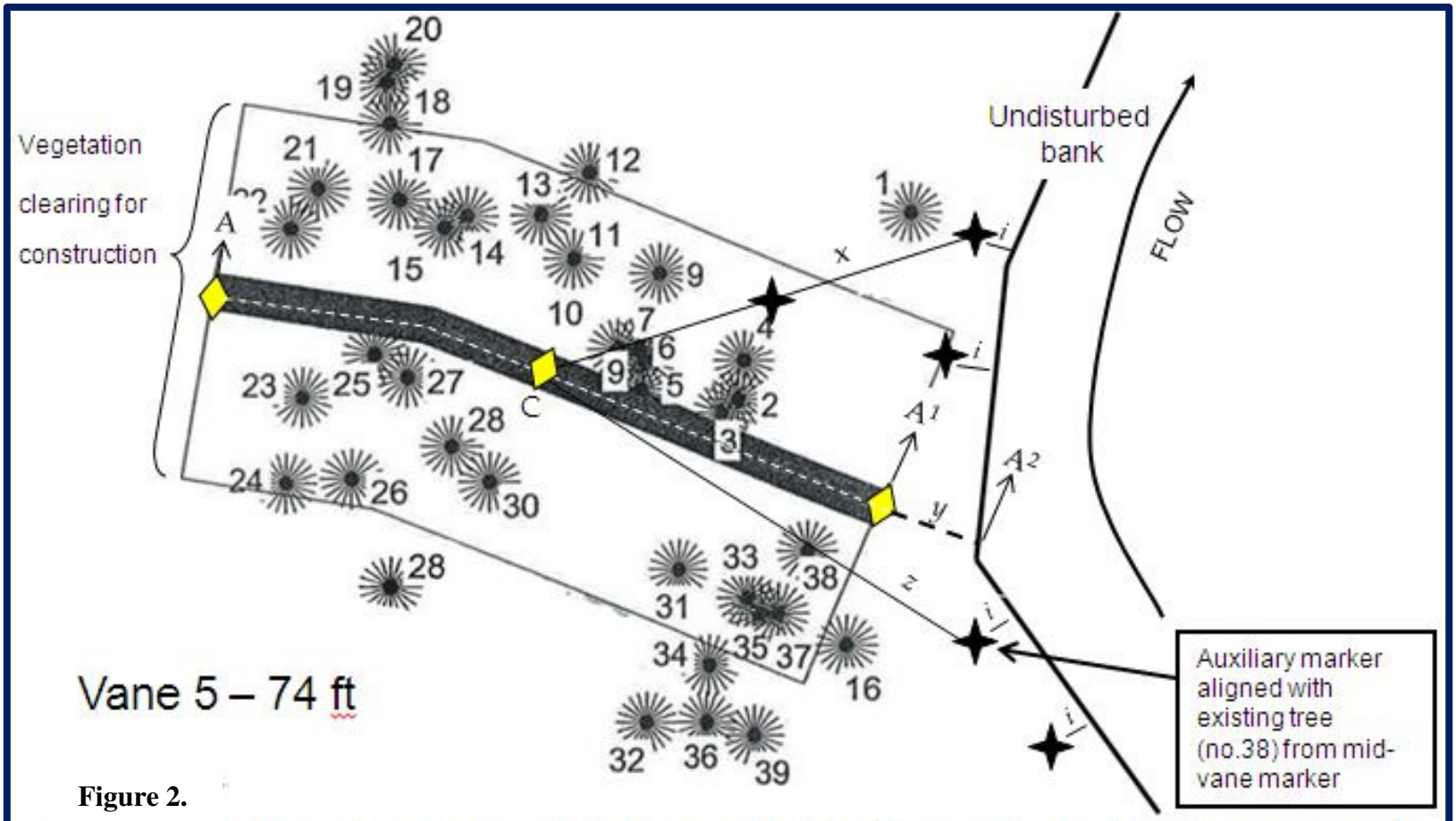


Figure 2.

Conceptual vane marker arrangement for vanes **angled** in relation to stream. Principal measurements are vane heel to toe length (**A**-**A**^{1}), vane heel to edge of undisturbed bank (**A**^{1}-**A**^{2}), lengths ***x***, ***y*** and ***z***. The weir toe (marker **A**^{1}) can serve as the primary benchmark. Auxiliary markers (✦) can be placed in areas of concern upstream or downstream of the vane. These are measured from a benchmark reference and assigned a streamward azimuth. Mid-vane markers (**C**) are used to establish additional transects. Vanes less than 100 ft. can use just one mid-vane marker at or near the vane mid-length. Trees can provide low maintenance, long-term markers. Measure distance from marker to the landward side of the tree for safety and consistency and correlate marked trees to other markers and site photographs. In this vane example, trees may serve as markers in most areas away from the undisturbed bank. All stream-adjacent markers or selected trees should be measured to closest point of disturbed bank (*i*).

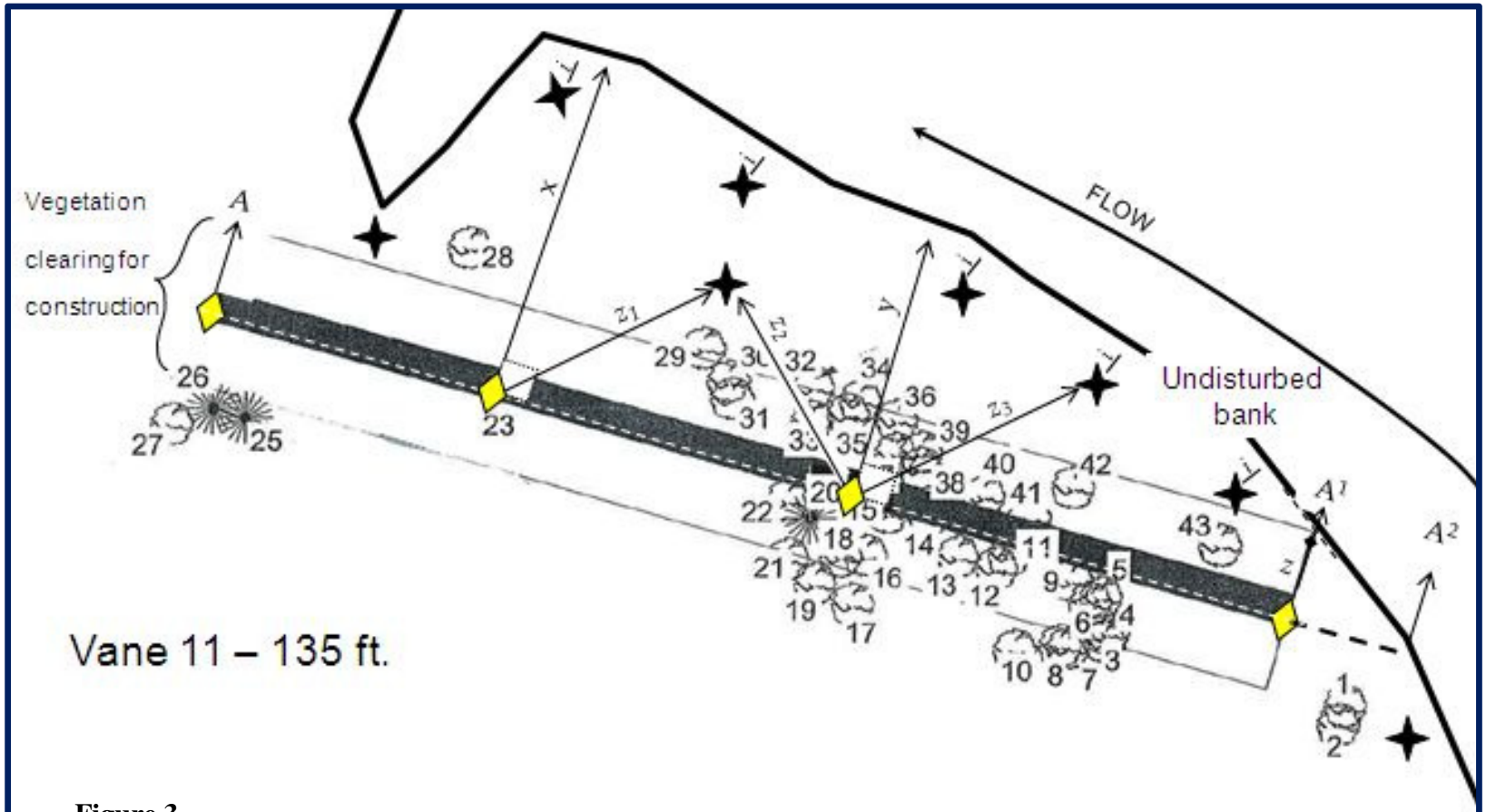


Figure 3.

Conceptual vane marker arrangement for vanes **parallel** in relation to stream. Principal measurements are vane heel to toe length (**A-A¹**), vane heel to edge of undisturbed bank (**A¹-A²**), lengths ***x, y*** and ***z***. The weir toe (marker **A**) can serve as the primary benchmark. Auxiliary markers (✦) can be placed in areas of concern upstream or downstream of the vane. Markers are measured from a benchmark reference and assigned a streamward azimuth. Mid-vane markers (C) are used to establish additional transects. Vanes less than 100 ft. can use just one mid-vane marker at or near the vane mid-length. Trees can provide low maintenance, long-term markers. Measure distance from marker to the landward side of the tree for safety and consistency and correlate marked trees to other markers and site photographs. In this vane example, trees may serve as markers in areas near the river away from the undisturbed bank. All stream-adjacent markers or selected trees should be measured to closest point of disturbed bank (*i*).

Figure 4. Example of how trees in vicinity of a rock-vane can be tagged and used as erosion markers with location tied into survey. Pre-numbered aluminum tags are recommended and installed on each selected marker tree with location correlated to rock-vane reference markers. Note aluminum nail not fully driven in to accommodate tree growth.

.**Figure 5.** Proposed channel cross-section locations.

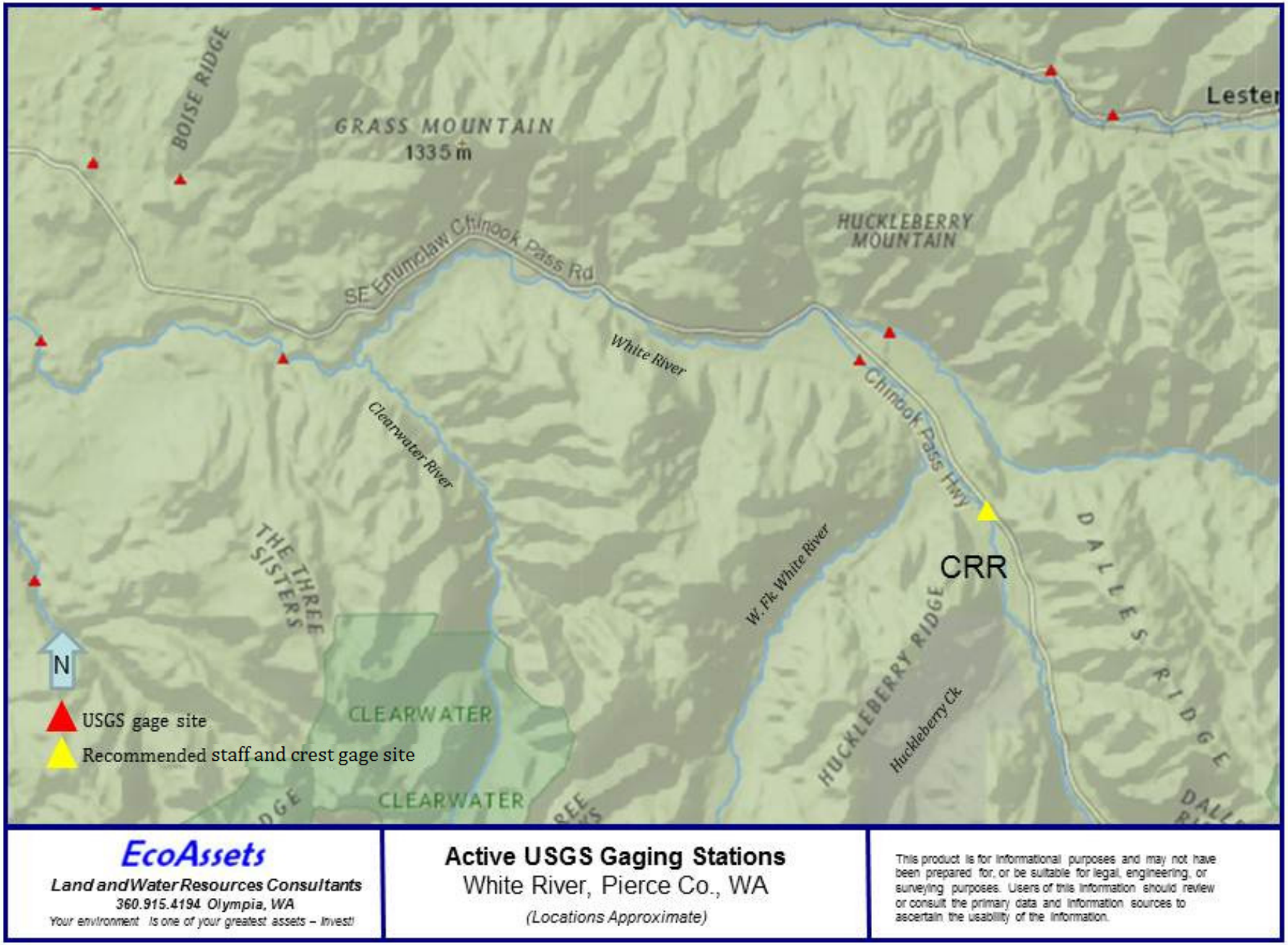


Figure 6. Active USGS stream gage stations and proposed location of additional gage

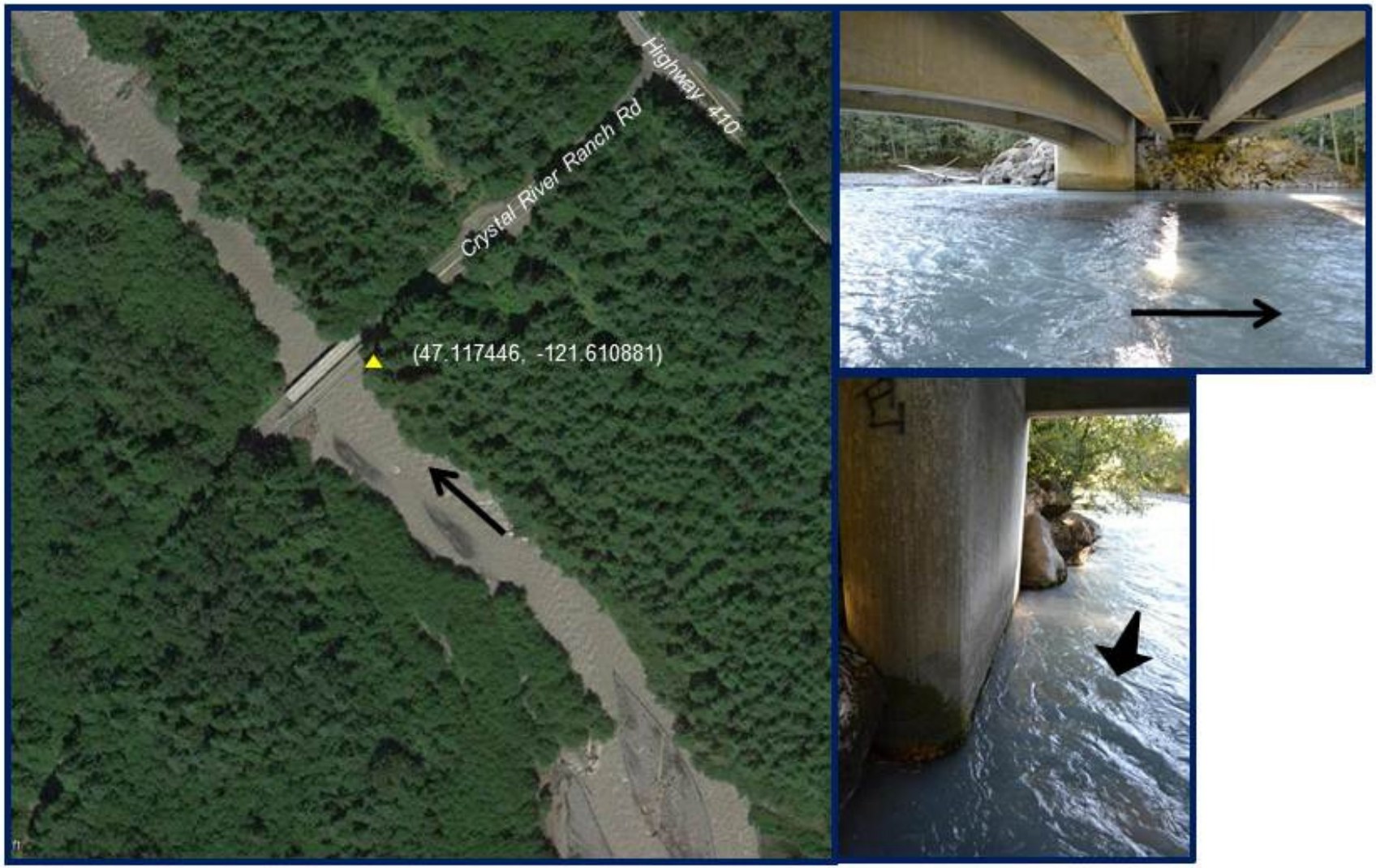


Figure 7. Proposed location of gage site (yellow marker with coordinates in decimal degrees) on Crystal River Ranch Road and view under the bridge. The staff gage should be placed so it is observable from the bridge or bank in a safe location during high flow events.

APPENDIX A – PHOTO REFERENCES FOR FUNCTIONAL RATING

1.

2.

3.

4.

5.

Picture references for helping observers rate vane functionality and erosion trend will need to be developed over a couple of years period as the area of erosion is formally observed for trends. Rapidly-eroding banks could have a few years of recovery due to channel shifts, vegetation establishment, or woody debris collection. With this mix of White River shoreline images (3 and 4) and shorelines elsewhere (1, 2, 5), the images are consistent with the ratings definition from densely vegetated stable banks (1) to over-steepened bank with active erosion and active flows at the bank toe (5). Intermediate ratings (2.5, 3.5, etc.) can be used to capture uncertainty of the trend or impact and/or if the observed condition staggers the definitions of two ratings.

APPENDIX B Comments on Baseline Assessment

Task C states "edit and advise on changes to cross-channel measurement process, data organization, report layout, and other elements contributing to a viable baseline assessment"

Cross channel measurement recommendations are included in the Technical Memorandum (EcoAssets 2012) recognizing that the upstream highway project cross sections are not viable references for long-term local project monitoring needs.

Channel width measurements are a simple alternative for general information but the high variability of channel widths and annual changes within the White River CCR reach suggest that cross sections are a more viable, defensible, and repeatable assessment and monitoring method. We recommend physical tape and transit or total station as opposed to rangefinder use for accuracy. Cross-section measurements to document change in channel characteristics may only be necessary after major flood events, and then only if additional information is needed that the shoreline erosion monitoring could not provide such as soil loss volume estimation or assessment of major channel shifts or aggradation to determine future risks.

CRR is compiling large amounts of data and correspondences. The information has been organized into binders chronologically to handle the proceedings of project activities and hearings to date. As CCR enters assessment and monitoring mode, document management might work best to separate out a strict resource-based compilation. The outline in Appendix C suggests a watershed-type approach but tailored to site conditions of the White River CRR reach. Natural resource agencies in Washington are familiar with this type of comprehensive outline and there are many assessments and reports in the region that contain relevant information that CRR could utilize.

Products that CRR has produced that aren't necessarily included in the outline can be introduced to supplement resource areas. For example the Crystal River Ranch Upland Erosion Control Project – Oct 2012 Restoration Status Report could eventually serve as an attachment or appendix to this comprehensive report once it serves its regulatory purpose. Information from technical memos could also be incorporated. The main point is that this resource information should be incorporated within a comprehensive overview rather than stand –alone documents. The stand-alone documents will always be retrievable but it is the compilation of information that is going to make the CRR story complete and maintain the management continuum.

The baseline assessment may include appendix-based attachments to incorporate status reports or local and regional shoreline management updates that CRR needs to make consideration for.

APPENDIX C White River Baseline Assessment Outline

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