APPENDIX E: LOW PH DISCUSSION

INTRODUCTION AND BACKGROUND

The pH scale is used to provide a numeric value that describes the intensity of the acidic or basic (alkaline) conditions of a solution. The pH of a solution is defined as the negative logarithm of the activity of the hydrogen ion. The pH scale runs from 0 to 14, where 7 is "neutral", below 7 is "acidic" and above 7 is "basic". Pure water has a neutral pH of 7 at 25°C, with an equal concentration of H^+ (hydrogen) and OH^- (hydroxyl) ions. As the proportion of OH^- ions increases, the solution becomes more basic. The pH scale is logarithmic so that for every one unit change (e.g. from 5 to 4), there is a ten-fold increase in acidity (Sherman and Russikoff 1988).

Stream pH levels usually fall between 6.5 and 8.5, although wide variations can occur because of local watershed geology. Streams that drain soils with high mineral content usually are alkaline, whereas streams that drain coniferous forests usually are acidic (Allan 1995). Most rainwater has a pH of 5.6 to 5.8, simply due to the presence of carbonic acid (H_2CO_3). The latter is formed by the interaction of water (H_2O) with atmospheric carbon dioxide (CO_2). Normally these acids are neutralized as rainwater passes through the soil. However, in watersheds with heavy rainfall, little buffering capacity and acidic soils, surface water pH may be largely reflective of the rainwater pH values. Anthropogenic factors including industrial runoff and acid rain may also impact surface water pH within a watershed.

Most aquatic organisms, including benthic macroinvertebrates, salmonids and amphibians, are sensitive to pH changes and prefer a pH in the range of 6.0 to 9.0 (EPA Quality Criteria for Water, 1986).

BENEFICIAL USES

Oregon Administrative Rules (OAR Chapter 340, Division 41, Table 6) lists the “Beneficial Uses” occurring within the Tualatin River Sub-Basin (**Table 1**). Numeric and narrative water quality standards are designed to protect the most sensitive beneficial uses. The pH criterion was developed to protect Resident Fish and Aquatic Life, which is the most sensitive beneficial use related to pH occurring within the Tualatin Sub-Basin.

Table 1. Beneficial uses occurring in the Tualatin River Sub-Basin
(OAR 340 – 41 – 442)
Beneficial uses protected by the pH Criteria are marked in gray

Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply	✓	Salmonid Fish Spawning (Trout)	✓
Private Domestic Water Supply	✓	Salmonid Fish Rearing (Trout)	✓
Industrial Water Supply	✓	Resident Fish and Aquatic Life	✓
Irrigation	✓	Anadromous Fish Passage	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Hydro Power	✓	Water Contact Recreation	✓
Aesthetic Quality	✓	Commercial Navigation & Transportation	

WATER QUALITY CRITERIA

The pH criterion for the Willamette Basin (OAR 340-41-442) states that pH values shall not fall outside the range of 6.5 to 8.5 pH units. Natural variability outside of the 6.5 to 8.5 pH range is addressed in OAR 340-41-(basin) (3):

> "Where the naturally occurring quality parameters of waters of the (Basin) are outside the numerical limits of the above assigned water quality standards, the naturally occurring water quality shall be the standard."

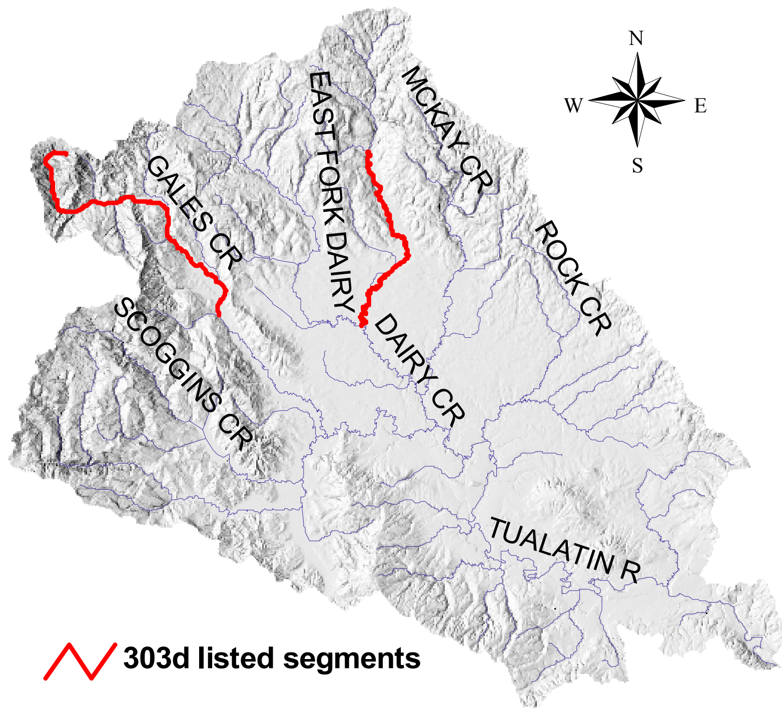
It should be noted that when natural variability causes values to fall outside the range of pH criteria, there is no remaining assimilative capacity in the waterbody and no anthropogenic change resulting in further excursions from the criteria will be allowed.

303(D) LISTED STREAM SEGMENTS

There are two stream segments within the Tualatin Sub-Basin that are on the 1998 303d list for pH: Gales Creek (Clear Creek to Headwaters) and East Fork Dairy Creek (Mouth to Whiskey Creek). **Figure 1** shows the location of the 303d listed portions of Gales and East Fork Dairy Creeks. Gales Creek is listed for Fall-Winter-Spring seasons, while East Fork Dairy Creek is listed only for the summer season. Both stream segments are 303d listed because pH was occasionally found to be below the lower criterion of 6.5 pH units.

There is a slight inaccuracy in the 303d listing for East Fork Dairy Creek. The segment that is 303d listed extends from the mouth (RM 0) to Whiskey Creek (RM 14), but data used for the listing was collected at Dairy Creek Road (RM 8.4), Fern Flat Road (RM 17.6) and near the Washington County boundary (RM 21.3). It would be more accurate to list East Fork Dairy Creek in its entirety (assuming the data are valid).

FIGURE 1. TUALATIN SUB-BASIN STREAM SEGMENTS ON THE 303D LIST FOR PH (BOLDED)



Discussion

Measurements of pH were collected by various agencies within the Tualatin Sub-Basin and reported to the Unified Sewerage Agency (USA). USA compiled the data and submitted it to the Department of Environmental Quality (DEQ), where it was included in the STORET national water quality database. The DEQ then tapped the STORET database to gather data for the 303d listing process. Consequently, some investigation was required to assess the source and accuracy of the data originally submitted to USA.

The Oregon Department of Forestry (ODF) collected data used for the 303d listing at 2 sites on East Fork Dairy Creek and 1 site on Gales Creek. Data collected by students from the Oregon Graduate Institute (OGI) at one site on East Fork Dairy Creek were also used as a basis for 303d listing. All data used for the 303d listing were collected using field pH meters.

As noted above, heavy rainfall in areas with acidic soils can result in relatively acidic surface waters. The upper portion of the Tualatin Basin is largely comprised of the medium-to-strongly acidic (pH 5.1 to 6.0) Olyic-Melby soil association (USDA 1982). **Figue 2** shows the distribution of soil pH within the Tualatin Sub-Basin.

Figure 2. Map showing surface soil pH in the Tualatin Sub-Basin

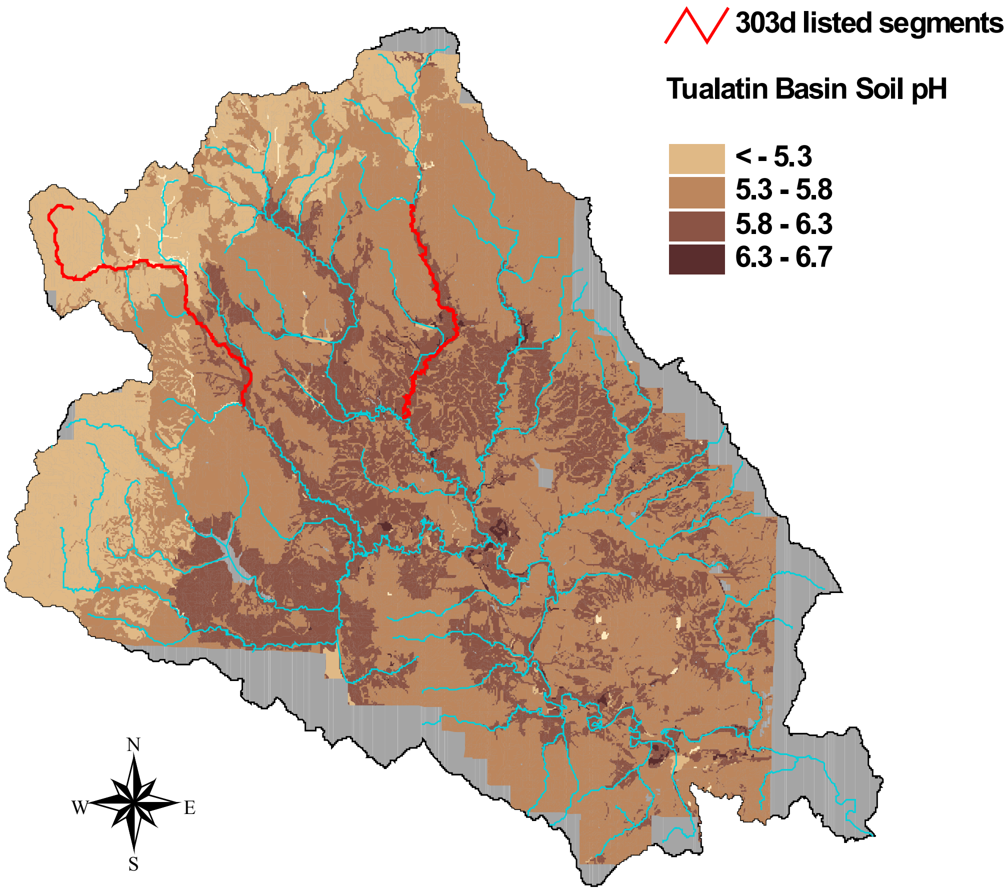
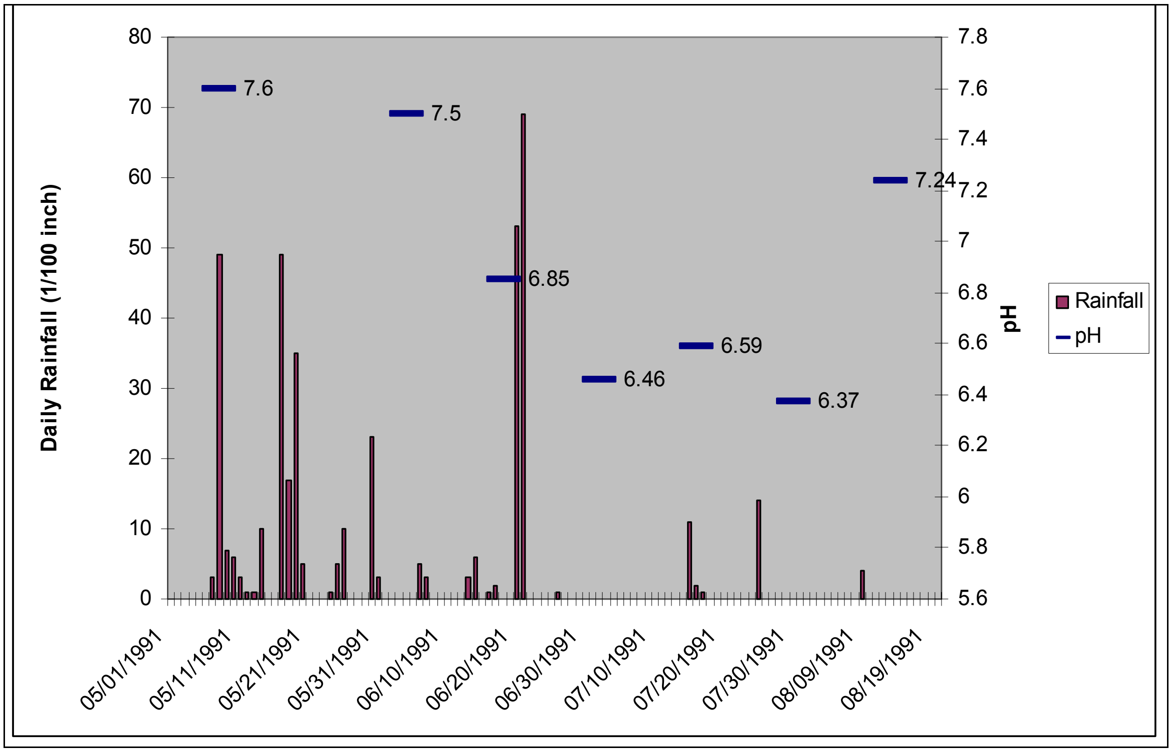

303d listed segments
Tualatin Basin Soil pH
< - 5.3
5.3 - 5.8
5.8 - 6.3
6.3 - 6.7
N
W
E
S

Figure 3 shows pH and rainfall at the Gales Creek Campground monitoring site during the summer of 1991. A visual analysis shows no relationship between significant rainfall events and low pH. In fact, it appears that the lowest pH measurements were made during periods of little or no rainfall. This scenario is typical for all four monitoring sites and for all years and seasons that monitoring data are available. It is possible that a targeted study may show a relationship between acid soils, rainfall events and low stream pH, but existing data do not support this hypothesis.

FIGURE 3. PH AND RAINFALL AT THE GALES CREEK CAMPGROUND MONITORING STATION



Another possible explanation for the low pH values observed in Gales and East Fork Dairy Creeks is simple sampling error. Measurement of pH in low ionic strength waters (waters below 50 umhos/cm^2 are generally considered to have low ionic strength) can be problematic (APHA 1986). Measuring pH in low ionic strength waters requires careful calibration of field pH meters and a longer probe equilibration time before readings are taken (generally at least one minute). Under these conditions the likelihood of erroneous readings increases substantially. A total of 71 field measurements of conductivity were collected at the RM 8.4 site between May 1994 and November 1998. Conductivity values ranged from 14 to 69 umhos/cm^2, with a median value of 41umhos/cm^2.

Lastly, anthropogenic influences may result in acidic or basic surface waters. However, there are no industrial discharges or other likely anthropogenic sources in this portion of the Tualatin Sub-Basin. In fact, the Upper Gales Creek area is heavily forested and in relatively pristine condition.

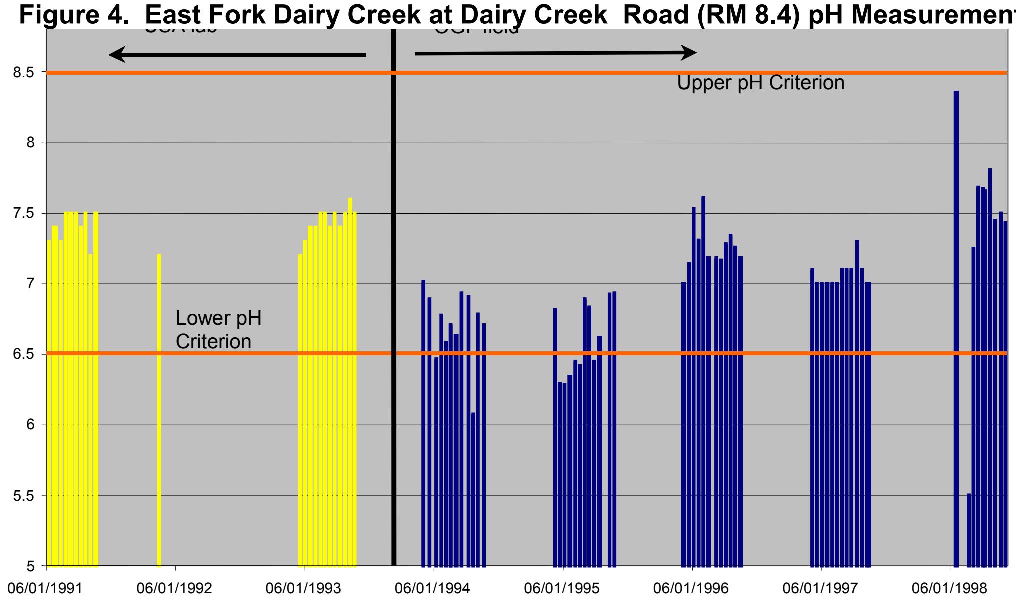
Given the acidic nature of upper Tualatin basin soils, it is reasonable to expect that surface water pH values would fall in the lower portion of the normal range. These conditions, coupled with low ionic strength waters and some sampling error, likely resulted in erroneous readings.

Data from 4 Tualatin Sub-Basin sampling stations was used in deciding to list portions of East Fork Dairy Creek and Gales Creek on the 1998 303d list. Each station will be evaluated individually in the following sections.

EAST FORK DAIRY CREEK AT DAIRY CREEK ROAD (RM 8.4)

Data was collected at the sampling station at East Fork Dairy Creek road (STORET #3818084) between 1991 and 1998. Between 1991 and 1993, OGI students collected water samples that were taken to USA's laboratory facility for pH analysis. No pH violations were observed for the 23 samples collected during this time (**Figure 4**). It should be noted that USA's laboratory procedures adhere to strict quality assurance/quality control procedures and that pH measurements made under those conditions tend to be extremely accurate. In the summer of 1994 OGI students began using field instruments to measure pH and USA laboratory analyses were discontinued. No documentation is available to assess quality control/quality assurance procedures used by OGI field personnel. However, in the years (except 1996 and 1997) following the transition from USA lab measurements to OGI field measurements there appears to have been an unusual amount of variability in the pH measurements. Nine of the 60 field pH measurements taken by OGI personnel fell below the 6.5 criteria (**Figure 4**). Due to the lack of field notes and instrument calibration data, it is difficult to determine the accuracy of these field measurements. It is likely that poor calibration and maintenance of field pH meters, coupled with the low ionic strength of the regions surface waters, resulted in erroneous and inconsistent measurements.

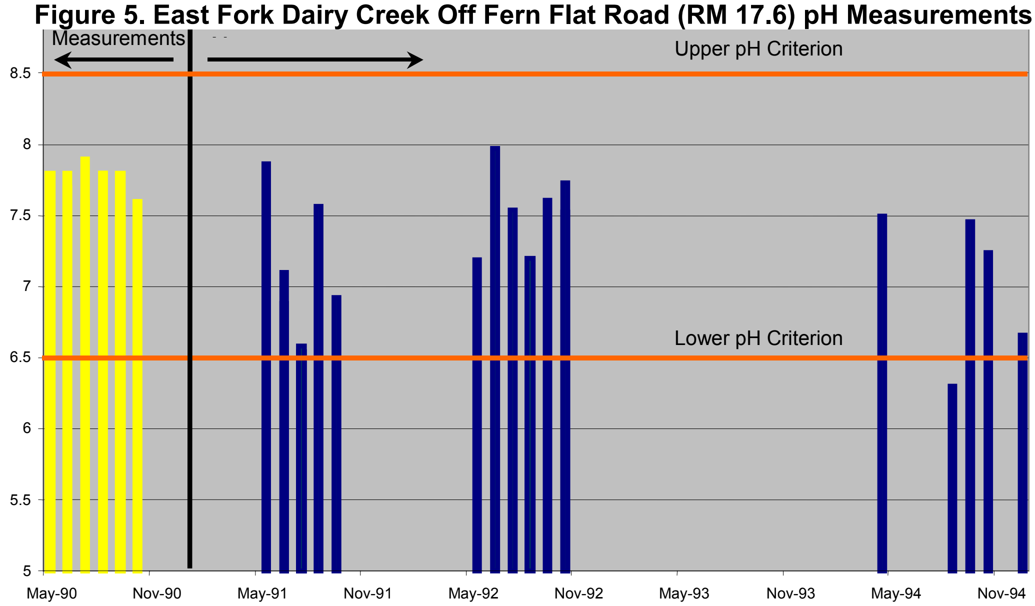
Figure 4. East Fork Dairy Creek at Dairy Creek Road (RM 8.4) pH Measurements



EAST FORK DAIRY CREEK AT FERN FLAT ROAD (RM 17.6)

Data was collected at the sampling station at Fern Flat Road (STORET #3818168) between 1990 and 1994. During 1990, ODF field personnel collected water samples that were taken to USA's laboratory facility for pH analysis. No pH violations were noted during this time (**Figure 5**). In 1991 ODF personnel began using field instruments to measure pH and USA laboratory analyses were discontinued. Again, variability increased dramatically after the transition from laboratory to field measurements and 1 out of 16 measurements fell below the 6.5 criterion. No documentation is available to assess the quality control and instrument calibration procedures used by ODF field personnel.

Figure 5. East Fork Dairy Creek Off Fern Flat Road (RM 17.6) pH Measurements



EAST FORK DAIRY CREEK AT COUNTY LINE BRIDGE (RM 21)

ODF personnel using field pH meters sampled the uppermost site on Dairy Creek (STORET # 3818209) from 1991 to 1993. Two of the 19 field measurements fell below the criterion of 6.5 pH units (**Figure 6**). Again, pH values were variable, not correlated with rainfall events, and not supported by field notes or instrument calibration data.

GALES CREEK AT GALES CREEK CAMPGROUND (RM 24.3)

ODF personnel collected field pH data at the Gales Creek Campground monitoring site (STORET #3810260) between 1991 and 1994. Six of the 18 field measurements fell below criterion of 6.5 pH units (**Figure 7**). As was the case with the previous ODF monitored sites, pH values are variable and not correlated with rainfall events. It is likely that poor calibration and maintenance of field pH meters, coupled with the low ionic strength of the regions surface waters, resulted in erroneous and inconsistent measurements.

DAIRY CREEK AT HIGHWAY 8 (RM 2.1)

USA collected more than 450 field and laboratory pH measurements between 1989 and 1998 from a monitoring site on Dairy Creek at Highway 8 (Storet #3815021). This monitoring site is approximately 16 miles downstream of the East Fork Dairy Creek at Dairy Creek Road monitoring site (RM 8.4) and below the confluence of East and West Fork Dairy Creeks. USA field crews collected samples for laboratory pH analysis and conducted field pH measurements. Only 1 out of the 450+ field pH measurements was below 6.5 and none of the laboratory measurements fell below 6.5 (**Figure 8**). Laboratory and field pH measurements made by USA during the summers of 1990-1993 at the Dairy Creek at Highway 8 site are consistent with concurrent measurements made by USA at the East Fork Dairy Creek sites (See **Figures 4**, **5** and **8**). USA laboratory and field pH measurements were also very consistent, implying good quality assurance procedures (**Figure 8**). This would further indicate that the low field pH values measured by ODF and OGI at the East Fork Dairy Creek sites were erroneous.

Figure 6. East Fork Dairy Creek at County Line Bridge (RM 21) pH Measurements

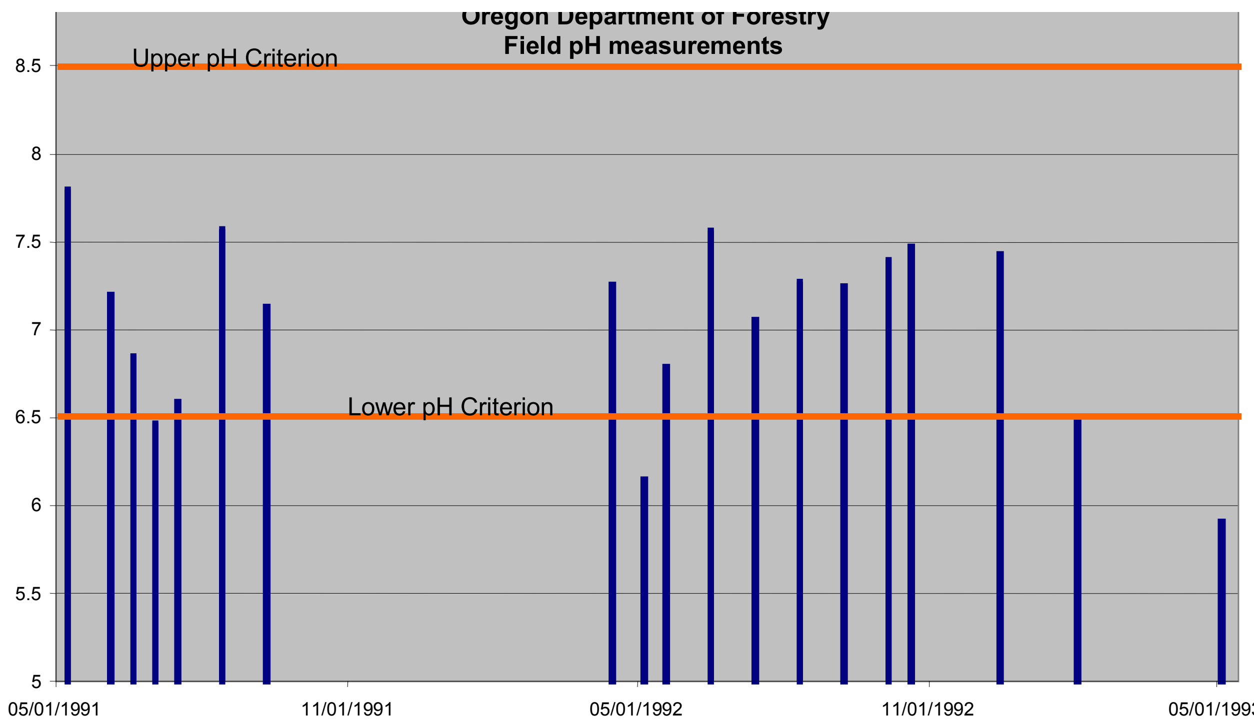


Figure 7. Gales Creek at Gales Creek Campground (RM 24.3) pH Measurements

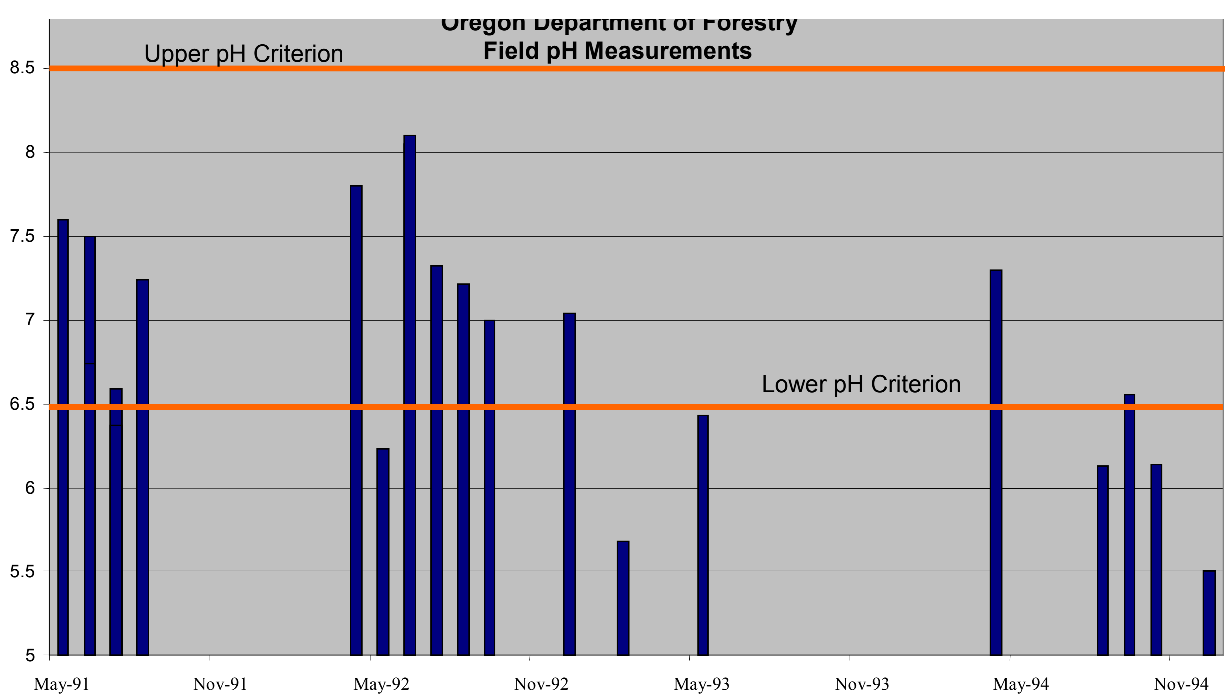
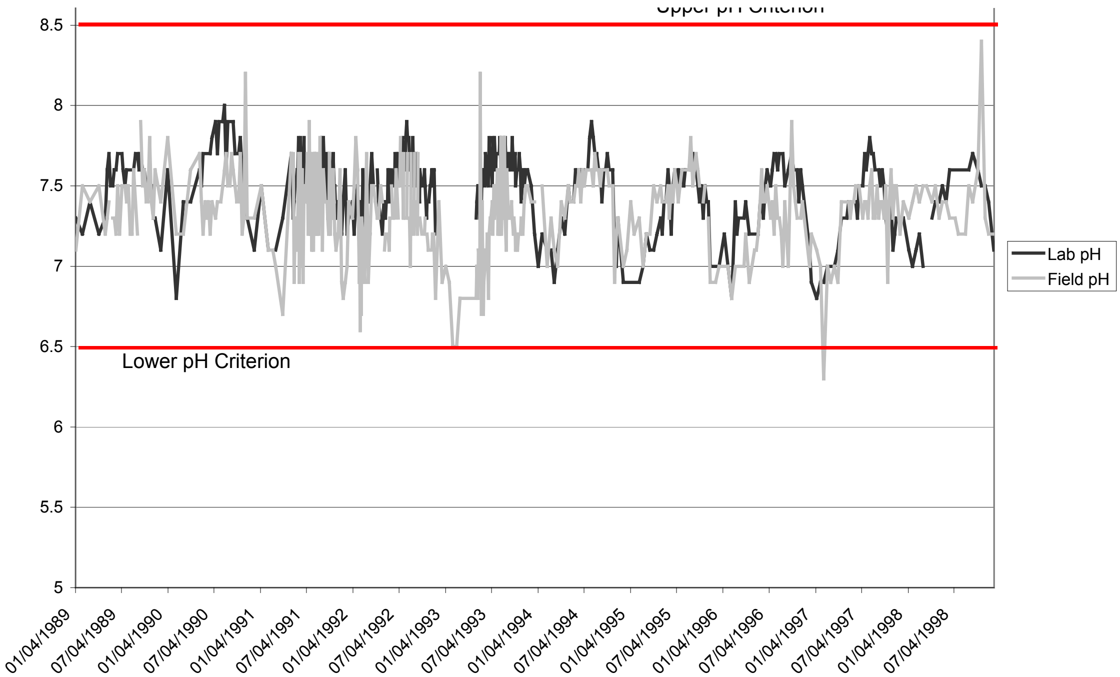


Figure 8. Dairy Creek at Highway 8 (RM 2.1) pH (1989-1998)



Summary

Upon closer examination of the data used to list Gales and East Fork Dairy Creeks on the 1998 303d list for pH, it appears that the data are questionable and that a TMDL should not be established for pH. While it is possible that heavy rainfall events, coupled with relatively low soil pH found in the upper portions of the Tualatin watershed, could result in low pH surface waters, data collected to date do not support this hypothesis. An analysis of rainfall events and pH measurements failed to show any relationship between heavy precipitation and low pH. It appears likely that improper calibration and/or maintenance of field pH meters, coupled with the difficulty of measuring pH in low ionic strength surface waters, resulted in erroneously low pH values.

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