APPENDIX A-3:

SITE POTENTIAL APPROXIMATION

Technical Memo

3/20/00

FROM: Umatilla TMDL Technical Committee

RE: Predictions of Site Potential Stream Cross Section and Riparian Vegetation Characteristics, based on available data and best professional judgement.

Morphology

Site Potential Stream Type [based in Rosgen (1996) classification]

Existing and future potential stream type assessment is summarized in the following table, based on 1997 and 1998 Rosgen Level II Inventories (Inventories) of nine Umatilla River mainstem reaches and best professional judgement. Further monitoring is recommended for additonal stream-typing, evaluation of potential width to depth ratios and to relate bankfull and near stream disturbance zone (NSDZ, described in the Umatilla TMDL) widths.

Reach		River Mile		Type (1997)	Type (1998)	Type (potential)
1	Forks to Bear Creek	90	87	B4c	F4	B4
2	Bear to below Rock Creek	87	86.3	-	-	C4
3	Below Rock Creek to Gray's property	86.3	82	-	F4	B4
4	Gray's to Meacham Ck.	82	78.8	-	-	C4/B4
5	Meacham Ck. to Squaw Ck.	78.8	76.7	C4	C4	C4
6	Squaw Ck. to Buckaroo Ck.	76.7	73.4	-	F4	C4
7	Buckaroo Ck. to Cayuse Bridge	73.4	67.5	-	F1/F4	C4/F1
8	Cayuse Bridge to above Mission Creek	67.5	60	-	-	C4
9	Above Mission Ck. to developed area	60	57	B1c	F1/F4	C4
10	Developed area to Hwy 11	57	55.5	-	B1c/ B3c	C4
11	Hwy 11 to Westgate Rd. (prison)	55.5	51.5	F1	F4	F4
12	Westgate Rd. to McKay	51.5	51	-	-	F4/B4c
13	McKay Ck. to Birch Ck.	51	48.3	-	-	C4/B4c
14	Birch Ck. to Yoakum Bridge	48.3	37	F4	-	C4
15	Yoakum Bridge to Stanfield Dam	37	32.3			C4
16	Stanfield Dam to Westland Dam	32.3	27.3	-	-	B4c**/C4
17	Westland Dam to Stage Gulch	27.3	21.5	F4	C4	C4
18	Stage Gulch to Maxwell Dam	21.5	15	-	-	C4
19	Maxwell Dam to below Hermiston Waste Water Treatment Plant	15	5	-	-	F4/C4
20	Hermiston Waste Water Treatment Plant to Three Mile Dam	5	3	-	-	F1
21	Three Mile Dam to mouth/slackwater	3	0	-	-	F1

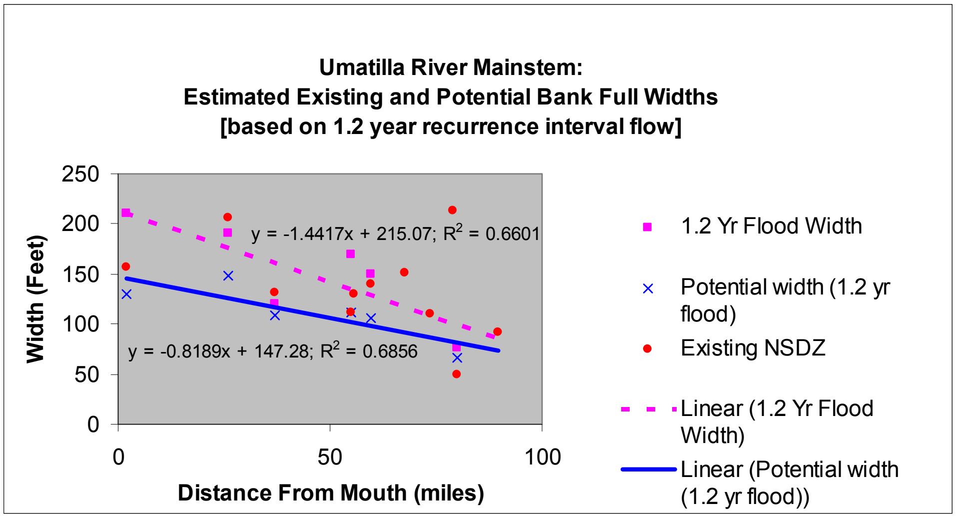
The group primarily characterized site potential (highest ecological status attainable without social constraints) because the alternative, site capability (considering social constraints), requires definition of constraints that generally have not been identified for the goal time frame of decades to centuries. Site capability was considered through the City of Pendleton where conditions influencing channel form are expected to remain (levees). Other current limiting factors were discussed and include: influences of channelization, levees, structures in floodplains, channel constriction (via roads, bridges, railroad), urbanization, management practices, historical and existing dams.

The following table lists cross-sectional areas (2 methods, refer to below) and goal width to depth ratios used in this analysis. The site potential width to depth ratio is not predictable with confidence, given available information, but goals can be roughly estimated. The site potential width/depth in this table is the mid-range of the dominant mode for US streams per stream type (data summarized in Rosgen, 1996). Morphologic data from these eleven sites represent the available Inventories on the Umatilla Mainstem.

Station Description [u/s = upstream, d/s = downstream]	River Mile	Site Potential Rosgen Class	Site Potential w/d	1.2 Year Flood Cross Sectional Area (ft^2)	Inventory Cross Sectional Area (ft^2)
Corporation	89.5	B4	16		218.4
USGS gage u/s Meacham	80.1	C4/B4	21	210	232
d/s Meacham	78.8	C4	21		296.7
u/s Thorn Hollow Brdg.	73.5	C4	21		291.6
near Cayuse Brdg.	67.5	C4	21		244.8
near Mission Brdg.	59.5	C4	21	540	355.3
near Hwy 11 Brdg.	55.5	C4/F4	21		302.6
u/s W. 10th St Brdg, Pdtn	55.0	F4	21	590	262.2
Yoakum Brdg. Gage	37.0	C4	21	570	432
near Echo Brdg.	26.0	C4	21	1040	180
USGS gage below 3 Mile Dam	2.1	F1	21	800	359

Site Potential Bankfull Width

The recommended site potential bankfull width goal is a reduction of 25 percent relative to existing conditions, through the length of the Umatilla River. The goal NSDZ width is not exceed bankfull width by greater than 5 percent. Both NSDZ and bankfull channel width reductions are recommended mainstem temperature TMDL surrogates. Modeling leading to site potential temperature predictions can be based on the site potential bankfull width regression in the graph immediately below plus 5% for the NSDZ width. The graph depicts the difference between current and desired future channel widths. Channel widths likely increase downstream in a step-wise manner as a function of discharge and possible stream type changes at major confluences. With insufficient data to characterize each major reach and because the Umatilla River channel width increase is relatively gradual downstream, this linear regression can approximately characterize widths along the Umatilla mainstem (n=6 measuring points - gage sites - along the mainstem).



Derivation of the preceding bankfull width goals is described in the following paragraphs.

$Wbf = (A*(w/d))^{0.5}$ .... [Rosgen 1996]

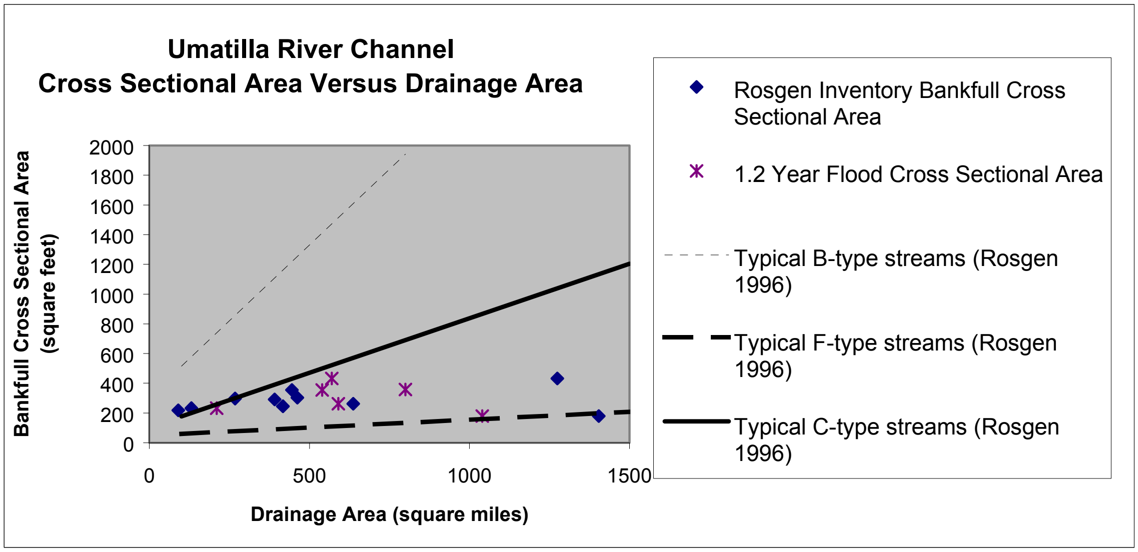
- Wbf = site potential bankfull width.
- A = existing bankfull channel cross-sectional area at each mainstem gage or Inventory station.
- w/d = working goal for site potential width/depth ratio. As described for the preceding table.

Two methods were employed to evaluate cross-sectional area ('A' above). First the Inventories were used. Second, as recommended in the Inventory procedure, these field measurements were compared to wetted widths at flow gage sites for a recurrence interval of between one and two years - that of the typical channel maintenance flow. Note that there are eleven sites with bankfull data from or equivalent to the Inventories (nine were Inventoried, the Yoakum measurementss are from Harza, 1999; cross-sectiol area/1.2 year flow and width/depth at the Umatilla site is assumed to be the same as at Yoakum). A subset of six of these sites are gage sites with data for flow-based cross-sectional area determination.

1.2 Year Recurrence Interval Discharge		
Station	River Mile	1.2 Year Recurrence Interval Flow (cubic feet per second)*
Gage at Gibbon	80.1	1300
CTUIR West Boundary	59.5	3000
Pendleton (PDTO)	55.0	3100
Yoakum Bridge (YOKO)	37.0	3700
Echo (UMUO)	26.0	3700 (Yoakum flow assumed)
Gage below 3 Mile Dam (UMAO)	2.1	3075

*1.2 year recurrence interval flows are from CTUIR, 1999.

The following graph compares existing widths from both methods with typical US river basin cross-sections.



Even at a recurrence interval of 1.2 years, three of six Inventories underestimate bankfull width, assuming that the flow-based method is accurate (widths from each method are tabulated below). The 1.2 year flood wetted widths and cross-sectional areas were chosen as the basis to best represent the Umatilla Basins current conditions and potential, with regard to bankfull width.

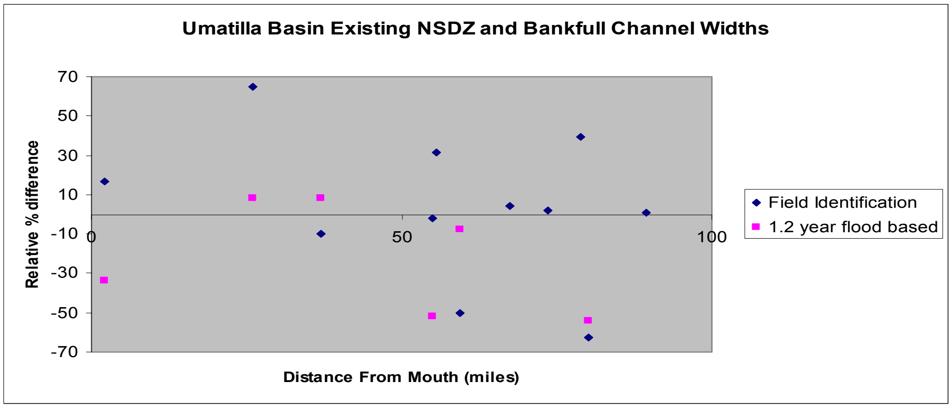
Except for the Umatilla gage, the cross-sectional area equation input are derived from regressions of discharge versus cross-sectional area at the 1.2 year recurrence interval flow. For the USGS gage near the city of Umatilla, discharge against velocity regression is used to calculate cross-sectional area at the 1.2 year flood discharge.
The table below lists bankfull widths based on the methods described above and the NSDZ measured from digital orthophotoquadrangle maps. The 'Field ID' bankfull width is taken directly from the Inventories. The 'at 1.2 year flow' bankfull widths are from agency flow gage transects. Flow was plotted against width and wetted widths were obtained at the 1.2 year flood level. Flow/width regressions were generally logarithmic. Data in this table, excluding the field or field-based determinations, are graphed in the preceding chart (page 2).

River Mile	Existing Bank Full Width (ft) Field ID	Existing Bank Full Width (ft) At 1.2 year flow	Site Potential Bank Full Width (ft) Field ID Based	Site Potential Bank Full Width (ft) At 1.2 year flow	Existing NSDZ (feet)
89.5	91		59		92
80.1	80	76	70	66	49
79.1	129		79		213
73.5	108		78		110
67.5	144		72		150
59.5	209	150	86	106	139
55.5	89		80		130
55.0	114	170	74	111	112
37.0	144	120	95	109	131
26.0	72	190	61	148	207
2.1	131	210	87	130	157

From this table, width relationships were evaluated. Relationships between field and between field and flow-based determinations of existing and potential widths lacked systematic correlation. For example, the standard deviation of the relative differences [(x-y)/y] between columns 2&3 and 2&4 were 0.4 and the widths did not increase downstream with any regularity. However, the relative differences between 1.2 year flood existing and site potential bankfull widths were relatively consistent with a standard deviation of 0.12. The mean relative difference was 25 percent with a range of 8 to 38 percent. This is the basis for the goal of 25 percent reduction in channel width. Favoring flow-based width determination over field identification of bankfull is consistent with the uncertainty inherent in field determinations of bankfull elevation. In addition, flood flow is a fundamental property intimately related to channel morphology and often less subject to human modification than channel shape.

Potential Near Stream Disturbance Zone

The relative difference between the existing NSDZ and the 1.2 year flood channel widths were calculated (next two graphs). At 4 of the 6 sites, the measured NSDZ width is less than the calculated 1.2 year flood channel width. It is improbable that the NSDZ width is actually less than channel width, indicating mis-measurement or misalignment of gage and NSDZ measurement sites (The NSDZ width reported in this memo is a mid-range of values over approximately 1/2 mile). A wide range of differences exists between the NSDZ width and the measured and flow-calculated bankfull widths as shown in the graph below [100*(NSDZ - channel width)/NSDZ)].



As the riparian zone becomes more stable through increased vegetation, NSDZ and bankfull widths are expected to become nearly equivalent. This is likely reflected in the smaller relative differences shown above for those sites which range from 1 to 10 percent. However, restoration NSDZ widths are not expected to uniformly equate to bankfull due to natural disturbance and aggradation particularly at point bars. **It is recommended that the site potential NSDZ goal be assumed at values of 5 percent more than bankfull width, throughout the Umatilla mainstem, based on best professional judgement. The same goal is assumed for tributaries, subject to refinement as more information becomes available.**

Tributaries
The lack of available data limits estimation of potential bankfull widths on major tributaries and lower order streams. It is recommended that bankfull width/depth, as a fundamental property of stream channels, be considered as a TMDL temperature surrogate. Stream classification has not been done for much of the Basin but the typical U.S. ranges for various types do not differ greatly. Maximum mid-range width/depth reported in Rosgen (1996) for the dominant mode of various types is A = 7, B = 17, C = 24, F = 29. D and E stream types are probably rare. Based on these ranges, **a general goal of bankfull width/depth less than 30 throughout the Basin, with width/depth less than 7 for steep streams (A-types have greater than 4% slope) is recommended**. These general goals for width/depth ratios as well as other channel form parameters can be refined development of regional curves (Rosgen 1996). Ongoing evaluation of site potential in the Umatilla Basin is recommended for future TMDL development.

RiparianVegetation Characteristics

Site potential riparian vegetation height, width and density are key temperature TMDL variables. **The estimated potential height of riparian zone vegetation is illustrated in the stream cross-section diagrams below. The estimated potential width, unless specified in the figures, is assumed to extend to the edge of the floodplain or to the width of simulation invoked in TMDL temperature modeling.** For healthy riparian conditions, a vegetation buffer width equal to the flood-prone with is desirable. The flood-prone width is defined (Rosgen, 1996) as the cross-sectional valley or floodplain width (perpendicular to the channel) at twice the bankfull height. These have been estimated (probable underestimation, see bankfull discussion above) as follows:

Umatilla Mainstem River Mile	Flood-prone width (ft)
89.5	123
80.1	90
78.8	410
73.5	116
67.5	167
59.5	245
55.5	154
55.0	130
26.0	223
28.5	340

The width of the NSDZ relative to bankfull is described in the previous section. The site potential riparian vegetation density is assumed to be 80 percent. Estimated potential riparian vegetation density for modeling purposes can be defined as the percent area of ground surface visible on aerial photographs or the percent open sky measured by an instrument such as a densiometer, within stream-side vegetated areas. The 80 percent values is based in professional judgement extrapolated from: (1) Umatilla Basin aerial photography interpretation of mature stands (2) satellite-based interpretation (canopy density for existing stands) reported by Pacific Meridian, CTUIR and ODF for the upper Basin and (3) knowledge of typical measured values, e.g., Cottonwood Galleries are normally 100 percent, pine forests 70-90 percent, etc. An overall average value was assumed due to the characteristic variability and complexity of riparian density and the inherent difficulty in extrapolation into the future.

Tree heights were selected from the literature and measured along the Umatilla River. The following vegetation either occurs or is likely to have occurred historically along the Umatilla River. Further monitoring is encouraged to refine this estimate of site potential vegetation height, width and density. Note that the intent is not to specify desired or required tree types but rather to characterize the potential riparian buffer dimensions. In instances where planting is considered, riparian species that support stream habitat, shade and pollutant buffering should be considered. In the future TMDL load allocations can be re-assessed to include alternative healthy riparian species.

<u>USDA 1974, maximum heights</u>

- Coyote Willow - 10 feet
- Bebb Willow - 15 feet
- Pacific Willow - 60 feet (expected in healthy E. Oregon riparian zones at lower elevations such as downstream from Pendleton)
- Mixed Willow - 30 feet (average of the three above)
- Thinleaf Alder - 30 feet
- White Alder - 80 feet (used 70 feet, measured below Pendleton)
- Black Cottonwoods - 200 feet, but average large Cottonwood local measurements are applied here: 112 feet above Pendleton, 100 feet in and below Pendleton
- Choke Cherry - 30 feet
- Red Osier Dogwood - 8 feet

<u>Other species, particularly in the upper Basin, including Englemann Spruce, Larch, Quaking Aspen, mixed Willow and various Firs, Pines and Alders are reported in *Crowe and Clausnitzer, 1997*. Mature heights (mid-range or average height) for shade producing species in this citation include:</u>

- Quaking Aspen - 75 feet
- Grand Fir - 135 feet
- Douglas Fir - 75 feet
- Mountain Alder - 35 feet

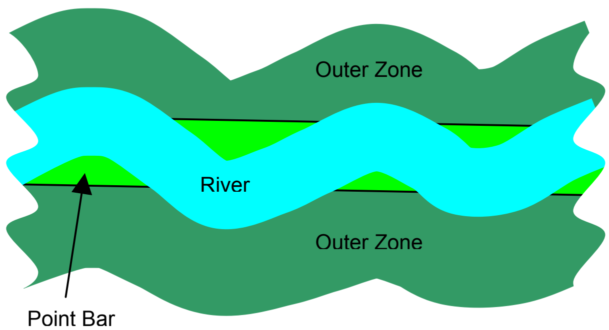
<u>Audubon Society, 1988, Field Guide to North American Trees</u>

- Ponderosa Pine - 95 feet (60-130 feet in height, Audubon, 1988; 125-180 feet, Bever, 1981)

Within each zone identified in the following table (unless otherwise noted) the mature heights of characteristic species within the zone are averaged, each with equal weight.

Reaches	Point Bar Zone (50% of stream length)		Outer Zone (50% of stream length)	
	Shade Producing Vegetation Types	Species Average Mature Height (feet)	Shade Producing Vegetation Types	Species Average Mature Height (feet)
Above Meacham Creek (N/S Forks to river mile 78.8)	Deciduous - Quaking Aspen, Black Cottonwood, Mountain Alder, mixed Willow, Red Osier Dogwood	50	Conifer - Grand Fir, Douglas Fir (Ponderosa Pine increasing downstream)	100
Meacham Creek to Pendleton (river mile 78.8-55.5)	Coyote Willow, Bebb Willow, Pacific Willow, Thinleaf Alder, White Alder, Cottonwood, Ponderosa Pine	55	Cottonwood Stands	112
Pendleton (Hwy 11 to McKay Creek, river mile 51-55.5)	Coyote Willow, Bebb Willow, Pacific Willow, Thinleaf Alder, White Alder, interspersed Cottonwood	50	Cottonwood Stands	100
Below McKay Creek to Butter Creek (river mile 15-51)	Coyote Willow, Bebb Willow, Pacific Willow, Thinleaf Alder, White Alder, interspersed Cottonwood	50	Cottonwood Stands	100
Butter Creek to mouth (river mile 0-15)	Coyote Willow, Bebb Willow, Pacific Willow, Thinleaf Alder, White Alder, interspersed Cottonwood	50	Same as Point Bar Zone	50

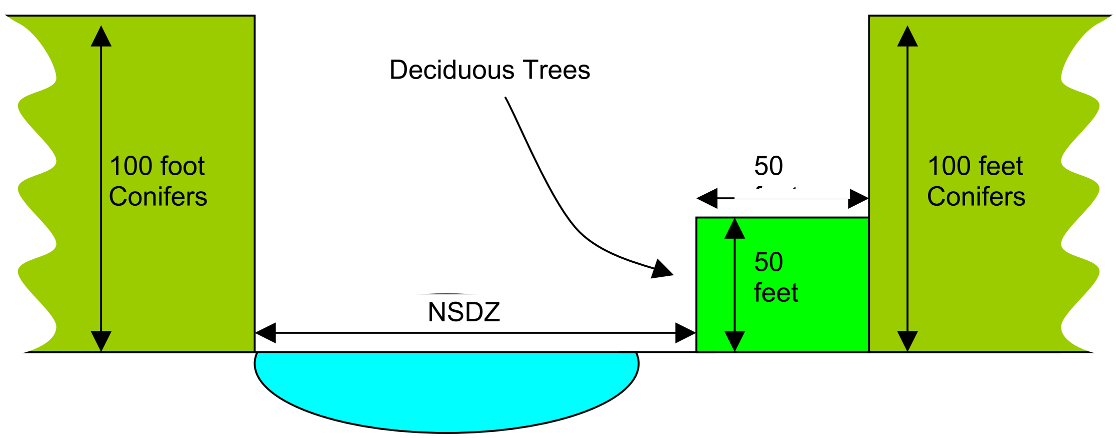
Where two distinct zones are identified in the preceding table, the inner width (point bar zone) is an average width applied along 50 percent of the length of each bank. The outer zone contacts the bank along the other 50 percent of its length. That is, both banks are full-length vegetated, but along each bank the zone in contact with the stream alternates as shown in the figure below. On each bank half the stream-length is occupied by the point bar zone vegetation and the other half by the outer zone vegetation. The outer zone is ever present, but only abuts a bank for half of the stream-length.



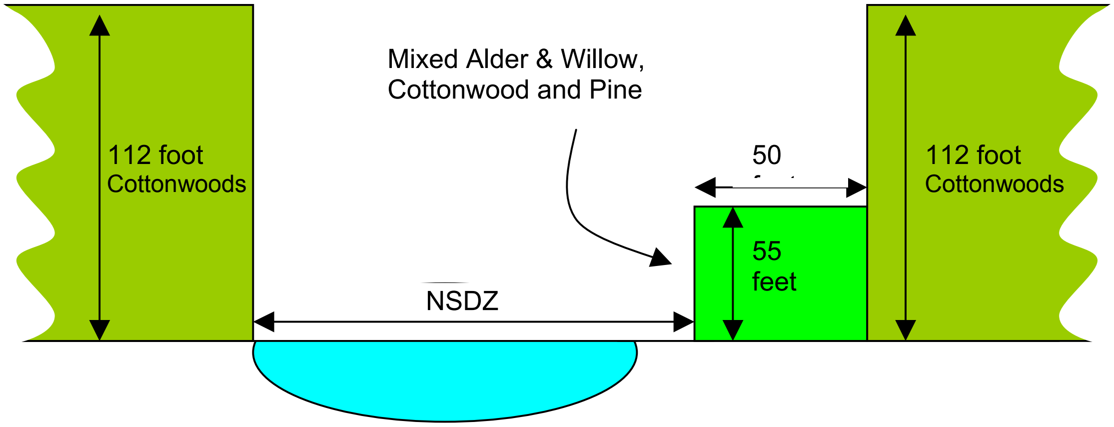
The potential width of the point bar zone, specified in the figures below, is a mean width measured perpendicular to the channel.

Upstream from Meacham Creek

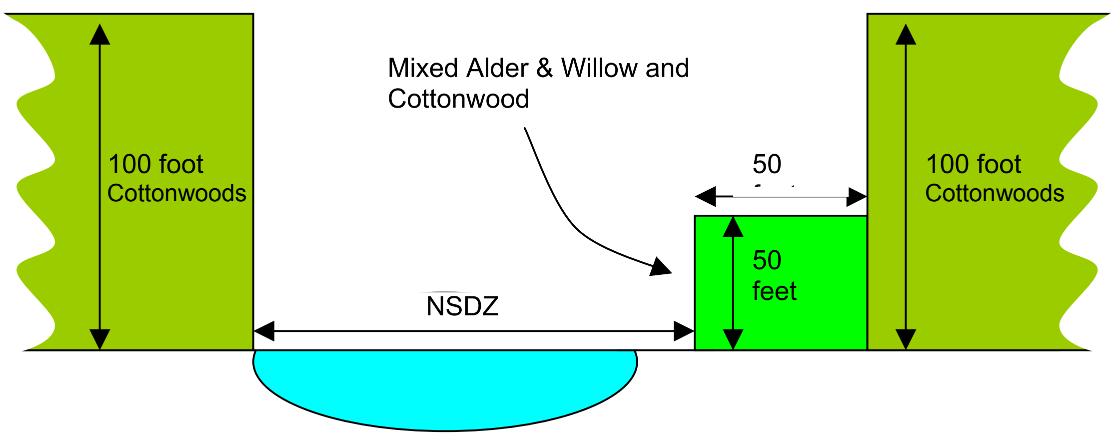
The vegetation dimensions illustrated below are the estimated site potential for the Umatilla Mainstem reaches upstream from Meacham Creek. The longitudinal distribution for each bank is 50% the right-bank geometry and 50 % the left, as described previously in this section. In this section and much of the river below, it is recognized that the level of natural disturbance and moisture availability in the point bar zone argues for an alternating band riparian assemblage as indicated in the figure below and in the map view at the beginning of this section.



Meacham Creek to Pendleton
The vegetation dimensions illustrated below are the estimated site potential for the Umatilla Mainstem reaches from Meacham Creek to Pendleton. The longitudinal distribution for each bank is 50% the right-bank geometry and 50 % the left, as described previously in this section. This zone has less tall conifers than the reaches above and in contrast with Pendleton is observed to support pine and taller Cottonwoods.

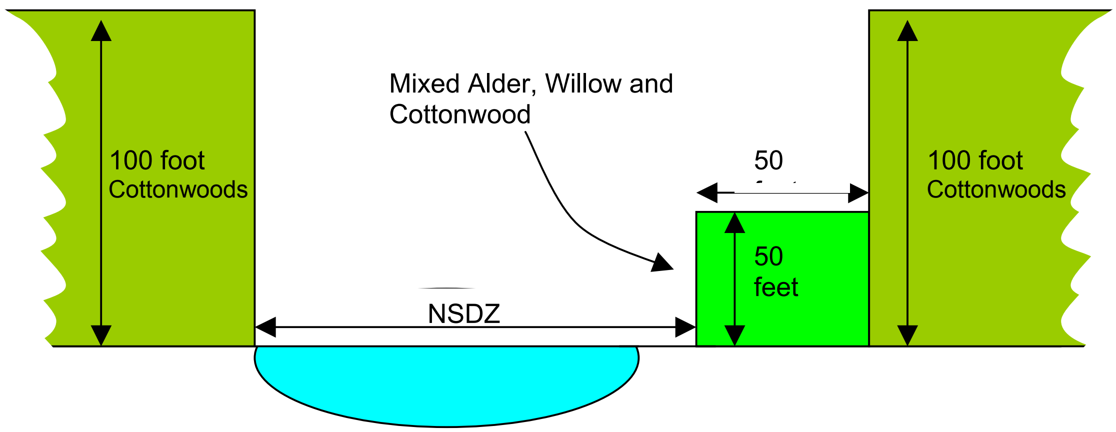


In Pendleton
The vegetation dimensions illustrated below are the estimated site potential for the Umatilla Mainstem reaches from the Highway 11 Bridge in Pendleton to McKay Creek. The longitudinal distribution for each bank is 50% the right-bank geometry and 50 % the left as described previously in this section. Occasional Cottonwoods are observed up to the rivers edge, interspersed with alder, willow and other trees of similar height to the alder/willow.



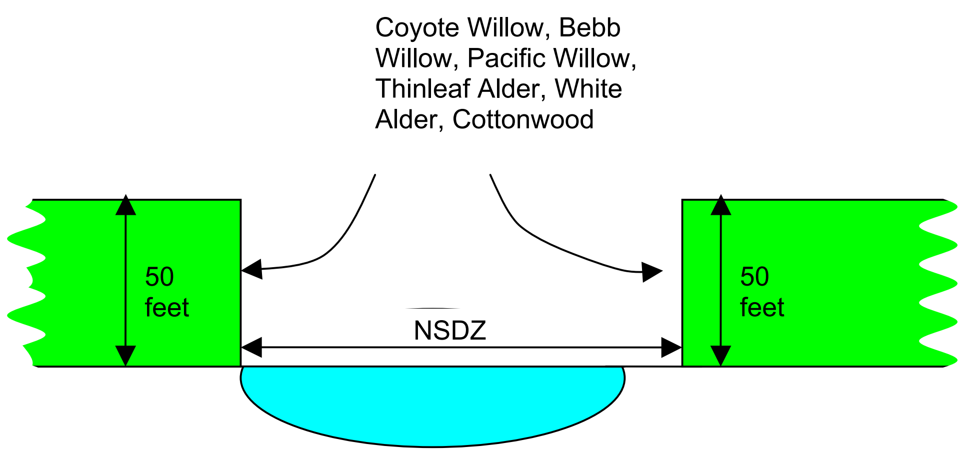
Between Pendleton and Butter Creek

The geometry illustrated below is the estimated site potential for the Umatilla Mainstem reaches from immediately below McKay Creek to Butter Creek. The longitudinal distribution for each bank is 50% the right-bank geometry and 50 % the left as described previously in this section. This section appears similar enough to Pendleton to be equivalently characterized. Width is probably less limited here.



From Butter Creek to the mouth of the Umatilla River

The vegetation dimensions illustrated below are the estimated site potential for the Umatilla Mainstem reaches below Butter Creek. Potential galleries of taller trees such as Cottonwoods would be scarce due to thin soils and relatively rocky banks and less groundwater availability though interspersed Cottonwoods and small stands are present currently, e.g., river mile 1.5, east bank.



Tributaries. Site potential vegetation goals are needed for the major tributaries and lower order streams. The vegetation geometry described for the Umatilla River upstream from Meacham Creek will be assumed for forested areas (using USGS land use map). The vegetation geometry described for the mainstem from Pendleton to Butter Creek will be applied elsewhere except for the thin soil on basalt area of Butter Creek between stream mile 20 and the forested area. The lower mainstem vegetation geometry below river mile 15 is assumed for this specified area along Butter creek. It is envisioned that future iterations of the TMDL will be based on more informed estimations of site potential and that the approximation herein serves as an appropriate working target, given the project scale, the necessity to tie goals to water quality endpoints and the limited available vegetation data.

References

USDA, 1974, Seeds of Plants in the United States, US Forest Service Agricultural Handbook Number 450.

Audubon Society, 1988, Field Guide to North American Trees, Western Region, Chanticleer Press, NY.

Bever, Dale, N., 1981, Northwest Conifers, A Photographic Key, Publisher Binford and Mort, Portland, Oregon.

Confederated Tribes of the Umatilla Indian Reservation, 1999, Flow Needs for Salmonids and Other Aquatic Organisms in the Umatilla River, Department of Natural Resources.

Harza Engineering Company, 1999, Westland/Ramos Reach of the Umatilla River, Engineering Feasibility Study and Preliminary Channel Design, Pendleton, OR.

Other references cited in this memo are listed in the reference sections of the accompanying TMDL document.