9. WATER QUALITY

This Chapter consists of a water quality assessment along fish-bearing streams in the upper Nehalem watershed. It should be regarded as supplemental to the PSU water quality assessment prepared by Johnson and Maser (2000). The primary purpose of this effort was to perform a remote assessment of riparian vegetation conditions to estimate the radiation-blocking angles along stream corridors and to make projections of potential stream temperatures based on current, historical and future riparian conditions. Within this assessment, vegetation heights, topographic blocking elements and reasonably achievable surface water temperatures are estimated for eleven management basins and two contiguous parcels falling within the ODF Forest Grove and Astoria Districts. The assessment also includes an update of other key water quality parameters to augment the PSU watershed analysis.

9.1 SURFACE WATER TEMPERATURE ASSESSMENT

The purpose of the riparian assessment was to assess the conditions in the watershed and determine how the current conditions compare to riparian characteristics typically present along various stream channel types for the ecoregions encompassing the watershed. In addition, ODF wished to forecast 50 to 100 years in the future and make an assessment of the potential feasibility of stands to provide appropriate conditions to maintain surface water temperatures.

9.1.1 Background

A watershed analysis was completed for the Nehalem watershed by Portland State University (Johnson and Maser 2000). This analysis provided a screening level assessment of water quality parameters in the watershed in accordance with the Oregon watershed assessment manual (Watershed Professionals Network 1999). Critical water quality questions addressed under the OWEB process included:

OWEB Critical Questions

1. *What are the designated beneficial uses of water for the stream segments?*
2. *What are the water quality criteria that apply to the stream reaches?*
3. *Are stream reaches identified as water quality limited on the 303(d) list by the state?*
4. *Are any stream reaches identified as high-quality waters or Outstanding Resource Waters?*
5. *Do water quality studies or evaluations indicate that water quality has been degraded or is limiting the beneficial uses?*

Water quality information was collected for beneficial stream uses, for 303(d) listed reaches, and for outstanding resource waters and available water quality data collected by ODEQ, Upper and Lower Nehalem Watershed Councils and the Isaak Walton League of America were summarized. Beneficial uses in the Nehalem River included those necessary to maintain salmonid habitat and aquatic life, domestic water supply, livestock watering, recreation and industrial water supply (Johnson and Maser 2000). Water quality impairments of particular parameters (temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity and macroinvertebrate communities) based on current water quality standards (or benthic indices of biological integrity for macroinvertebrates) for the stream reaches and beneficial uses in question were identified according to the following OWEB protocol:

Not Impaired	=	< 15% of samples exceed the state water quality standard
Moderately Impaired	=	15 to 50% of samples exceed the water quality standard
Impaired	=	> 50% of samples exceed the water quality standard

Although water quality sampling was limited in the basin, the PSU analysis found no impairments for dissolved oxygen (D.O.), pH, bacteria (as represented by *E. coli*), phosphate, turbidity or contaminants during their data review in 1998 and 1999 in the middle and upper Nehalem Subbasins (Johnson and Maser 2000). The analysis noted elevated levels of nutrients, primarily nitrate, in the fall, winter and spring. The impairments were attributed to heavy rainfall which may have eroded organic materials from stream banks, hillslopes and fields. A macro-invertebrate analysis conducted in 1998 by the Nehalem Watershed Councils indicated clear evidence of stream disturbance as highlighted in the Index of Biotic Integrity (IBI) downstream of Fishhawk dam. Other sites were considered either slightly impaired or not impaired compared to reference sites in the region.

The PSU watershed analysis included a riparian shade assessment based on 1995 aerial photos as well as a water quality temperature assessment of current temperature monitoring data. The riparian inventory categorized the existing shade conditions using the size of the stream and the vegetation continuity and age along each reach as factors for determining whether the riparian areas represented high, moderate or low shade conditions as follows:

High	=	Shade > 70% (stream surface on aerial photos not visible or visible in patches)
Moderate	=	Shade 40 – 70% (stream surface on aerial photos is visible, but banks are not visible)

Low	=	Shade < 40% (stream surface and banks are visible on aerial photos)

The PSU assessment indicated that the mainstem river and large stream reaches in the Lower, (HUC #1710020203), Middle (HUC #1710020202) and Upper Nehalem River (HUC #1710020201) subwatersheds received a moderate amount of riparian shade and the small stream reaches generally received a high degree of shade. A few exceptions occurred in the subwatersheds where vegetation was lacking due to land use practices (Refer to Figure 7-5 of the PSU watershed analysis).

At the time of the PSU report, water temperatures along the mainstem Nehalem River were seasonally high. Multiple water bodies, including the mainstem Nehalem River from its mouth to Rock Creek was listed (on 303(d) list) as water quality limited due to elevated summer water temperatures. DEQ defined the designated fish use in the Upper Nehalem watershed as "core, cold-water habitat." The seven-day-average maximum temperature (7-Dmax) for core, cold-water habitat use may not exceed 16.0ºC (60.8ºF) (OAR 340-041). Temperature data reviewed indicated that peak summer water temperatures routinely exceeded this standard along the mainstem river upstream to the confluence of Rock Creek near Vernonia, in the EF Nehalem River and in Fishhawk, Little Fishhawk, Beneke, Deep and Rock creeks (Johnson and Maser 2000). Historic water temperature data prior to land use activities in the upper watershed were not available.

The information presented in the PSU watershed analysis was sufficient to answer the OWEB critical questions and will not be further evaluated herein. The assessment included in this chapter should be considered supplemental to the PSU watershed analysis and it specifically addresses the ODF additional questions concerning surface water temperatures of stream reaches adjacent to ODF lands in the Upper Nehalem Watershed as itemized below:

ODF Supplemental Questions for Water Quality

1. *What stream temperatures are reasonably achievable on State Forests?*
2. *How do the current shade levels along streams compare to historic levels by sub-watershed and stream size?*
3. *How do the current stream temperature levels compare to historic levels by sub-watershed and stream size?*
4. *How do water temperatures compare to other nearby basins with similar flows and geology?*

The assessment also updated other key water quality parameters monitored in the basin since publication of the PSU Nehalem Watershed Analysis (Section 9.2).

9.1.2 Methods

The range and variability of historic temperature conditions in the watershed were unknown. However, with a few assumptions historical conditions were estimated. The state of Washington guidelines for conducting watershed analysis provide a View-to-the-Sky (VTS) methodology that is appropriate for addressing the ODF supplemental questions (Washington Forest Practices Board 1997). A description of this methodology is provided in Appendix E. The VTS temperature approach estimates the potential maximum surface water temperatures based on channel size, elevation and riparian canopy closure, following the Washington state temperature/elevation screen (Sullivan et al. 1990).

The VTS methodology is a geometric expression of the relationship between vegetation height and stream channel width. It is a measure of the fraction of a hemisphere centered over the stream that is unobstructed by either vegetation or topography. These factors control the relative openness of a channel and the amount of incoming and outgoing solar radiation. A waterbody's openness to the sky (often regarded as the opposite of shade or canopy closure) is a major factor influencing stream temperature, especially as it relates to the blockage of direct incoming and outgoing solar radiation. The proportion of the sky effectively blocked by streamside vegetation and topography determines the relative degree water temperatures will be depressed below ambient air temperatures. Coupled with a temperature elevation screen (Sullivan et al. 1990), VTS calculations can be used to estimate potential stream temperatures (Washington Forest Practices Board (WFPB) 1997). Campbell and Kvam (2003) found the VTS calculations produced a good representation of measured stream temperatures, unless streams exhibit strong thermal responses to either groundwater influx or wetland/ponded water runoff.

Sullivan et al. (1990) also suggested that a relationship exists between the ability of shade to influence water temperatures and the distance from the watershed divide. When stream channels become sufficiently wide and deep, shade no longer has an effect on moderating stream temperatures. Sullivan et al. (1990) referred to this point as a "threshold" distance where the mean daily water temperatures equilibrate primarily to local air temperatures. They implied that under normal channel conditions the "threshold" distance would typically lie 31 to 37 miles from the divide where water temperature equilibrate to ambient air temperatures regardless of shade. Shade reductions caused by land use processes were assumed to have little influence on water temperatures at low elevations in watersheds. Sullivan et al. (1990) referred to this point as the "threshold distance" from the stream origin where water temperature was determined by air

temperature. Upstream of this "threshold" elevation, shade could have a pronounced effect on surface water temperatures and could influence the degree that stream temperatures are depressed below ambient average air temperatures as well as the range of daily fluctuations.

Input factors and the specific approach taken in developing a VTS temperature model for the upper Nehalem watershed are described in Appendix F.

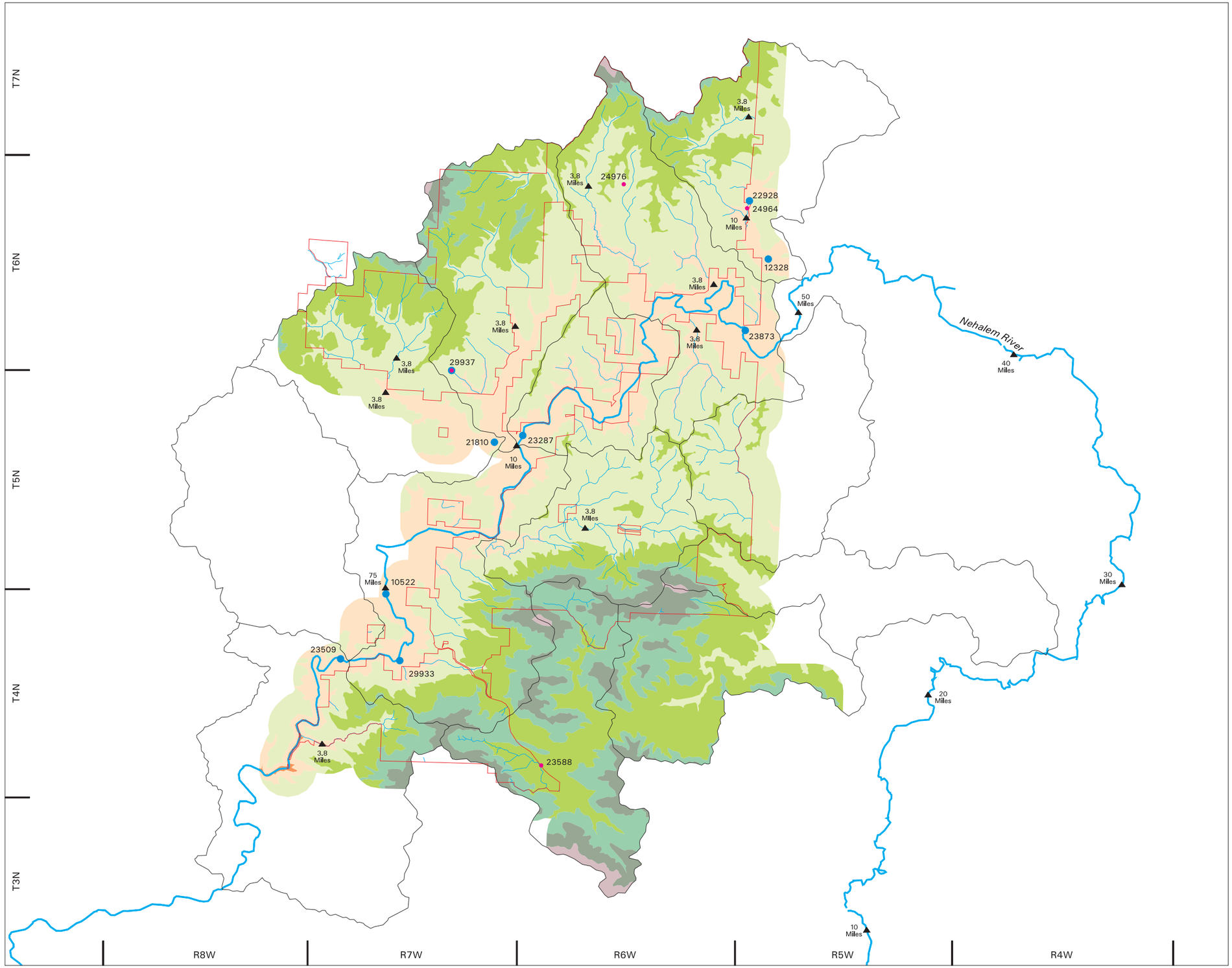
9.1.3 Results

9.1.3.1 Reference Riparian Conditions

Reference surface water temperatures for the upper Nehalem watershed based on channel size, channel confinement and elevation bands are shown as ranges in Table 9-1 and are included in Table 9-3. The low end of the range represents the expected surface water temperatures under assumptions of mature timber, either conifer or hardwood species, growing immediately adjacent to the channels. The upper end of the range represents the expected water temperatures with an estimate of 20 percent openings in an otherwise mature hardwood forest canopy.

According to the VTS model, ODF stream channels in the Forest Grove and Astoria Districts prior to European influence likely supported 7-Dmax summer water temperatures between 12.7ºC and 17.5ºC, depending upon channel size and elevation. Fish-bearing waters on ODF lands encompass a wide range of elevations and channel sizes from a low of 300 feet msl along the mainstem Nehalem River in the Quartz Management Unit (Astoria District) to a high of 2,700 feet msl on a small, unnamed tributary to the SF of Rock Creek in the Wheeler Management Unit (Forest Grove District). A brief summary of reference temperatures as a function of channel size, elevation and reference riparian tree heights is provided in Table 9-1 (Figures 9-1a,b).

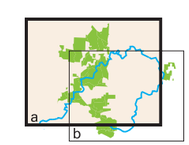
According to the model, streams wider than 50 feet BFW in the watershed downstream of 680 feet msl in elevation were not anticipated to achieve the summer core, cold-water temperature standard of 16ºC under mature coniferous forest canopy. The height of radiation blocking elements would need to be on the order of 181 feet to achieve the temperature standard compliance for a 50-feet bankfull channel at the downstream end of the ODF assessment area (~ 300 ft msl). Similarly, the average large-size stream in the watershed of 40 feet was anticipated to naturally exceed the state core, cold-water standard downstream of 540 feet msl elevation in hardwood-dominated situations and downstream of 320 feet msl elevation in conifer-dominated situations. The balance of stream channels in the watershed under a mature riparian canopy should have the potential to comply with the current state standards.



Legend

- 2400 to 2960 feet msl
- 1960 to 2400 feet msl
- 1640 to 1960 feet msl
- 1160 to 1640 feet msl
- 680 to 1160 feet msl
- 320 to 680 feet msl
- < 320 feet msl
- Water Temperature Station
- Water Quality Station
- Distance from Watershed Divide
- Fish Bearing Stream
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.7 Miles

0 2

Miles

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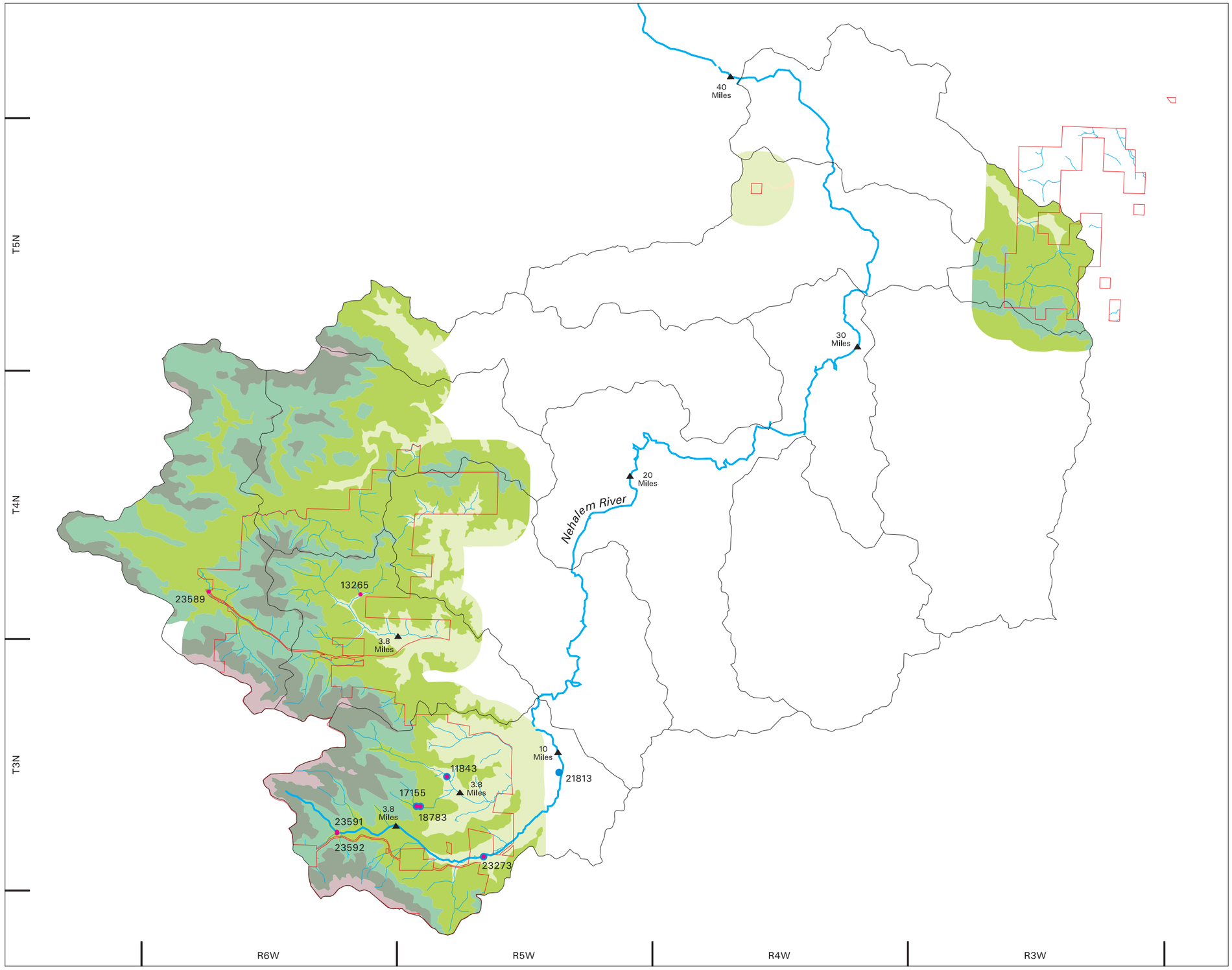
Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-1(a)

Elevation and Distance Zones for Reference Temperatures

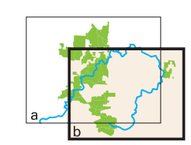
Astoria District



Legend

- 2400 to 2960 feet msl
- 1960 to 2400 feet msl
- 1640 to 1960 feet msl
- 1160 to 1640 feet msl
- 680 to 1160 feet msl
- 320 to 680 feet msl
- < 320 feet msl
- Water Temperature Station
- Water Quality Station
- Distance from Watershed Divide
- Fish Bearing Stream
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.3 Miles

0 2

Miles

R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

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Upper Nehalem Watershed Analysis

Figure 9-1(b)

Elevation and Distance Zones for Reference Temperatures

Forest Grove District

9.1.3.2 Existing Riparian Conditions

Existing riparian condition codes from stream adjacent stands included in Table 6-1 were used to approximate the current stand heights as shown in Table 9-2. VTS estimates of the range of existing surface water temperatures are shown in Figures 9-2a,b to 9-4a,b and are summarized in Table F-1, (Appendix F). The data were organized by riparian stand characteristics for each of the ODF management basins and 6th field HUCs within the upper Nehalem watershed in Table 9-3.

Table 9-1. Lookup Table for Reference Temperature Codes in the Upper Nehalem Watershed.

Reference Temperature Codes

Conifer-Dominated andf Mixed Stands (150-ft mature tree height)

Elevation Bands for 16C	Stream Type = Small; BFW = 10' Potential View-to-Sky (V%)	Maximum Allowable View - to the - Sky[1] (S%)	Reference Temp. (T°C)	Stream Type = Medium; BFW = 20' Potential View-to-Sky (V%)	Maximum Allowable View - to the - Sky[1] (S%)	Reference Temp. (T°C)	Stream Type = Large; BFW = 40' Potential View-to-Sky (V%)	Maximum Allowable View - to the - Sky[1] (S%)	Reference Temp. (T°C)
>3920	2.1	100	9.0	4.2	100	9.2	8.4	100	9.5
3600	2.1	90-99	9.8	4.2	90-99	9.9	8.4	90-99	10.2
3280	2.1	80-90	10.5	4.2	80-90	10.7	8.4	80-90	11.0
2960	2.1	70-80	11.2	4.2	70-80	11.4	8.4	70-80	11.7
2400	2.1	60-70	12.0	4.2	60-70	12.1	8.4	60-70	12.5
1960	2.1	50-60	12.7	4.2	50-60	12.9	8.4	50-60	13.2
1640	2.1	40-50	13.5	4.2	40-50	13.6	8.4	40-50	13.9
1160	2.1	30-40	14.2	4.2	30-40	14.4	8.4	30-40	14.7
680	2.1	20-30	15.0	4.2	20-30	15.1	8.4	20-30	15.4
<200	2.1	10-20	15.7	4.2	10-20	15.9	8.4	10-20	16.2

Hardwood-Dominated Stands in Unconfined Channel Types (99-ft mature tree height)

Elevation Bands for 16C	Stream Type = Small; BFW = 10' Potential View-to-Sky (V%)	Maximum Allowable View - to the - Sky[1] (S%)	Reference Temp. (T°C)	Stream Type = Medium; BFW = 20' Potential View-to-Sky (V%)	Maximum Allowable View - to the - Sky[1] (S%)	Reference Temp. (T°C)	Stream Type = Large; BFW = 40' Potential View-to-Sky (V%)	Maximum Allowable View - to the - Sky[1] (S%)	Reference Temp. (T°C)
>3920	3.2	100	9.1	6.4	100	9.3	12.7	100	9.8
3600	3.2	90-99	9.8	6.4	90-99	10.1	12.7	90-99	10.5
3280	3.2	80-90	10.6	6.4	80-90	10.8	12.7	80-90	11.3
2960	3.2	70-80	11.3	6.4	70-80	11.6	12.7	70-80	12.0
2400	3.2	60-70	12.1	6.4	60-70	12.3	12.7	60-70	12.8
1960	3.2	50-60	12.8	6.4	50-60	13.1	12.7	50-60	13.5
1640	3.2	40-50	13.6	6.4	40-50	13.8	12.7	40-50	14.3
1160	3.2	30-40	14.3	6.4	30-40	14.5	12.7	30-40	15.0
680	3.2	20-30	15.1	6.4	20-30	15.3	12.7	20-30	15.8
<200	3.2	10-20	15.8	6.4	10-20	16.0	12.7	10-20	16.5

V% = Potential View-to-Sky under mature riparian forest conditions (tree height; conifer = 150 ft; hardwood = 99 ft).
S% = Target View-to-Sky range for ODEQ core cold-water fish habitat = 7-Dmax 16C).
Ref. T°C = Reference highest 7-day average of the maximum temperatures (7-Dmax) under mature riparian forest conditions.
BFW = Bank-full Channel Width.

Table 9-2. Existing and Future Riparian Vegetation Heights based on Forest Successional Pathways (WFPB 1997).

Riparian Characterization Code (Current)	Tree Ht.	Riparian Characterization Code 50 - Yr. (unmanaged)	Tree Ht.	Riparian Characterization Code 100 - Yr. (unmanaged)	Tree Ht.
Water	0	Water	0	Water	0
Bareground	0	Bareground	0	Bareground	0
Grass	<3	Grass	<3	Forbs/STS	<3
Shrub	<15	Shrub	<15	Shrub/STS	<15
CRS	<15	CMS/CMD	83 - 150	CLS/CLD	>150
CRD	<15	CMD	83 - 150	CLD	>150
HSS	<74	HMS	74 - 99	HMS/HLS	74 - >99
HSD	<74	HMD	74 - 99	HMS/HLS	74 - >99
MSS	<83	MMS/MMD	83 - 150	MLS/MLD	>150
MSD	<83	MMD	83 - 150	MLD/CLD	>150
CSS	<83	CMS/CMD	83 - 150	CLS/CLD	>150
CSD	<83	CMD	83 - 150	CLD	>150
HMS	74 - 99	HLS/HMS	>99	HLS/HMS	74 - >99
HLS	>99	HLS	>99	Shrub	<15
HMD	74 - 99	HLD	>99	HLS	>99
MMS	83 - 150	MLS/MLD	>150	MLS/CLS/MLD/CLD	>150
CMS	83 - 150	CLS/CLD	>150	CLS/CLD	>150
CLS	>150	CLS	>150	CLD/STS	>150
HLD	>99	HLS	>99	Shrub	<15
MLS	>150	MLS/CLS	>150	CLS/STS	>150
CMD	83 - 150	CLD	>150	CLD	>150
MMD	83 - 150	MLD/CLD	>150	CLD	>150
MLD	>150	MLD/CLD	>150	CLD	>150
CLD	>150	CLD	>150	CLD	>150

Species Composition

C = Conifer (>70% Conifer)
M = Mixed (30 - 70 % Conifer)
H = Hardwood (>70% Hardwood)

Average Stand Size

R = Regen
S = Small (mean dbh < 12 ")
M = Medium (mean dbh 12 - 24")
L = Large (mean dbh >24")

Stand Density

S = Sparse (more than 1/3rd of the ground visible on aerial photos)
D = Dense (less than 1/3rd of the ground visible on aerial photos)

Table 9-3a. Predicted range of existing surface water temperatures in 6th field HUCs in ODF Management Basins in the Astoria District.

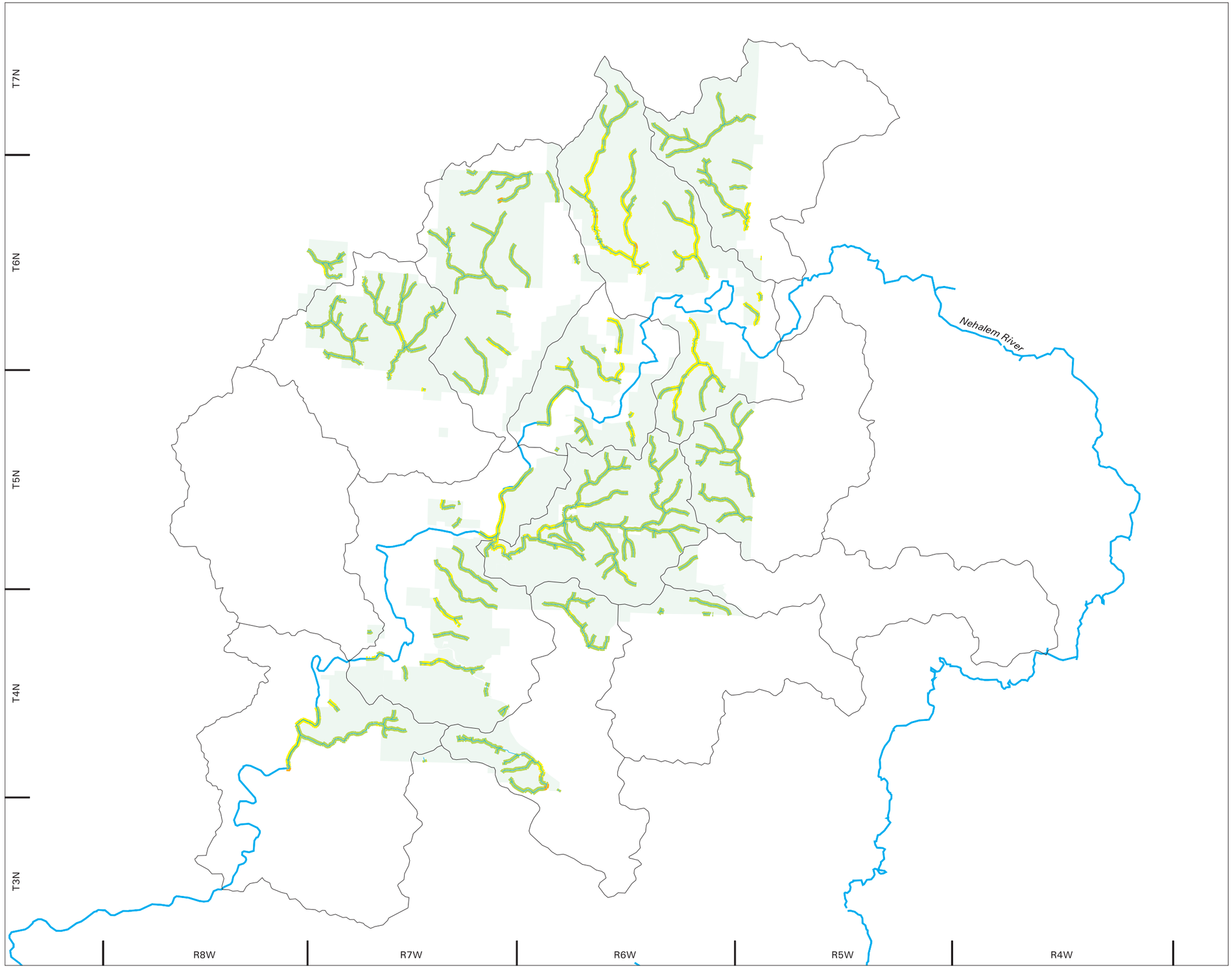
	ODF Management Basins in Astoria District									
	Beneke	Buster						Crawford		
Temp Range	Total	171002020105	171002020106	171002020107	171002020304	171002020305	Total	171002020301	171002020302	Total
12.1C to 16.0C	97%	97%	100%	100%	93%	87%	92%	64%	100%	65%
16.1C to 18.0C	2%	3%	-	-	7%	13%	7%	35%	-	33%
18.1C to 20.0C	1%	-	-	-	-	-	-	-	-	-
>20.0C	1%	-	-	-	0.3%	0.1%	0.2%	1%	-	1%
Stream Length (mi)	37.4	7.1	3.5	1.3	60.0	16.9	88.8	10.6	0.4	11.0

	ODF Management Basins in Astoria District									
	Fishhawk	Hamilton			Louisignot			Northrup		
	Total	171002020303	Young's Bay	Total	171002020205	171002020208	Total	171002020208	171002020302	Total
12.1C to 16.0C	91%	95%	100%	96%	70%	50%	54%	43%	78%	44%
16.1C to 18.0C	8%	4%	-	4%	29%	49%	46%	52%	14%	51%
18.1C to 20.0C	0.3%	0%	-	0%	-	-	0%	2%	8%	2%
>20.0C	0.0%	0%	-	0%	1%	0.4%	1%	2%	-	2%
Stream Length (mi)	21.2	33.4	3.3	36.7	2.5	12.3	14.8	26.9	0.7	27.6

	ODF Management Basins in Astoria District									
	Quartz					Sager				Scattered
	171002020105	171002020305	171002020307	171002020402	Total	171002020206	171002020208	171002020301	Total	Total
12.1C to 16.0C	79%	80%	83%	82%	70%	99%	45%	84%	77%	44%
16.1C to 18.0C	9%	19%	16%	18%	29%	0.5%	53%	16%	23%	51%
18.1C to 20.0C	2.8%	-	-	-	-	-	0.2%	-	0.1%	2%
>20.0C	9.3%	1%	1%	-	1%	0.1%	1%	-	1%	2%
Stream Length (mi)	12.3	5.4	9.8	0.1	27.6	18.2	14.3	4.9	37.4	0.3

Table 9-3b. Estimated range of existing surface water temperatures in 6th Field HUCs in ODF Management Basins – Forest Grove District.

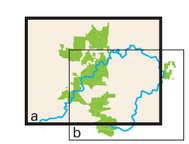
Current Temperature Range	ODF Management Basins in Forest Grove District									
	McGregor					Wheeler				Wilark
	171002020102	171002020103	171002020105	171002020106	Total	171002020101	171002020102	171002020105	Total	Total
<12C	-	-	-	-	-	0.3%	-	-	0.2%	-
12.1C to 16.0C	79%	100%	100%	97%	89.8%	96%	100%	79%	93.8%	95.9%
16.1C to 18.0C	21%	0.3%	0.0%	2.4%	10.0%	2.4%	0.0%	21%	5.1%	3.3%
18.1C to 20.0C	0%	0.0%	0.1%	0.0%	0.1%	1.2%	0.2%	0.1%	0.9%	0.0%
>20.0C	0%	0.0%	0.2%	0.2%	0.1%	0.3%	0.0%	0.2%	0.2%	0.8%
Stream Length (mi)	13.9	4.2	4.2	9.2	31.4	35.7	5.8	7.8	49.3	6.2



Legend

- < 12.0C
- 12.1C to 16.0C
- 16.1C to 18.0C
- 18.1C to 20.0C
- > 20C
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.7 Miles

0 2

Miles

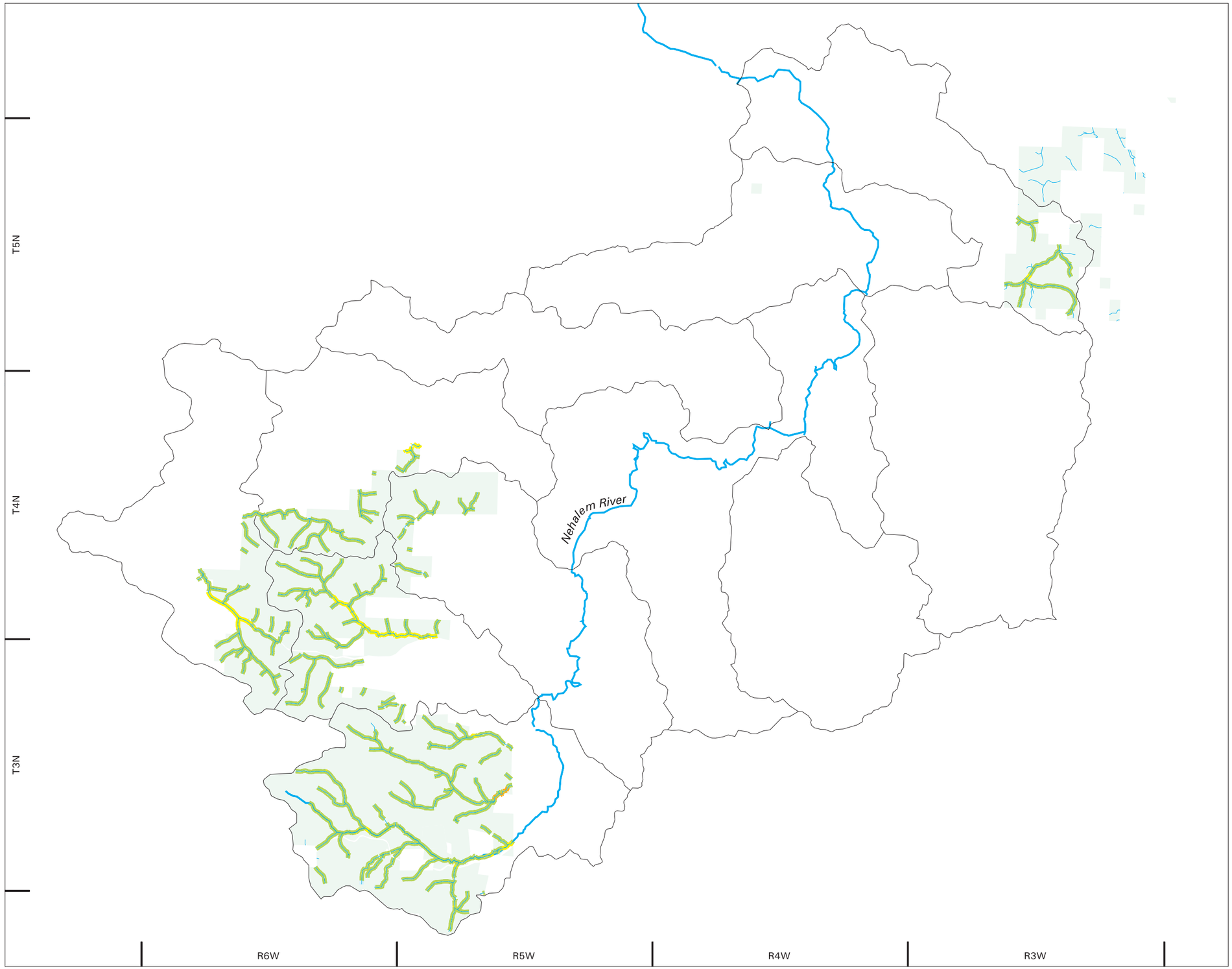
R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-2(a)

Current VTS Temperature Estimate Ranges

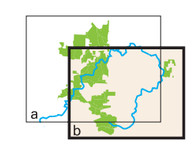
Astoria District



Legend

- < 12.0C
- 12.1C to 16.0C
- 16.1C to 18.0C
- 18.1C to 20.0C
- > 20C
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.3 Miles

0 2

Miles

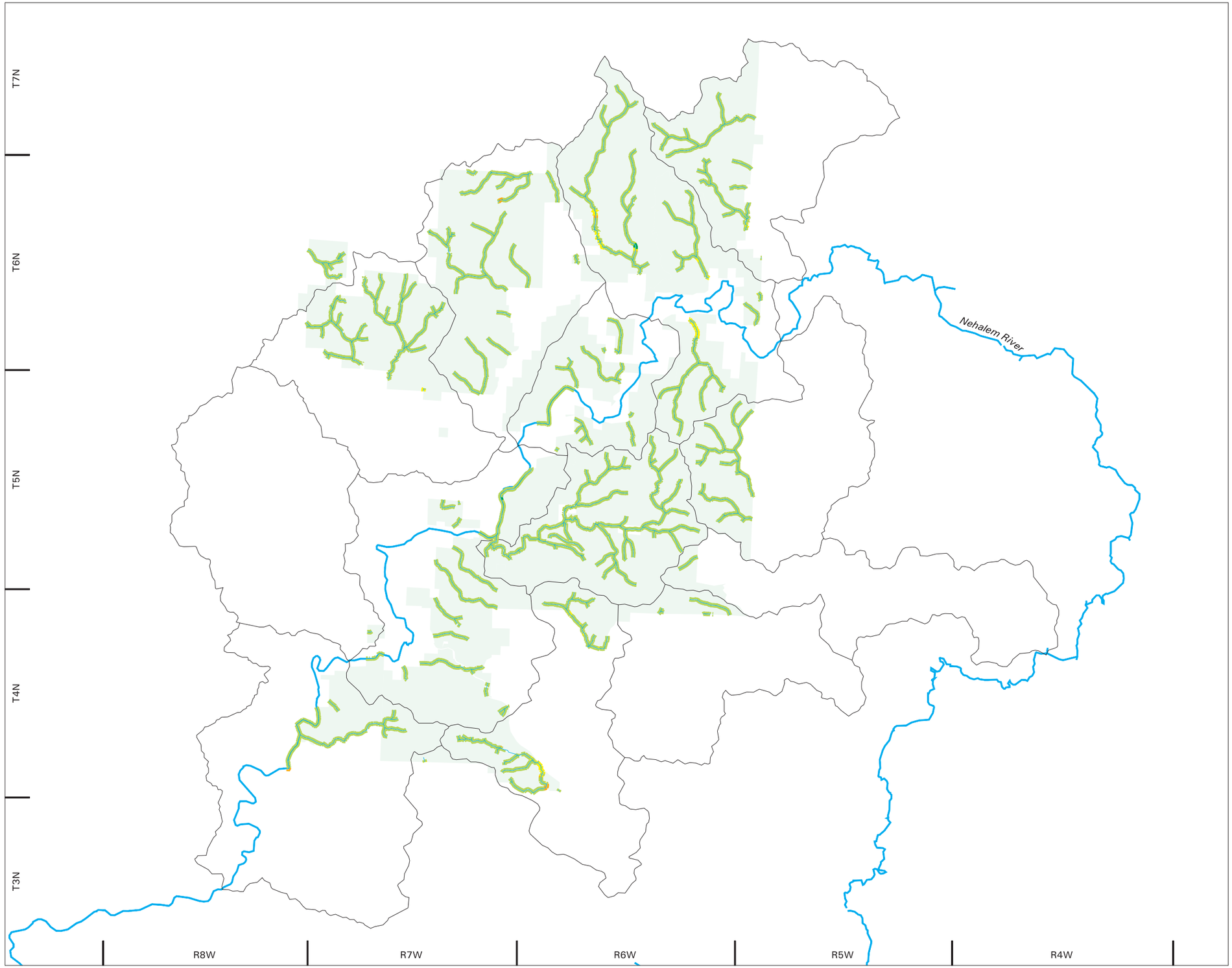
R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-2(b)

Current VTS Temperature Estimate Ranges

Forest Grove District



Legend

- < 12.0C
- 12.1C to 16.0C
- 16.1C to 18.0C
- 18.1C to 20.0C
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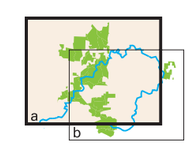
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.7 Miles

0 2

Miles

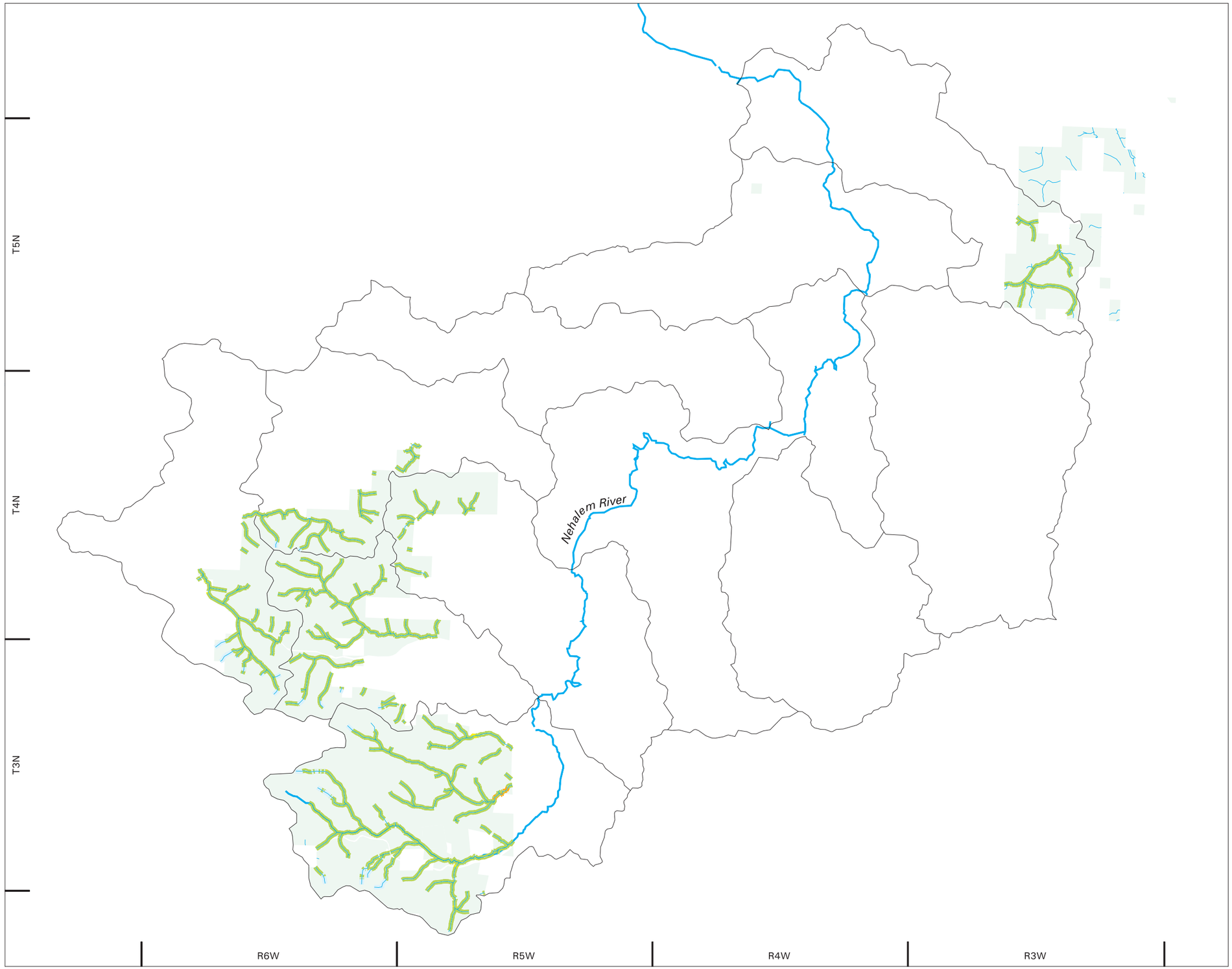
R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-3(a)

50-Year VTS Temperature Estimate Ranges

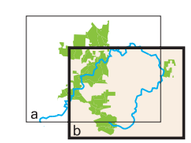
Astoria District



Legend

- < 12.0C
- 12.1C to 16.0C
- 16.1C to 18.0C
- 18.1C to 20.0C
- > 20C
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.3 Miles

0 2

Miles

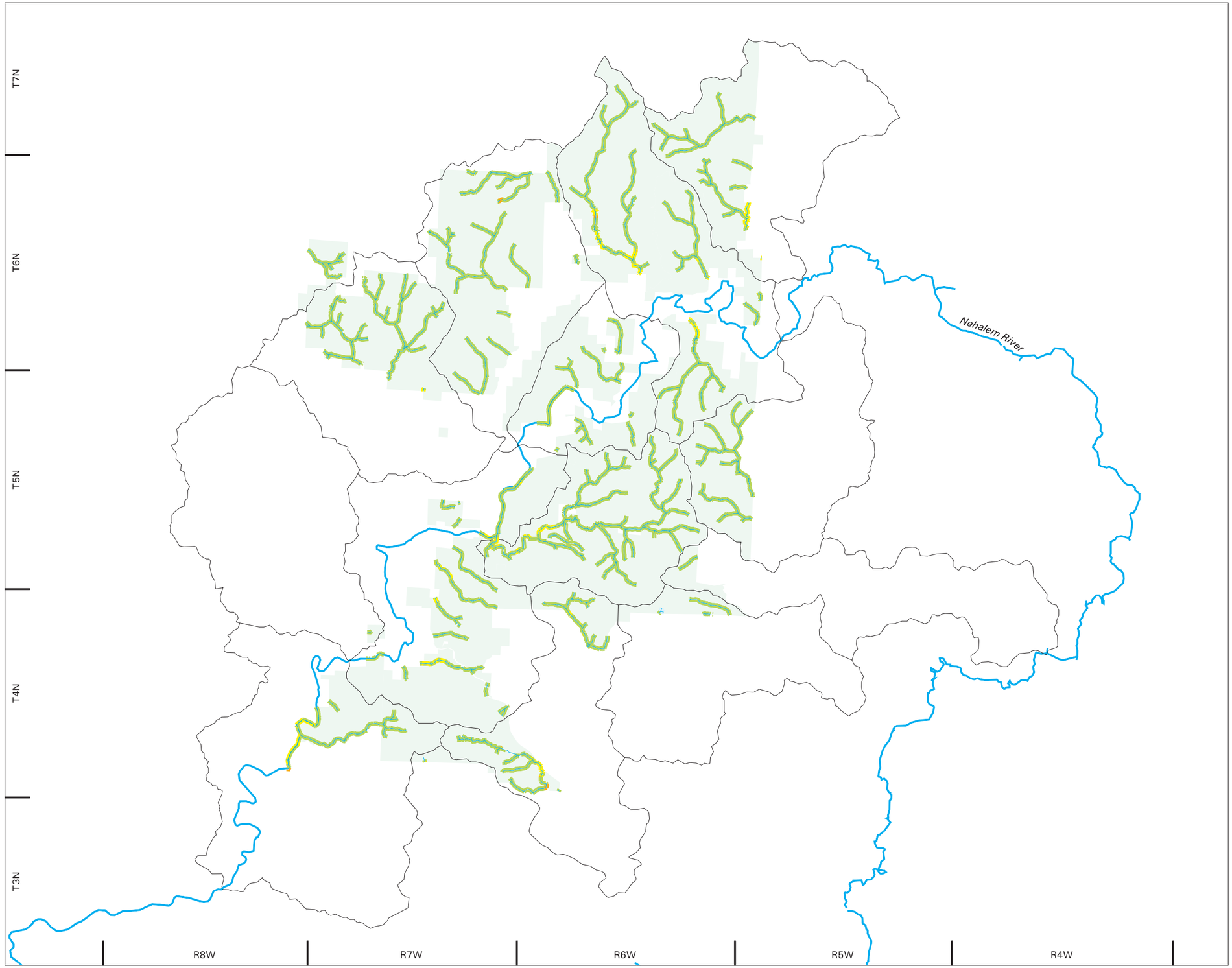
R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-3(b)

50-Year VTS Temperature Estimate Ranges

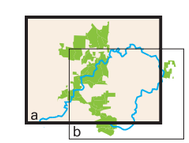
Forest Grove District



Legend

- < 12.0C
- 12.1C to 16.0C
- 16.1C to 18.0C
- 18.1C to 20.0C
- > 20C
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.7 Miles

0 2

Miles

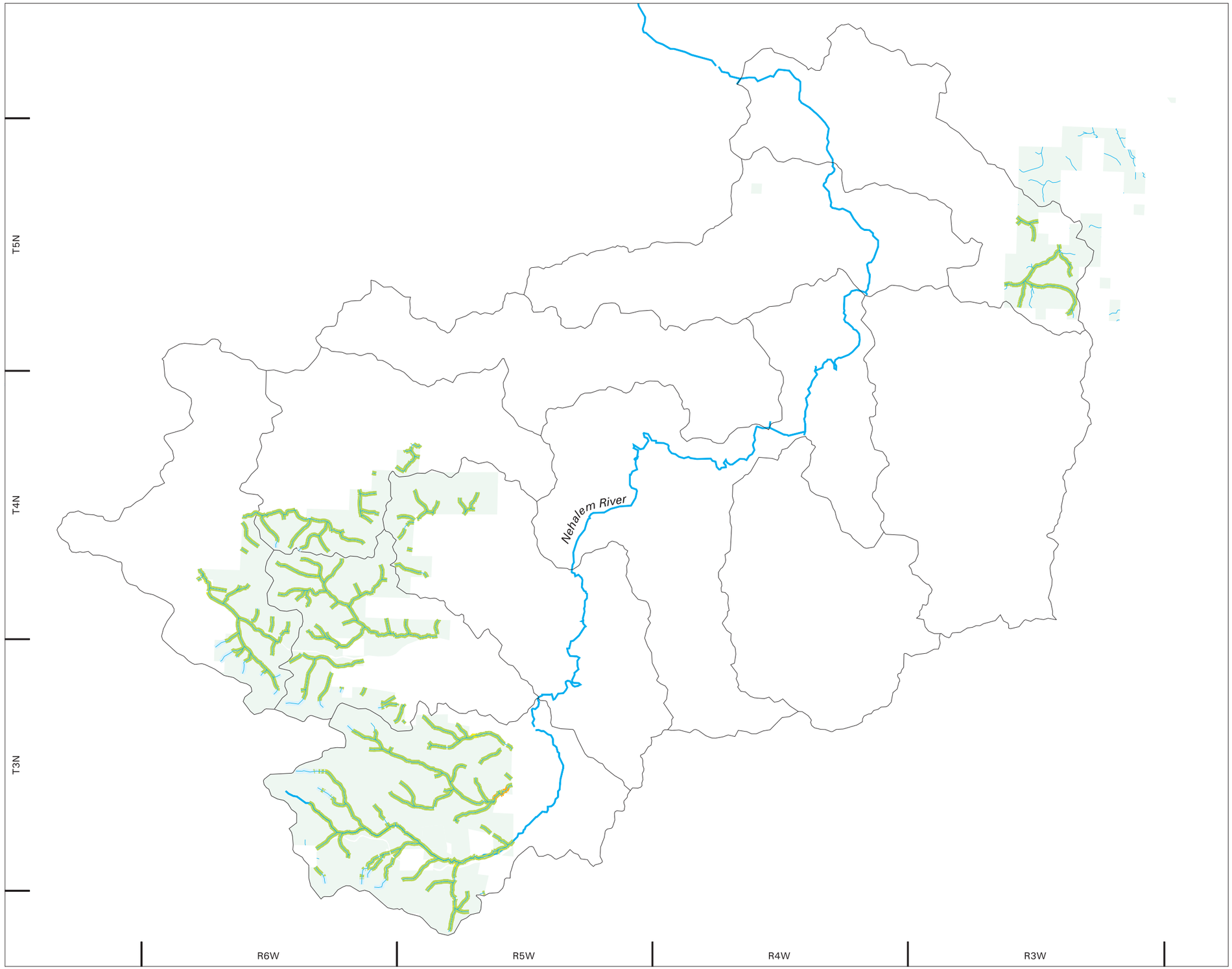
R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-4(a)

100-Year VTS Temperature Estimate Ranges

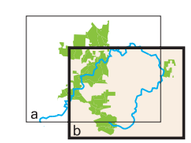
Astoria District



Legend

- < 12.0C
- 12.1C to 16.0C
- 16.1C to 18.0C
- 18.1C to 20.0C
- > 20C
- Major River
- Project Area
- 6th Field HUC (171002020109)

Map Key



N

1 Inch = 2.3 Miles

0 2

Miles

R2 Resource Consultants * map_r2rpt_1205.aml * 08 Dec 05

Oregon Department of Forestry
Upper Nehalem Watershed Analysis

Figure 9-4(b)

100-Year VTS Temperature Estimate Ranges

Forest Grove District

9.1.3.3 Field Verification

The results of the field verification occurring March 14-18, 2005 were used to estimate the average effective stand height. The field verification along samples of small, medium and large channel sizes in the upper watershed indicated good agreement with riparian site conditions and the 1995 aerial photo assessment. The instances when the field effort did not confirm the photo assessment were few (<10%) as previously described in Section 6.1.3.2. Although small shifts in the existing riparian conditions may exist on the ground, the watershed analysts were confident the original photo-based assessment was adequate to characterize the existing riparian conditions relative to their potential to block radiation to stream channels.

9.1.3.4 Forecasted Stand Conditions 50 to 100 Years in the Future

The results for future tree heights are shown in a matrix of stand conditions along a trajectory of 50-yr increments in Table 9-2. The projection of future riparian stand conditions should be considered a coarse screen tool, given the broad range of conditions potentially occurring under each of the riparian condition codes and variations in site class condition across the landscape. The approach assumes a mean 100-yr site potential tree height equivalent to 150 feet (24-in. dbh) on average for conifer species and 99 feet (24-in. dbh) maximum for hardwood species in the upper Nehalem watershed. Although variability in site characteristics and disturbance regimes exists, these assumptions should be representative of a general reference stand condition.

General Situations

Sparse Stands. In general, sparse stands need to develop either: (1) a closed coniferous canopy or (2) a second cohort underneath to develop into a dense stand capable of supporting a high VTS blocking potential over the 100-yr time frame. For shade intolerant species like Douglas-fir; the canopy needs to be open (RD <25) and understory conditions sufficient for seedling initiation to support ingrowth of a second cohort.

It is unlikely an existing sparse, riparian stand could generate appropriate conditions for ingrowth of shade intolerant species, with the exception of stands beginning as conifer regeneration and/or small, sparse stands (riparian condition codes: CRS/CSS). Current mature, but sparse stands, would likely grow without future ingrowth of a second cohort within 50 to 100 years. Some mixed stands could become conifer-dominated due to hardwood senescence, but they would likely remain in an overall sparse condition.

Mixed Stands. In mixed stands, conifer trees are free to grow when they overtop the hardwood community. The overall stand heights between conifer and mixed stands are likely the same, but

conifer density may be lower due to the lower overall conifer abundance in mixed stands. The degree of openings in mixed stands may influence the radiation blocking potential of the riparian zone.

Inner Riparian Zones (RA1). Hardwood communities often dominate the riparian species composition on low terraces and areas of frequent flood or debris flow disturbance along stream channels. Red alder (*Alnus rubra) w*ere the most prevalent disturbance species in the Upper Nehalem watershed. The typical species configuration and target riparian condition for this zone was dense stands of moderate-sized hardwood species (HMD). The width of the RA1 zone varied in accordance with channel confinement from a narrow 25-feet strip along confined channel types upward to 75 feet along broad, unconfined floodplain type channels, regardless of the designated Ecoregion in the watershed (Table 6-1). Growing conditions were not generally conducive to conifer establishment and these zones were not predicted to support conifer in the future. Repeated disturbances in this zone may keep the hardwood species in an early successional state. Without such disturbances, the hardwood species could mature and, given their relatively short longevity, could succeed to shrub-dominated vegetation communities in these zones (WFPB 1997). However, it is unlikely this situation would develop in the inner riparian zone, since natural disturbance regimes are typically more frequent than the 100-year life cycle of some hardwood tree species.

Outer Riparian Zones (RA2). Conifer or mixed species compositions typically dominate the riparian hillslope areas alongside streams where the soils are better drained than the low-lying terraces. The typical species configuration and target riparian conditions for this zone are dense stands of large-sized conifer and mixed hardwood:conifer species (MLD, CLD). For the purposes of this assessment, the RA2 zone lies adjacent and upslope of the RA1 zone out to a distance of 100 feet on either side of the streams. The width of the RA2 zone subsequently varies in accordance with channel confinement and the width of the RA1 zone. The widest outer riparian areas are found along the confined channel types (Table 6-1).

The inner riparian zone (RA1) immediately adjacent to the stream channels has a more direct influence on radiation blocking angles, and hence stream temperatures, than areas further away. Even moderate-size alder (> 12 inches dbh, >74 ft in height) provide narrower VTS angles than mature conifer (> 24 inches dbh, > 150 ft in height) located in outer riparian zone (RA2), for any of the channel habitat types (CHTs). The only exception occurs when the local topography in the outer zone rises sharply above the channel. Mature conifers on steep ground add additional blocking angles to vegetation in RA1.

Specific Situations

Specific assumptions and forecasts for each of the vegetation categories leading to low, moderate or high predictions of the current, 50-year and 100-year VTS blocking potentials are summarized in Appendix F.

9.1.3.5 Summary of Existing Riparian Conditions by Management Unit

Astoria District

Fishhawk Management Basin. A total of 21.2 miles of fish-bearing channels occur on ODF lands in the Fishhawk Management Basin. These streams lie between 528 feet and 1,503 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 13.7ºC and 16.3ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	97.4	91.0	94.7	94.7
16.1 to 18.0ºC	2.6	8.0	5.3	5.3
18.1 to 20.0ºC		0.3		
> 20.0ºC		0.0		

The riparian situation in the Fishhawk Basin with respect to stream shading was determined to be favorable at the time of this assessment. Approximately 91 percent of the fish-bearing stream length in the management basin provided sufficient riparian blocking height to maintain water temperatures below 16ºC. The riparian situations along 95 percent of the streams have the potential for maintaining temperatures less than 16ºC in 50 and 100 years. Approximately 1.1 miles (5.3%) are estimated to remain in a low shade situation. This distribution of temperatures is consistent with the range of temperatures under reference conditions.

Northrup Management Basin. A total of 13.8 miles of fish-bearing channels occur on ODF lands in the Northrup Management Basin. These streams lie between 518 feet and 1,811 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 13.3ºC and 16.3ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	86.2	44.0	84.0	89.0
16.1 to 18.0ºC	13.8	51.0	13.0	8.0
18.1 to 20.0ºC		2.0	1.0	0.9
> 20.0ºC		2.0	2.0	2.2

Riparian conditions in the Northrup basin were generally open with respect to the degree of channel exposure. The VTS model predicted approximately 44 percent of the fish-bearing stream length in the basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC. Of the balance of streams currently predicted to exceed the 7-Dmax of 16ºC, 2 percent were predicted to exceed 18ºC, and 2 percent were predicted to exceed 20ºC, based on the existing level of channel openness, channel width, and elevation across the management basin. Approximately 84 percent of the fish-bearing stream network was predicted to provide peak summer temperatures less than 16ºC in 50 years and 89 percent would likely achieve such levels in 100 years. Approximately 3.1 percent or 0.4 miles of the fish-bearing stream network were estimated to exceed 16.3ºC in 100 years, without some form of silvicultural management, due to the lack of existing trees in riparian communities dominated by grasses and shrubs.

Beneke Management Basin. A total of 18.7 miles of fish-bearing channels occur on ODF lands in the Beneke Management Basin. These streams lie between 541 feet and 1,549 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 13.6ºC and 15.6ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	100.0	96.7	98.4	98.4
16.1 to 18.0ºC		1.6	0.1	0.1
18.1 to 20.0ºC		0.8	0.7	0.7
> 20.0ºC		0.9	0.9	0.9

The riparian situation in the Beneke basin with respect to stream shading was found to be one of the most favorable of the management basins in both Astoria and Forest Grove districts. Riparian conditions on ODF lands adjacent to fish-bearing streams in the Beneke basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 97 percent of the stream distance. All but 2 percent (0.6 miles) of the current low canopy closure situations should develop sufficient characteristics to achieve 16ºC or less in 50 years. Riparian conditions along the stream miles not anticipated to comply with 16ºC in 50 years would require stand manipulation to achieve the desired conditions due to the presence of bare ground, grass, or shrub-dominated stands. More than 40 percent of the riparian stands along fish-bearing waters in the Beneke Management Basin are hardwood-dominated forests. According to the VTS model, the influence of natural hardwood stand thinning in 100 years due to senescence on water temperatures is very small. Although deciduous stands may become more sparse than at the 50-year time frame, subsequent tree growth is anticipated to offset the thermal effect of thinning such that the "effective" radiation blocking tree height and view-to-the-sky angles remain similar between 50 and 100 years. The only change in achieving PFC for water temperature due to hardwood senescence in this management basin is forecasted to occur in large stream channels downstream of 680 ft msl.

Lousignot Management Basin. A total of 7.4 miles of fish-bearing channels occur on ODF lands in the Lousignot Management Basin. These streams lie between 515 feet and 988 feet msl.

The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 14.6ºC and 16.3ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	92.8	54.0	97.2	93.8
16.1 to 18.0ºC	7.2	46.0		5.7
18.1 to 20.0ºC		0.0	2.2	0.0
> 20.0ºC		1.0	0.5	0.5

Riparian conditions on ODF lands adjacent to fish-bearing streams in the Lousignot basin indicated that 54 percent of the stream mileage is likely to maintain peak summer water temperatures below 16ºC. Nearly ninety seven percent of the fish-bearing stream network should develop appropriate stand height and closure to maintain water temperatures below 16ºC in 50 years. According to the VTS model, the situation was anticipated to deteriorate slightly in 100 years due to senescence of mature hardwood stands. Nevertheless, the stream temperature situation at 100 years nearly mimics the reference conditions. Less than 0.1 stream miles (0.5%) of fish-bearing waters would require stand manipulation to achieve the desired conditions in 100 years along these stream reaches due to either the existence of roadways, or shrubs influencing vegetative stand development.

Hamilton Management Basin. A total of 18.4 miles of fish-bearing channels occur on ODF lands in the Hamilton Management Basin. These streams lie between 666 feet and 1,683 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 13.4ºC and 16.0ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	100.0	95.2	99.1	99.2
16.1 to 18.0ºC		4.0	0.4	0.4
18.1 to 20.0ºC		0.3		
> 20.0ºC		0.5	0.5	0.4

Riparian conditions on ODF lands adjacent to fish-bearing streams in the Hamilton basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 95 percent of the stream mileage. With the exception of 0.2 stream miles of young conifer reproduction, mixed species and hardwood forests, nearly all of the existing low canopy closure situations should develop appropriate stand characteristics to achieve 16ºC or less in 50 years. More than 40 percent of the riparian stands along fish-bearing waters in the Hamilton Management Basin are hardwood-dominated forests. According to the VTS model, the influence of natural hardwood stand thinning in 100 years due to senescence on water temperatures is very small. Although deciduous stands may become more sparse than at the 50-year time frame, subsequent tree growth is anticipated to offset the thermal effect of thinning such that the "effective" radiation blocking tree height and view-to-the-sky angles remain similar between 50 and 100 years. The only change in achieving PFC for water temperature due to hardwood senescence in this management basin is forecasted to occur in large stream channels downstream of 680 ft msl.

Crawford Management Basin. A total of 5.5 miles of fish-bearing channels occur on ODF lands in the Crawford Management Basin. These streams lie between 472 feet and 679 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 15.0ºC and 15.5ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	100.0	65.2	98.6	98.6
16.1 to 18.0ºC		33.4		
18.1 to 20.0ºC		0.0		
> 20.0ºC		1.4	1.4	1.4

Riparian conditions on ODF lands adjacent to fish-bearing streams in the Crawford basin offered sufficient canopy closure to maintain water temperatures below 16ºC along 65 percent of the stream mileage. Ninety nine percent of the fish-bearing stream miles should develop sufficient canopy closure in 50 and 100 years to meet 16ºC. Slightly more than 1 percent of the existing riparian situations (0.05 stream miles) offered bare ground and may require some form of soil manipulation to achieve tree growth. The distribution of surface water temperatures in this management basin is consistent with expected levels under reference conditions.

Sager Management Basin. A total of 18.7 miles of fish-bearing channels occur on ODF lands in the Sager Management Basin. These streams lie between 495 feet and 1,024 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin with a provision for 20 percent openings in the canopy likely fell between 14.5ºC and 16.3ºC depending upon elevation and channel size.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	98.2	76.5	96.3	96.3
16.1 to 18.0ºC	1.8	22.9	3.1	3.1
18.1 to 20.0ºC		0.1		
> 20.0ºC		0.6	0.6	0.6

Riparian conditions on ODF lands adjacent to fish-bearing streams in the Sager basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 77 percent of the stream mileage. Ninety six percent of the stream mileage should develop moderate and high shade levels sufficient to achieve a 7-day maximum temperature of 16ºC in 50 and 100 years. Approximately 0.4 stream miles (1.9%) are estimated to remain in a low shade situation in 100 years compared to the distribution of stream temperatures under reference conditions.

Buster Management Basin. A total of 44.4 miles of fish-bearing channels occur on ODF lands in the Buster Management Basin. These streams lie between 423 feet and 1,982 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 12.7ºC and 16.5ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		0.4
12.1 to 16.0ºC	95.3	92.4	99.4	95.8
16.1 to 18.0ºC	4.7	7.4	0.4	3.6
18.1 to 20.0ºC		0.0		
> 20.0ºC		0.2	0.2	0.2

Riparian conditions on ODF lands adjacent to fish-bearing streams in the Buster basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 92 percent of the stream mileage. More than 99 percent of the stream miles should develop moderate and high shade levels to achieve 7-day maximum surface water temperatures of 16.5ºC or less in 50 years. Less than 0.1 stream miles (0.2%) of the fish-bearing stream network was projected to exceed reference conditions in this management basin due to riparian conditions dominated by shrubs and sparse hardwood conditions. Approximately 3.5 fish-bearing stream miles (3.8%) in the basin are estimated to remain in a low shade situation in 100 years. This level is consistent with the distribution of stream temperatures under reference conditions.

Quartz Management Basin. A total of 13.8 miles of fish-bearing channels occur on ODF lands in the Quartz Management Basin. These streams lie between 300 feet and 1,923 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 12.8ºC and 16.0ºC. The exception is the mainstem Nehalem River in the Quartz Management Basin. This wide portion of the river (~ 100 ft active channel width), situated at approximately 300 feet msl and more than 90 miles downstream from the watershed divide, was likely naturally warm. Under a canopy of mature timber, the VTS model predicts summer 7-Dmax. surface water temperatures would have been historically near 17.5ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	96.0	80.5	89.9	84.0
16.1 to 18.0ºC	4.0	13.6	4.2	10.0
18.1 to 20.0ºC		1.2	1.2	1.2
> 20.0ºC		4.7	4.7	4.7

The current riparian conditions on ODF lands adjacent to fish-bearing streams in the Quartz basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 80 percent of the stream mileage. Ninety three percent of the stream miles should develop moderate and high levels in 50 years sufficient to achieve a distribution of temperatures consistent with reference conditions. Although senescence of hardwood species was anticipated in 100 years, the distribution of surface water temperatures was predicted to be similar to the 50-year time frame. Approximately 0.8 stream miles (5.9%) will likely remain in a low shade situation throughout the 100-year assessment period. If appropriate, stand manipulation may be needed to achieve the desired temperature conditions along these reaches.

Contiguous Parcels

Young's Bay. A total of 1.7 stream miles of fish-bearing streams adjacent to ODF lands in the headwaters of the Young's Bay watershed lie in the Hamilton Management basin. Based on the elevation, channel width and degree of canopy closure, all of these streams were projected to maintain water temperatures below 16ºC now and in the future.

Forest Grove District

McGregor Management Basin. A total of 31.4 miles of fish-bearing channels occur on ODF lands in the McGregor Management Basin. These streams lie between 883 feet and 2,221 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 12.3ºC and 15.7ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0	0.6	0.6
12.1 to 16.0ºC	100.0	89.8	99.0	99.0
16.1 to 18.0ºC		10.0	0.1	0.1
18.1 to 20.0ºC		0.1	0.1	0.1
> 20.0ºC		0.1	0.1	0.1

Riparian conditions on ODF lands adjacent to fish-bearing streams in the McGregor basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 90 percent of the stream mileage. More than 99 percent of the stream miles have the potential to develop moderate and high riparian shade levels in 50 and 100 years. Approximately 0.1 stream miles (0.3%) are estimated to remain in low shade situations. The distribution of surface water temperatures in this management basin were predicted to be consistent with reference water temperatures.

Wheeler Management Basin. A total of 49.3 miles of fish-bearing channels occur on ODF lands in the Wheeler Management Basin. These streams lie between 833 feet and 2,681 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the basin likely fell between 11.6ºC and 15.7ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC	4.8	0.2	7.4	9.3
12.1 to 16.0ºC	95.2	93.8	90.8	88.9
16.1 to 18.0ºC		5.1	0.7	0.7
18.1 to 20.0ºC		0.9	0.9	0.9
> 20.0ºC		0.2	0.2	0.2

Riparian conditions on ODF lands adjacent to fish-bearing streams in the Wheeler basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 94 percent of the stream mileage distance. Ninety eight percent of the stream miles have the potential to develop moderate and high riparian shade levels in 50 and 100 years. Approximately 0.9 stream miles (1.8%) were estimated to remain in low shade situations throughout the 100-year time frame. If appropriate, stand manipulation may be required to achieve the desired temperature conditions along these stream reaches.

Wilark Management Basin. A total of 6.2 miles of fish-bearing channels occur on ODF lands in the Wilark Management Basin. These streams lie between 764 feet and 1,660 feet msl. The distribution of historical reference temperature conditions based on cumulative stream miles in the Basin likely fell between 13.4ºC and 15.9ºC.

Predicted Temperature Range (TºC)	Reference Conditions (%)	Current Conditions (%)	50-Year Conditions (%)	100-Year Conditions (%)
<12ºC		0.0		
12.1 to 16.0ºC	100.0	95.9	99.2	99.2
16.1 to 18.0ºC		3.3		
18.1 to 20.0ºC		0.0		
> 20.0ºC		0.8	0.8	0.8

The riparian situations in the Wilark Management Basin were determined to be favorable with respect to canopy closures and water temperatures. Riparian conditions on ODF lands adjacent to fish-bearing streams in the Wilark basin offered sufficiently high VTS blocking potential to maintain water temperatures below 16ºC along 96 percent of the stream mileage distance. On the order of 0.2 stream miles were currently projected to exceed 16ºC with 0.05 miles predicted to exceed 20ºC. Ninety nine percent of the stream miles have the potential to develop moderate and high riparian shade levels sufficient to achieve a 7-day maximum of 16ºC in 50 and 100 years. Approximately 0.05 stream miles (0.8%) are estimated to remain in a low shade situation due to the prevalence of riparian shrubs and stream parallel roads. The distribution of surface water temperatures in this management basin were predicted to be consistent with reference water temperatures. If appropriate, stand manipulation could be considered to achieve the desired temperature conditions along the short reaches, predicted to exceed 20ºC but the overall effect on the management basin would be small.

Contiguous Parcels

Clatskine. There was a current lack of riparian habitat data along ODF lands in this watershed. At this point, the Clatskine basin remains a data gap with respect to riparian conditions and projections of water temperature data.

9.1.3.6 Summary of Existing Water Temperature Data

DEQ water temperature data from the Laboratory Analytical Storage and Retrieval (LASAR) database included an extensive array of temperature records and stations throughout the Upper Nehalem watershed (http://deq12.deq.state.or.us/wq/lasar). Many of these measurements occurred in response to the Nehalem Basin Temperature TMDL and as a result of the Oregon Salmon Plan. Some of the records were solitary spot measurements of temperature at a given point and time, while others included continuous monitoring gauges such that the 7-day running average of the daily maximum values could be calculated. A comparison of VTS predicted peak summer temperatures and measured temperatures is shown in Appendix G. The comparison provides an indication of the appropriateness VTS current condition temperature estimates and which stations appear to be good approximations for reference stream conditions.

Data indicate that the VTS model provided an accurate assessment of water temperatures in the portion of the basin within a threshold distance from the watershed divide, where riparian vegetation was predicted to have a thermal influence on surface waters (Sullivan et al. 1990; BioSystems et al. 2003). Various threshold distances are shown in each of the Management Basins in Figure 9-1a,b. Conversely, the VTS model underpredicted surface water temperatures where streams became too wide and too deep for the moderating effects of riparian canopy (Table 9-4).

Table 9-4. Comparison of the predictive capability of the VTS model in relation to the threshold distance from the watershed divide

	Distance from the Watershed Divide			
Temperature Comparison	**< 3.8 Miles**	**>3.8 Miles**	**>10.0 Miles**	**>30.0 Miles**
Much Cooler (groundwater influence)	5			
Slightly Cooler	1			
Within Range	6		1	
Slightly Warmer		6		1
Much Warmer		4	3	4
Lake Influence			2	
Total	12	10	6	5

Data were considered "within range" if the predicted and measured summer peak values were within ± 5 percent of each other. "Slightly cooler or warmer" meant the measured values were within ± 10 percent of the predicted temperatures. "Much cooler or warmer" categories included temperatures that exceeded a 10 percent difference.

Excluding stations reflecting a high incidence of groundwater influence, the VTS model predicted summer temperatures within 5 percent of measured values in 86 percent of the cases where monitoring stations were located within 3.8 miles of the watershed divide. Most of the ODF forest lands were located upstream of this distance in each of the management basin. The model was less effective in regions where the thermal influence of riparian vegetation diminishes. As shown in Table 9-4, this finding was evident when site conditions like lake water runoff (Fishhawk Lake) influenced downstream water temperatures or in the Mainstem Nehalem River when the distance from the divide exceed 30 miles.

Regional Environmental Monitoring and Assessment Program (REMAP) sites in the Nehalem watershed # 1710020205, on the NF Nehalem River at RM 13.1 (Station ID 12514; STORET ID 405276) and E. Foley Creek at RM 2.5 (STORET ID 11844; 404533) have received bio-monitoring reference condition status for macroinvertebrate communities (Canale 1999; Drake 1999). Water temperature data from these undisturbed sites were considered as logical estimates of reasonably achievable surface water temperatures within the basin.

The North Fork Nehalem River site at RM 13.1 was large channel located at elevation 315 feet msl. Surface water temperatures from spot measurements of North Fork Nehalem River at RM 13.1 sampled between July 29 and September 20, 1995 and 1996 ranged between 13.5ºC and 14.5ºC (DEQ LASAR and STORET Legacy Data Retrieval). These temperatures are below: (1) the VTS reference conditions of 16.0ºC for this site elevation and channel size and (2) the current prediction of 16.6ºC based on the existing vegetation characteristics. The data collected to date either imply the site was groundwater influenced or that the sampling effort did not represent the full range of summer temperature extremes. Using these data as a temperature reference site was considered inappropriate.

The E. Foley Creek macroinvertebrate reference site was a large channel located at an elevation of 217 feet msl. Temperatures from spot measurements in E. Foley Creek at RM 2.5 in late August 1994 and early September 1992 ranged between 12.0ºC and 12.5ºC. These temperatures were less than the VTS reference conditions of 16.3ºC for the site elevation and channel size and a current temperature prediction of 18.0ºC based on existing vegetation characteristics. Similarly, the data either did not represent the mid-summer maximum temperature levels or groundwater has a considerable effect on surface water temperatures.

As a consequence, monitoring records from the two macroinvertebrate reference stations may not have reflected achievable water temperatures based on riparian canopy closure levels and they thus, would not make good temperature reference stations for the upper Nehalem basin. Individual site characteristics of elevation, stream flow, ground or ponded water influence and sampling limitations, made establishment of any reference sites within the basin or in adjacent basins for estimating reasonably achievable temperatures problematic. Use of the VTS model for this purpose was a reliable approach within an estimated 3.8 miles of the watershed divide.

9.2 SURFACE WATER QUALITY ASSESSMENT

9.2.1 Methods

Data for other key water quality parameters were accessed via ODEQ's LASAR database for the Nehalem River Basin. The database included a compilation from various entities collecting information in the basin. Key water quality parameters for this assessment included: dissolved oxygen levels and percent saturation, pH, conductivity, turbidity, total suspended solids, nutrients, and bacteria (fecal coliforms; *E. coli*).

9.2.2 Results

Water quality data collected in the upper watershed to date were limited. I*n-situ* water quality measurements for the key parameters have been collected in the upper Nehalem watershed intermittently since 1998 at fourteen stations located on or immediately downstream of ODF lands. Only four of the 14 stations was located within streams bordering ODF lands; three (3) in Lousignot Creek (Wheeler Management Basin) and one (1) in Gilmore Creek (Beneke Management Basin). A summary table of the water quality results from various stations on or near ODF lands in the basin is included in Appendix H. Station locations are shown in Figure 9-1a,b. The ranges of available data from the four ODF sampling sites were in line with reasonably achievable levels for all of the parameters in forested mountain streams. Overall, water quality data from the sampled waters were rated good for summer fish rearing and they were consistent with biological use criteria.

The water quality data in the watershed varied between stations and through time. Variation between stations reflected influences such as elevation, land use, groundwater input, wetland or lake outflow, and riparian canopy cover. Variation through time reflected influences such as annual weather conditions (e.g., air temperature, streamflow, and snow pack volume) and the occurrence of disturbances such as floods and debris flows. Variation in each of the major parameters is discussed below:

Dissolved Oxygen (DO)

Dissolved oxygen levels in streams were not generally a concern due to high re-aeration rates in turbulent flowing water. Dissolved oxygen concentrations in streams may be adversely influenced under special cases where the decomposition of high levels of organic matter results in high oxygen demand; in areas supporting very warm stream temperatures; in shallow, slow-moving stream environments (<1% gradient); at the junction of a wetland discharges to streams or during the low streamflow season when groundwater contributions are high relative to surface water volumes.

Measured DO concentrations in the upper Nehalem watershed ranged between 7.8 and 11.5 mg/l. The DO saturation levels were between 84 to 103 percent. The DO standard for Cold Waters of the state is a 30-day average of 8.0 mg O_2 /L or greater with an absolute minimum value of 6.0 mg O_2 /L. In lieu of long-term measurements the oxygen levels should exceed 90 percent saturation at all times. Approximately 26 percent of the DO saturation measurements fell slightly below this saturation level. The exceedances were of low magnitude with the lowest saturation measured during the months of July through September at 80 percent in Fishhawk Creek (Sta #12328), downstream of both Lousignot and Fishhawk Management Basins. Most of the exceedances in the watershed occurred during the low stream flow period of the year. In general, the low flow period has less re-aeration capacity, warmer surface water and a greater relative contribution of groundwater to base stream flows than during the balance of the year. The recorded DO levels were not of sufficient magnitude to have a deleterious effect upon summer rearing life stages of fish species present in the watershed. The lowest DO levels were recorded in the late summer and early fall after the incubation period for salmonid fish species. Incubation represents the most sensitive life history stage for salmonid fishes that requires DO to be near saturation. The incubation periods for salmon and trout occur during the winter and spring months, respectively.

In summary, DO levels in the surface waters of the watershed were expected to comply with the state standard throughout the stream network except for local areas of quiescent waters that exhibit low re-aeration rates and/or high level of groundwater contribution during the late summer or early fall low streamflow period.

Hydrogen Ion Activity (pH):

The pH of sampled waters in the WAU ranged from 5.7 to 7.8 pH units. Twenty-eight of 196 (14%) values fell below the water quality criterion of pH 6.5, indicating slightly acidic waters. Slightly acidic waters are normal for forested headwater streams in western Washington that share similar conditions to streams in the Project Area. The pH values below or near 6.5 were

infrequent and isolated in nature and lacking any specific pattern in the watershed and they remain above a pH level of 5.0, the minimum requirement for fish survival (U.S. Environmental Protection Agency 1986).

Hydrogen Ion Activity (pH)

The pH of flowing waters was generally not influenced by forest management practices. The buffering capacity of the soil precludes forest practices from materially affecting stream pH (Stottlemeyer 1987; MacDonald et al. 1991). Water quality standards for pH consists of water between 6.5 to 8.5 +/- 0.5 pH units.

Spot measurements of pH in the watershed indicated neutral waters (6.6 to 7.7 pH units). All readings represented natural conditions. The pH levels were very stable throughout the channel network indicative of a well-buffered system. This assessment concluded the waters within the Upper Nehalem watershed offer neutral acidity, were well-buffered, and remained within water quality standards. The pH levels were not necessarily sensitive to inputs from forest practices in the stream network.

In summary, pH levels in the surface waters of the watershed were expected to comply with the state standard throughout the stream network. The pH levels monitored to date were not anticipated to have an adverse affect upon aquatic biota in the watershed.

Ammonia

Ammonia nitrogen (NH_3-N) is a chief end product of nitrogen metabolism in most aquatic animals and it is a by-product of organic decomposition. In flowing waters high levels of ammonia can be toxic to aquatic biota. Under normal stream pH levels, ammonia is typically bound in ammonium salt (NH_4OH) and unavailable for biological uptake. Un-ionized ammonia is the available and highly toxic form of ammonia, but at the pH levels measured in the upper watershed more than 98% of the ammonia nitrogen would be in the bound rather than the un-ionized form. A safe level of un-ionized ammonia in streams is 0.02 mg/l, while ammonia-nitrogen is recommended to remain below 0.5 mg/l (USEPA, Water Quality Criteria 1986). All of the reported results on and near ODF lands in the watershed for ammonia-nitrogen and un-ionized ammonia remained within recommended concentrations for aquatic life.

Stream Nutrients

The prior PSU watershed analysis (Johnson and Maser 2000) indicated a concern for nitrate-nitrogen levels in the watershed. However, data from the upper basin indicate a low level of nitrates, suggesting the nutrient concern was more likely an issue in the lower portions of the

basin. Forested mountain streams in the Pacific Northwest are generally very low in both nitrogen and phosphorus and primary productivity is often naturally low. Nitrogen levels often peak in autumn during leaf fall. As a nitrogen-fixing plant, the presence of alder can increase levels of nitrate in streams. Forest management practices generally do not have a considerable influence on nutrient concentrations in surface waters. Although harvesting and burning can increase nitrate levels, the inputs remain relatively low (Bisson et al. 1992; Fredricksen et al. 1975).

Nutrients are generally assessed relative to the likelihood of increasing nuisance aquatic plant growth and potentially adverse effects on dissolved oxygen levels in surface waters. The typical objective is to exclude management-induced nutrient contributions from elevating stream and lakes to a higher trophic status. Nitrogen concentrations in streams of less than 0.30 mg NO_3 – N / L will generally prevent downstream eutrophication (WFPB 1997).

Nitrogen concentrations collected to date ranged between 0.005 and 0.410 mg/l, suggesting the waters are generally low in dissolved levels of nitrate. The low N:P ratio (10:1) indicated nitrogen is likely limiting plant growth in the upper Nehalem watershed. This finding was consistent with the observation that forested mountain streams are most often N-limited (Gessel et al. 1979; Salminen and Beschta 1991; MacDonald et al. 1991; and Wolf 1992). The data suggest changes in nitrogen, rather than phosphate, inputs to streams are likely to have a direct influence on aquatic productivity.

Eighteen of nineteen measurements (95%) in the watershed indicate nitrate levels represented a low risk to increased plant growth. The highest single measurement of 0.410 mg /L occurred in one sample collected in Quartz Creek downstream of the ODF Quartz Management Basin in June, 2003. This result may have represented an unnatural source of nitrate, possible via groundwater influx as suggested by the relatively high levels of mineralization (conductivity). Dissolved oxygen saturation levels, ranging between 95 and 101 percent, did not suggest deleterious levels of algal production in Quartz Creek. More detailed information is needed to assess the effects of nitrate-nitrogen levels in Quartz Creek.

A review of the PSU assessment indicates nitrogen concentrations increased in the downstream direction with more intensive land uses compared to the nature of lands in the headwater regions. Based on available literature and the longitudinal trends in the nearby data collected to date, nitrates were assumed to be low (<0.05 mg/L) in the headwater streams. Because there was a general low level of nitrogen contribution from forest practices, headwater streams in the watershed contributing to streams in the valley floor were assumed have a low level of nitrogen input.

Phosphate levels recorded in the watershed were relatively low, ranging from < 0.01 to 0.04 mg/L. These levels were within natural ranges found in forested mountain streams and they did not imply an unnatural source of nutrient enrichment.

Turbidity/Total Suspended Solids

Turbidity and total suspended solids (TSS) are two related measures of water clarity that typically have a high degree of correlation between each other. High levels of either turbidity or TSS may indicate a source of fine sediment inputs to streams. Forest management practices through harvesting and road construction, maintenance and use can influence the loading of fine sediments to surface waters. Other landuses in the watershed also have the potential to contribute fine sediments to the channel network.

Turbidity measurements in the watershed ranged from <1 to 8 NTU. These levels were low, but likely did not represent the full range of turbidity levels throughout the year. Water quality sampling rarely occurs during peak storm events or high seasonal stream flows. The highest recorded turbidity levels were recorded in March, 1997 on Fishhawk Creek (Sta #12328), downstream of both Lousignot and Fishhawk Management Basins.

Similarly, TSS values ranged from <1 to 54 mg/L in the fourteen monitoring stations in the upper Nehalem watershed. Approximately 75 percent of the observations were below 10 mg/L and 98 percent of the measurements were recorded below 18 mg/L. The single highest recording of 54 mg/l occurred in the mainstem Nehalem River at Vesper (Sta # 23873) on March 28, 2001. The highest recorded TSS value was typical of a spring storm event. The remaining values were characteristic of TSS levels during dry periods or low level rainfall events in the watershed.