10/16/02

**Documentation of stream data sets and models developed for the Willamette Basin Alternative Futures project.**

**FILE DESCRIPTIONS**

Every effort has been made to ensure that this data is complete and accurate, but EPA cannot be held responsible for raw data errors or misinterpretations. Mention of corporation names, trade names or commercial products does not constitute endorsement or recommendation for use.

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**<u>Model datasets</u>**

The datasets below are all compressed into a single ZIP file, **WMETTEBASIN.STREAM.DATASETS.ZIP**. Decompression produces the following four files, each in spreadsheet format (Dbase IV), totaling about 20 MB.

**REGDATF.DBF –** Data for 151 sites sampled for fish in the Basin. Includes physiographic and LULC estimates for each site. To build most fish regression models, we used only the 130 sites having INCLUDE="YES", because the other 21 sites employed a substantially different sampling effort than that of the standard EMAP protocol. The data set also includes sample data for aquatic invertebrate indicators (EPT richness and WINOE), but a few of the sites used to develop the invertebrate models are not included here (contact A. Herlihy for further details; Herlihy.Alan@epa.gov). See **Appendix A** for variable definitions.

**ALLCHAR4.DBF –** Physiographic driving variables for all 4045 stream reaches (2-4 order) in the basin. Each reach corresponds to one arc segment in the MODELSTRMS coverage. In making model projections, all driving variables are assumed fixed over all scenarios. Variables are defined in **Appendix B**.

**ALLSCEN4.DBF –** Land use/land cover (LULC) driving variables for all 4045 stream reaches. Estimates are given for all 5 alternative scenarios. Variables are defined in **Appendix C.**

**PROJALT.DBF –** Model projections for all model indicators and all scenarios, on all stream reaches. Also includes all components of the summer streamflow budget (Sec. 3 below). Model projections do not include uncertainty propagation. Variables are defined in **Appendix D**.

**ARC coverages** – Each coverage is in ARC interchange format (.e00) which has then been compressed via gzip:

ALLPTCOV **–** Point coverage of 151 stream sample sites.

SITELIST **–** Point coverage of the 130 stream sample sites used in developing most Alternative Futures fish models.

MODELSTRMS **–** Coverage of 2-4 order model stream reaches, defined as individual arc segments in the full River Reach 2 stream network for the Basin. Segments greater than 5 km in length were split so that no model reach exceeded 3 km. Segments coded as ditches, aqueducts or reservoir centerlines were not modeled. Model projection results and/or driving variable data can be merged with the attribute table of this coverage, via the SEGID attribute.

## MODEL DOCUMENTATION

### 1. Fish IBI, Native Fish Richness, Cutthroat Trout Abundance, EPT Richness, and WINOE.

Table 1. Final models used for projection of stream condition indicators under alternative scenarios. AGRC and DVLP in all models are percentages of agriculture and developed land, respectively, in a 120m riparian corridor along the entire upstream network. N = number of sites used for final model fit, and $R^2$ = percent of indicator variance explained by each model (not available for negative binomial cutthroat trout model). Standard errors of coefficients are in parentheses under each coefficient. Footnotes identify transformed variables.

| Indicator | Region | Model | $R^2$ | N |
|---|---|---|---|---|
| Fish IBI | Lowland | 67.86 – 0.45∗AGRC – 0.40∗DVLP<br>(4.2) (0.07) (0.07) | 37 | 82 |
| Native Fish Richness[a] | Lowland +Upland | 0.36 + 0.52∗ORDER<br>(0.41) (0.24)<br>+ LDIS∗(4.85 – 8.52∗LEL300 – 0.18∗GRADIENT – 0.038∗AGRC – 0.026∗DVLP)<br>(0.66) (1.33) (0.09) (0.006) (0.007) | 70 | 129 |
| WINOE[b] | Lowland | 100∗(42.79 – 0.34∗LON + 0.11∗SPOW - 0.004∗AGRC – 0.003∗DVLP)<br>(11.52) (0.09) (0.04) (0.0008) (0.0009) | 52 | 55 |
| Invertebrate EPT[b] | Lowland | 0.29 + SPOW∗(6.51 – 0.069∗AGRC – 0.062∗DVLP)<br>(1.32) (0.82) (0.012) (0.014) | 61 | 55 |
| Cutthroat trout abundance | Lowland +Upland | exp[ 7.59 + 0.027∗WSAREA – 0.059∗AGRC – 0.040∗DVLP ]<br>(0.47) (0.007) (0.010) (0.010) | -- | 149 |

[a] LDIS = $\log_{10}$(DIVDIS). LEL300 = $\log_{10}$(ELEV)-$\log_{10}$(300), if ELEV > 300m. Otherwise LEL300 = 0.

[b] SPOW = $(\text{STRMPOW}+0.01)^{0.25}$.

### 2. Habitat Suitability Index (HSI) for cutthroat trout.

The Habitat Suitability Index (HSI) model for cutthroat trout is an expert-based model developed by Stan Gregory and co-workers at Oregon State University (Stan.Gregory@orst.edu). It was derived from a conceptual understanding of how stream ecosystems function and the types of stream habitat preferred by cutthroat trout. Field data on cutthroat trout occurrence in Willamette streams were examined to evaluate the reasonableness of each model component. Separate HSI models were developed for streams with watersheds predominately in the Willamette Valley ecoregion (lowland streams) versus streams with watersheds predominately in the Cascade or Coast Range ecoregions (upland streams).

HSI is calculated from 10 metrics representing 10 factors expected to affect the quality of stream habitat for cutthroat trout (Table 2). For each metric, the first step is to convert the measured or estimated values for the variable to a scale from 0 to 1. Operationally this is done by subtracting the minimum value for the variable in the Circa 1990 landscape and then dividing by the range (maximum minus minimum values) in the Circa 1990 landscape (Table 3). If values outside this range occurred in other scenarios, the metric value was set to 0 or 1, whichever was nearest. For five metrics (Table 3) the model assumes a negative relationship between the metric and habitat suitability, so the above value was subtracted from 1 to produce the final metric.

**Table 2. Cutthroat Trout Habitat Suitability Index: Metrics and Metric Weights**

| Metric | Wt. Valley Streams | Wt. Upland Streams |
|---|---|---|
| Stream gradient (SLOPEP) | 0.065 | 0.05 |
| Annual mean flow (QMEAN) | 0.065 | 0.10 |
| Valley Floor Width Index (VFWI) | | 0.10 |
| Wood Potential (WDVOLUN) | 0.20 | 0.25 |
| Closed Forest in Riparian Network (CFORMED) | | 0.35 |
| % Natural Vegetation in Riparian Network (RIPBMED) | 0.34 | |
| Road Density in the Watershed (RDENLRG) | 0.065 | 0.05 |
| Closed Forest in the Watershed (CFORLRG) | 0.065 | 0.025 |
| % Development land in Riparian Network (DVALMED) | 0.10 | 0.05 |
| % Agriculture in Riparian Network (AGRCMED) | 0.10 | 0.025 |

**Table 3 – Observed minima and maxima of raw HSI metrics**

*NOTE: SHADING DENOTES THOSE VARIABLES THAT ARE NEGATIVELY SCALED.*

| | | **Valley** | | **Upland** | |
|---|---|---|---|---|---|
| Primary Category | Variable | **Min** | **Max** | **Min** | **Max** |
| Physical | SLOPEP | 0.00 | 42.94 | 0.00 | 42.67 |
| | QMEAN | 0.67 | 1883.48 | 0.26 | 1924.54 |
| | VFWI | | | 0.50 | 1.00 |
| Wood Potential | WDVOLUN | 0.00 | 67.56 | 0.00 | 94.67 |
| Network Riparian | CFORMED | | | 0.21 | 100.00 |
| | RIPBMED | 0.94 | 99.74 | | |
| Basin Conditions | RDENLRG | 0.00 | 0.02 | 0.00 | 0.01 |
| | CFORLRG | 0.00 | 99.84 | 0.30 | 100.00 |
| Other Human | DVALMED | 0.00 | 96.37 | 0.00 | 20.00 |
| | AGRCMED | 0.00 | 97.88 | 0.00 | 90.81 |

HSI was then calculated as a weighted sum of the 10 metrics (weights in Table 2), with low values (on a scale of 0 to 1) indicating poorer cutthroat trout habitat. The model thus assumes a linear, additive relationship, either negative or positive, between individual metrics and overall HSI.

Two landscape variables were unique to the HSI model: Valley floor width index (VFWI) and wood potential (WDVOLUN). VFWI (for Upland streams only) was set equal to 1 if more than 33% of the reach was identified as unconstrained in GIS analyses based on the 30-m digital elevation model (DEM). VFWI equals 0 if 33% or LESS of the reach was unconstrained.

WDVOLUN represents the potential contribution of large wood to the stream from the riparian area immediately adjacent to the reach. It was calculated as the weighted sum of 11 different forest vegetation classes (Table 4), with older conifers being weighted most heavily. The weighting factors for each forest class represent the relative wood volume (scaled to the maximium) that would be contributed from each class, as estimated by detailed mechanistic modeling of wood inputs from riparian stands (Meleason 2001).

**Table 4 –** Wood recruitment potential (WDVOLUN) is a weighted sum of the areal percentages of LULC forest classes found in 30m (each side) riparian corridor adjacent to the reach. LULC codes are from the Hulse et al. Existing Conditions Legend, Version 6. See http://inti.uoregon.edu/lulcweb/ise_legend6d.html for more detail.

| Stand Type | LULC CODE | Weight |
|---|---|---|
| Closed conifer, 0-20yr | 56 | 0.0441 |
| Semi-closed Mixed | 52 | 0.1073 |
| Semi-closed Hardwood | 62 | 0.2039 |
| Semi-closed Conifer | 55 | 0.2235 |
| Closed conifer, 21-40yr | 57 | 0.3503 |
| Closed mixed, 1-80yr | 54 | 0.3578 |
| Closed conifer, 41-60yr | 58 | 0.5488 |
| Closed hardwood, 1-100yr | 53 | 0.6795 |
| Closed conifer, 61-80yr | 59 | 0.6802 |
| Closed conifer, 81-200yr | 60 | 0.7450 |
| Closed conifer, 200+ | 61 | 1.0000 |

## 3. Stream flow.

Stream flow in all reaches was modeled for the low-flow period (August-September) of a “typical” dry year. First, we estimated the “natural” flow (QNAT80) from long-term records of average August and September flows at 32 gages in the Basin on small streams (watershed area <650 $km^2$) having little to no upstream water withdrawals for domestic, agricultural or other uses and no upstream dams. A typical dry year flow was defined as the 80th percentile exceedance flow of each long-term record.

To estimate natural flow in ungaged stream reaches, we developed a regression model for QNAT80 (in cfs) as:

$$\log10(QNAT80) = -1.9709 + 1.1727*\log10(0.003861*WSAREA) + 0.0127*(0.0394*AVG\_PPT),$$

with $R^2 = 0.82$ and both regressors significant with $p<0.001$. Units on watershed area (WSAREA) are hectares, and on average annual precipitation (AVG_PPT) are mm. Natural flow was assumed to remain constant over all scenarios.

We then estimated “actual” summer low flow (QACT80), by subtracting human consumption estimates from natural flow, as:

$$QACT80 = QNAT80 – CONSUMPT + INSTRM + DAMRLS$$

Here, CONSUMPT is total consumption, estimated for each scenario. A few of the larger reaches lie downstream of dams and have summer flows augmented by releases

(DAMRLS). In addition, the Conservation 2050 scenario assumed new instream water rights (INSTRM) for some reaches, which were included in total consumption estimates for that scenario. The INSTRM flow must then be added back in, to obtain QACT80. All estimates for CONSUMPT, INSTRM and DAMRLS were provided by applications of the Water Master model in the Willamette basin (Niemi et al. 2002). For all model development sites (data in REGDATF), INSTRM and DAMRLS were zero.

Long–term annual average flow (QMEAN; cfs) was also estimated from the regression :

log10(QMEAN) = -0.1847+1.0508*log10(0.003861*WSAREA)+.0088*(0.0394*AVG_PPT) + 2.582E-5*(ELEV_MN*3.281).

Here, ELEV_MN has units of meters, and other variables are as above. The model ($R^2$ = 0.98; all regressors significant with $p<0.02$) was developed using flow data from 59 streams in the basin having flow record durations of 15 to 30 years during the period 1957-1987 (Oregon Water Resources Department 2001). We used records from gaged watersheds ranging in area from the smallest available (18 $km^2$), up to 650 $km^2$.

## 4. Habitat width, cross-sectional area, surface area and volume.

We modeled the impact of flow changes on the fish and invertebrate habitat that would be expected during summer low-flow conditions in a dry year, by estimating the wetted channel width and cross-sectional channel area for each reach. Measured channel width (XWIDTH) and rectangular cross-sectional area (XAREA = XWIDTH * stream depth) was regressed on physiographic and flow variables, giving the final models:

VALLEY

log10(XWIDTH) = 0.3061 +0.2744*log10(0.01*WSAREA) +0.1330*log10(QACT80)
($R^2$=.72, RMSE=0.15)

log10(XAREA) = -0.6184 +0.4844*log10(0.01*WSAREA) +0.3011*log10(QACT80)
($R^2$=.84, RMSE=0.21)

UPLAND

log10(XWIDTH) = 0.4198 +0.3584*log10(0.01*WSAREA) +0.0965*log10(QACT80)
($R^2$ = .82, RMSE=0.13)

log10(XAREA) = -0.3590 +0.4026*log10(0.01*WSAREA) +0.3147*log10(QACT80)
($R^2$ = .85, RMSE=0.19)

Multiplication of wetted width by reach length (SEGLEN) yields an estimate of the total surface area of water, and hence of habitat, that is available in a reach. Likewise, multiplying XAREA by SEGLEN yields an estimate of the total habitat volume available in a reach.

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**Appendix A. – Variable definitions for model development set REGDATF. Data is from 151 streams sampled in the Basin. See Appendices B and C for further details of LULC and some physiographic variables.**

| NAME | LABEL |
|---|---|
| AGDVLRG | %(AGRC+DVAL), watershed |
| AGDVMED | %(AGRC+DVAL), 120m riparian corridor |
| AGDVSML | %(AGRC+DVAL), 30m riparian corridor |
| AGLOLRG | %(AGRC+DVLO), watershed |
| AGLOMED | %(AGRC+DVLO), 120m riparian corridor |
| AGLOSML | %(AGRC+DVLO), 30m riparian corridor |
| AGRCLRG | %(AGRC), watershed |
| AGRCMED | %(AGRC), 120m riparian corridor |
| AGRCSML | %(AGRC), 30m riparian corridor |
| AVG_PPT | Annual mean precip (mm) from PRISM |
| CFORLRG | %(CFOR), watershed |
| CFORMED | %(CFOR), 120m riparian corridor |
| CFORSML | %(CFOR), 30m riparian corridor |
| CHINABUN | number chinook captured |
| CHLFABUN | number cool/cold-water fish caught |
| CHLFRCH | cool/cold fish spp richness |
| COHOABUN | number coho captured |

CONMLRG %(CONM), watershed
CONMMED %(CONM), 120m riparian corridor
CONMSML %(CONM), 30m riparian corridor
COUNTY County of site
CUTABUN number coastal cutthroat trout caught
CUTPA coastal cutthroat trout presence/absence
DATE sampling date
DISDIVID crow-flies distance(km) to uppermost watershed boundary
DISRIVR5 network distance(km) to 5th-order river
DOM_ECO4 dominant ecoregion of watershed
DVALLRG %(DVAL), watershed
DVALMED %(DVAL), 120m riparian corridor
DVALSML %(DVAL), 30m riparian corridor
DVHILRG %(DVHI), watershed
DVHIMED %(DVHI), 120m riparian corridor
DVHISML %(DVHI), 30m riparian corridor
DVLOLRG %(DVLO), watershed
DVLOMED %(DVLO), 120m riparian corridor
DVLOSML %(DVLO), 30m riparian corridor
ELEV site elevation(ft)
ELEV_DN elevation(m) of downstream end of arc
ELEV_MN mean elevation(m) of arc
ELEV_UP elevation(m) of upstream end of arc
EPT_RICH EPT Distinct Invertebrate Taxa Richness
EXTFABUN number exotic fish captured
EXTFPA presence/absence of exotic fish
EXTFRCH exotic fish richness
FISHABUN total number fish caught
FISHRCH fish richness
HDWDLRG %(HDWD), watershed
HDWDMED %(HDWD), 120m riparian corridor
HDWDSML %(HDWD), 30m riparian corridor
HUC 8-digit hydro unit (subbasin)
IBI_FIN Fish IBI Score (Hughes et al. 1998)
INCLUDE Yes=standardized sampling effort
LAT_DD site latitude (decimal degrees)
LON_DD site longitude (decimal degrees)
MODUSE sample split indicator for model development and validation
NATFABUN number native fish captured
NATFRCH Native fish richness
NETLEN total length(m) of all upstream streams
O_EVAL Observed/Expected Invertebrate Richness for Valley Region (WINOE)
PNTR index of RR2 arc for site
PNTR2 index of split arc for site
QL50 low-flow discharge(cfs), 50% exceedance
QL80 low-flow discharge(cfs), 80% exceedance

QMEAN mean annual discharge(cfs)
RDENLRG Road density, watershed
RDENMED Road density, 120m riparian corridor
RDENSML Road density, 30m riparian corridor
REGION Valley=lowland, Upland=Casc&CoastRnge
RIPBLRG %(RIPB), watershed
RIPBMED %(RIPB), 120m riparian corridor
RIPBSML %(RIPB), 30m riparian corridor
RNBWABUN number rainbow trout captured
RP100 Residual Mean Depth (cm)
RPBFLRG %(RPBF), watershed
RPBFMED %(RPBF), 120m riparian corridor
RPBFSML %(RPBF), 30m riparian corridor
SALMABUN number salmonids captured
SALMRCH salmonid richness
SEGLEN Length(m) of arc segment for site
SENFABUN number fish caught of sensitive species (Hughes et al. 1998)
SENFRCH sensitive fish species richness
SLOPEP mean reach slope (%) from DEM
STRAHLER stream order, 1:100000 scale
STRMNAME Stream Name from 7.5 Map
STRMPOW stream power index=QMEAN*SLOPEP
STRM_ID site code
STUDY study code
TOTABUN total vertebrates caught
TOTLLRG Total area (ha), watershed
TOTLMED Total area (ha), 120m riparian corridor
TOTLRCH Total area (ha), reach
TOTLSML Total area (ha), 30m riparian corridor
V1W_MSQ LWD Volume in active channel (m3/m2-all sizes)
VISIT_NO Sample visit number
WSAREA watershed area(ha)
WSDIAM watershed diameter = sqrt(area)
XBKF_H Bankfull height-Mean (m)
XBKF_W Bankfull Width--mean (m)
XCDENMID Mean mid-channel canopy density (%)
XDEPTH Thalweg mean depth (cm)
XFC_NAT Fish cover-- natural types (Sum of areal proportions)
XSLOPE mean slope (%) at site
XWIDTH Wetted width -- mean (m)
YEAR Sample year

**APPENDIX B – Variable definitions for data set ALLCHAR4: Physiographic variables**

AVG_PPT Annual mean precip (mm)of watershed, from PRISM
DAMS Number of upstream dams, from ORDAMS
DISDIVID Crow-flies distance(km) to uppermost watershed boundary
DISRIVR5 Network distance(km) to nearest downstream 5th-order river
DOM_ECO4 Dominant ecoregion of watershed
ELEV_DN Elevation(m) of downstream end of reach
ELEV_MN Mean elevation(m) of reach
ELEV_UP Elevation(m) of upstream end of reach
HUC 8-digit hydrologic unit (Reach locator 1)
LAT_DD Latitude of watershed outlet(decimal degrees)
LON_DD Longitude of watershed outlet (decimal degrees)
NETLEN Total length(m) of all upstream steams
PNTR Index of RR2 arc segment (reach locator 2)
PNTR2 Index of split RR2 arc segment (reach locator 3)
QMEAN Mean annual discharge(cfs)
QNAT80 Natural summer streamflow(cfs), for typical dry year
QACT80 Actual dry-year summer flow(cfs) = QNAT80-CONSUMPT
CONSUMPT Human consumption of summer flow (cfs)
RCHECO Ecoregion of reach
RDENLRG Road density of watershed. (m. roads per sq.m. area).
(see appendix B for LRG, MED, SML definitions)
RDENMED Road density, 120m riparian corridor
RDENSML Road density, 30m riparian corridor
REGION Valley=Lowland, Upland =(Cascades or Coast Range Ecoregion)
SEGID Unique reach ID: HUC+PNTR+PNTR2
SEGLEN Reach Length(m)
SLOPEP Mean reach slope (%) from DEM
STRAHLER Reach order, 1:100000 scale
STRMPOW Stream power index=QMEAN*SLOPEP
TOTLLRG Total area (ha), watershed
TOTLMED Total area (ha), 120m riparian corridor
TOTLRCH Total area (ha), reach
TOTLSML Total area (ha), 30m riparian corridor
VFWI Valley floor width index, for HSI model
WSAREA watershed area(ha)

**Appendix C. Variable definitions for data set ALLSCEN4: LULC variables**

Variables are defined in 4 major groups (C.1-C.4):

**C.1-- Reach and Scenario IDs** --

HUC 8-digit hydrologic unit (Reach locator 1)
PNTR Index of RR2 arc segment (reach locator 2)
PNTR2 Index of split RR2 arc segment (reach locator 3)
SCENARIO: EC90 = Existing conditions, ca. 1990.
HIST = Historical (Pre-European settlement.
CN50 = Conservation, 2050.
PT50 = Plan Trend, 2050.
DV50 = High Development, 2050.

**C.2-- Aggregated LULC variables**

Variable names are each 7 characters, with the first 4 characters denoting LULC classes (C.2.1), and the last 3 denoting the area of influence (AOI; see C.2.2). Unless otherwise noted, each variable represents the percentage of total area in the AOI that is made up of the specified LULC. Examples are given in C.2.3.

**C.2.1 -- LULC CLASSES**. Class codes are from the Hulse et al. Existing Conditions Legend, Version 6. See http://inti.uoregon.edu/lulcweb/ise_legend6d.html for details of the classes.

| Variable Name (first four characters) | LULC classes included | Description |
|---|---|---|
| DVHI | 2-4, 6-11, 19-22, 26, 27 | High/Moderate Density Development |
| DVLO | 1,5,12, 16-18,24,25,28 | Low-Density Development |
| DVAL | DVHI + DVLO | All developed areas. |
| AGRC | 67-85, 88, 90-94 | All agriculture |
| CONM | 60, 61 | Mature Conifers (80+ yrs.) |
| CFOR | 53,54,57-61,66,95 | All closed forest |
| HDWD | 53, 62 | Hardwoods (closed or semi-closed) |
| RPBF | 51-62, 85-87, 94 | Natural vegetation - 1. All trees, shrubs, natural grassland, pasture |
| RIPB | 51-62, 86-89,66,95,49, 97-100 | Natural vegetation - 2. Use instead of RPBF. Similar, but no pasture. |
| TOTL | Total area of AOI | Units are hectares |
| RDEN | Road Density | Units are m. roads per sq m watershed area |

**C.2.2 -- Areas of Influence (AOI), and 3-letter component of variable name.**

LRG -- Large -- Entire watershed.

MED – Medium-- Entire upstream riparian corridor, including first- order streams, within 120m on each side of stream.

SML -- Small – Upstream corridor (30m each side of stream) within a circle of radius 10-km that is centered on watershed delineation point.

**C.2.3. Examples of LULC variable names**

AGRCLRG -- Percent of total watershed area that is agriculture.

DVALSML -- Percent of Small AOI that is developed at either High or Low intensity.

TOTLMED -- Total area (ha) of medium AOI. Area includes both sides of stream, 120m wide on each side.

RDENSML -- Road density in the Small AOI.

**C.3 Single-class areas for wood recruitment potential metric (WDVOLUN) of HSI.**

Areal percentage of individual forest classes at the Medium (MED) and Reach (RCH) scale are denoted by variable names of the form CXXMED or CXXRCH. In these names, XX is one of the numeric codes shown in Table 4. For example, C55RCH is the percentage cover of semi-closed conifer at the Reach scale.

**C.4 Experimental composite LULC variables.**

Please contact J.P. Baker (Baker.Joan@epa.gov) with questions about these classes.

AOI1AGRC – Weighted average of the percent agriculture within the Small AOI, within the Medium AOI but outside the Small AOI, and within the Large AOI, but outside the Medium AOI. Relative weights for the three regions are 3:2:1, respectively.

AOI2DVLO – Weighted average percent DVLO within above regions, with relative regional weights of 1:1:1.

AOI2DVAL Weighted average percent DVAL within above regions, with relative regional weights of 1:1:1.

AOI2DVHI   Weighted average percent DVHI within above regions, with relative regional weights of 1:1:1.

A2AG122  -- Weighted average percent agricultural lands within the above regions, with relative regional weights of 1:1:1. In computing the percentage, hay, pasture and orchard areas are weighted half as much as areas with any other agricultural usage.

A2DV41  --  Weighted average percent developed lands within the above regions, with regional weights of 1:1:1. In computing the percentage, DVHI areas are weighted 4 times more than DVLO areas.

**Appendix D -- Variable definitions for data set PROJALT:   Model projections under alternative scenarios of land and water use.**

HUC 8-digit hydrologic unit (Reach locator 1)
PNTR Index of RR2 arc segment (reach locator 2)
PNTR2 Index of split RR2 arc segment (reach locator 3)
SCENARIO: EC90 = Existing conditions, ca. 1990.
HIST = Historical (Pre-European settlement.
CN50 = Conservation, 2050.
PT50 = Plan Trend, 2050.
DV50 = High Development, 2050.
SEGID Unique reach ID: HUC+PNTR+PNTR2
SEGLEN Reach Length(m). Used to weight reach results in regionally-aggregated statistics.
REGION Valley=Lowland, Upland =(Cascades or Coast Range Ecoregion)

CUTABUN Coastal cutthroat trout abundance (projected)
IBI_FIN Fish IBI Score (Hughes et al., 1998) (projected)
NATFRCH Native fish richness. (projected)
EPT_RICH EPT Distinct Invertebrate Taxa Richness (projected)
O_EVAL Observed/Expected Invertebrate Richness for Valley Region (WINOE) (projected)
HSI Cutthroat trout habitat suitability index (projected).
WDVOLUN Wood recruitment index (projected).

QNAT80 Natural summer streamflow(cfs), for typical dry year
DAMRLS Upstream dam release flow (cfs; projected)
INSTRM Flow protected by instream water right (cfs; projected).
CONSUMPT Human consumption of summer flow (cfs; projected)
QACT80 Actual dry-year summer flow (cfs; projected)
XWIDTH Channel wetted width at dry-year summer flow (m.; projected)
XAREA Channel wetted cross-sectional area, at dry-year summer flow ($m^2$; projected)