

**MEMO: PIEZOMETER MONITORING IN
CHUMSTICK AND MISSION CREEKS**

Groundwater–Surface Water Interactions
along Chumstick Creek and Mission Creek in WRIA 45
Chelan County, Washington

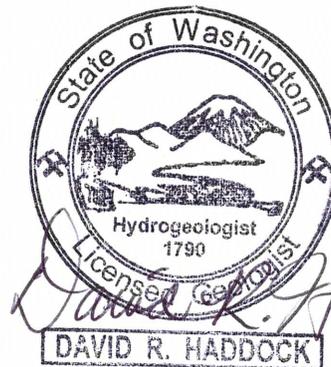
February 13, 2009
Project No. 12817.001

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David R. Haddock, L.Hg
Principal Hydrogeologist

2/13/2009





Memo

To: Lee Duncan, Project: 12817.001
Chelan County Natural Resource Department

From: Dave Haddock and Steve Ellis,
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Date: February 13, 2009

Subject: Piezometer Monitoring in Chumstick and Mission Creeks
Groundwater–Surface Water Interactions along Chumstick Creek and Mission Creek
in WRIA 45, Chelan County, Washington

INTRODUCTION

The Wenatchee Watershed (Water Resource Inventory Area [WRIA] 45) has been identified by the Washington State Department of Ecology as one of 16 watersheds in the state where water quantity is a probable limiting factor for anadromous fisheries resources. Increasing competition for hydrologic resources in the watershed in conjunction with seasonal low-flow conditions contribute to inadequate streamflows for fish, particularly during periods of late summer and early fall (Wenatchee Watershed Planning Unit [WWPU], 2006).

In an effort to address the condition of water resources within the Wenatchee Watershed, a final Wenatchee Watershed Management Plan (WWMP) was completed in April 2006. The WWMP identified insufficient streamflow, diminished water quality, and a lack of geologic and hydrologic data on which to evaluate water availability and management strategies within two Wenatchee subwatersheds (Chumstick Creek and Mission Creek). In 2007 existing data were utilized to prepare a water balance for the Chumstick Creek and Mission Creek subwatersheds and recommendations were provided to collect additional data that would reduce uncertainties associated with the water balance (Geomatrix, 2007a, 2007b). One of these recommendations was to collect data to gain a better understanding of groundwater–surface water interactions in Chumstick Creek and Mission Creek and surface water discharge during critical low-flow periods.

This memorandum provides the results of a study designed to gain a better understanding of the interaction of surface water and groundwater by measuring the vertical hydraulic gradient at monitoring locations in Chumstick and Mission Creeks during low-flow conditions during August to November 2008.

METHODS

Piezometer Installation

Vertical hydraulic gradients were measured by installing ¾-inch-diameter Solinst® Model 615 stainless-steel piezometers at selected monitoring locations within the Chumstick Creek subwatershed (Figure 1) and Mission Creek subwatershed (Figure 2). Each piezometer was driven into the creek bed using a fence post driver to a depth of approximately 5 feet. Station locations and the depth range of the screened portion of the piezometers are provided in Tables 1 and 2.

Piezometer installations were completed in accordance with the project Quality Assurance Project Plan (AMEC, 2008). All piezometer installations occurred under the supervision of a Washington State licensed well driller.

Piezometers were allowed to equilibrate for approximately a week following installation. Following this interval the piezometers were purged and temperature, specific conductivity, and dissolved oxygen were measured in the piezometer and overlying creek water using a Model 85 YSI water quality meter. Because it is not possible to install a standard surface seal for the piezometer beneath the water surface, there is a potential for direct hydraulic communication between surface water and the piezometer intake due to annular leakage along the outside wall of the piezometer. Substantial differences of piezometer and surface water quality parameters results were used as evidence that minimal hydraulic communication was occurring.

Vertical Hydraulic Gradient

A manometer board (Figure 3) was constructed to measure head gradients in the stream and water levels in the piezometers (Winter et al., 1988). The difference in water levels between the mini-piezometers and the surface water body provides an indication of vertical flow direction. If river stage is higher than water elevation in the piezometer, flow is downward through the streambed in the immediate vicinity of the piezometer. Alternatively, if river stage is lower than water elevation in the piezometer, groundwater flow is upward through the streambed and the stream is gaining in the area immediately surrounding the piezometer.

Vertical hydraulic gradients were calculated using

$$i = \frac{dh}{dl},$$

where i is the vertical hydraulic gradient (ft/ft), dh is the difference between water height in the mini-piezometer and river stage (ft), and dl is the vertical distance (ft) between the streambed and the center of the mini-piezometer perforations (Simonds and Sinclair, 2002). Following standard conventions, negative values indicate losing gradients while positive values indicate gaining gradients.

RESULTS

Piezometer and Creek Water Quality Comparisons

The comparison of water quality parameters in piezometers and overlying creek water in the Chumstick Creek subwatershed is shown in Table 3. The water quality data for the Chumstick Creek subwatershed shows that the piezometers were successfully installed with evidence that piezometers represent groundwater conditions and there is minimal mixing with surface water. This interpretation was based on the following observations:

- Water temperature at the creek monitoring locations was consistently colder than piezometer water temperatures by 1.2 to 7.4°C.
- Dissolved oxygen concentration in the creek was consistently higher than in the piezometers by 0.7 to 4.2 milligrams per liter (mg/L).
- With one exception (Chumstick Creek below Eagle Creek), specific conductivity was lower in creek water than in the piezometers. Specific conductivity was similar in the creek and piezometer at two sites (Chumstick Creek below Spromberg and Chumstick Creek below Sunitsch Canyon); specific conductivity at all other sites differed by relative percent differences that exceeded 10 percent.

The comparison of water quality parameters in piezometers and overlying creek water in the Mission Creek subwatershed is shown in Table 4. The water parameters measured at two sites (Mission Creek above Yaksum Creek and Mission Creek above Tripp Creek) show only small differences between the creek and piezometer water. This suggests that the data collected from these piezometers does not reflect groundwater conditions. Comparisons of water quality at the other Mission Creek subwatershed monitoring locations show differences that suggest that piezometers were successfully installed. This interpretation is based on the following observations:

- Water temperature at the creek monitoring locations was consistently colder than piezometer water temperatures by 0.7 to 1.5°C.
- Dissolved oxygen concentration in the creek was consistently higher than in the piezometers by 1.2 to 4.1 mg/L.
- Specific conductivity was not measured at all sites because the minimum volume necessary to submerge the meter probe was not obtained during the purging of the piezometers. Piezometer conductivities at locations where this parameter could be measured were higher than creek water.

Vertical Hydraulic Gradients

Chumstick Creek Subwatershed

Measurements of hydraulic gradients were attempted at Chumstick Creek subwatershed monitoring sites on the following dates:

- August 27, 2008
- September 10, 2008
- October 7, 2008
- November 18, 2008

Six locations were monitored in Chumstick Creek and two locations were monitored in Eagle Creek, a tributary to Chumstick Creek. The manometer board readings and calculated vertical hydraulic gradients are shown in Table 5. Vertical hydraulic gradient values varied by an order of magnitude between locations, with the highest positive and negative values occurring in the lower portion of Chumstick Creek above the confluence with Eagle Creek (Figure 1, Site CC4). Sites with negative gradients (losing stream reach) throughout the monitoring period were located in the middle portion of Chumstick Creek (Figure 1, Sites CC6 and CC7) and the farthest upstream site in Eagle Creek (Figure 1, Site EC3). Sites with positive gradients (gaining stream reach) throughout the monitoring period were located at the farthest upstream site in Chumstick Creek (Figure 1, Site CC10), in the middle portion of Chumstick Creek (Figure 1, Site CC5), and downstream from the two losing gradient stations (Figure 1, Sites CC6 and CC7). The direction of groundwater flow varied with monitoring date at the other sites within Chumstick and Eagle creeks.

Mission Creek Subwatershed

Measurements of hydraulic gradients were attempted at Mission Creek subwatershed monitoring sites on the following dates:

- September 3-4, 2008
- October 8-9, 2008

Seven locations were monitored in Mission Creek. The manometer board readings and calculated vertical hydraulic gradients are shown in Table 6. Vertical hydraulic gradient values varied by an order of magnitude between locations, with the highest negative gradients occurring in the middle Mission Creek below the confluence with Sand Creek (Figure 2, Site MC5). Negative gradients (suggesting a losing reach of the creek) occurred throughout the monitoring period at all Mission Creek sites except the two sites that were identified above as possibly being unsuccessful installation sites due to the similarity of water quality parameters in creek and piezometer water.

DISCUSSION

Direct exchanges of water in Chumstick Creek and Mission Creek and groundwater can occur in three ways. The creeks can gain water from groundwater inflow through their streambed, they can lose water through their streambed to groundwater, or they may do either in different locations or at different times (Winter et al., 1988). Monitoring within the Chumstick Creek subwatershed identified areas that show all three types of interactions between creek water and groundwater. Within the Mission Creek subwatershed all monitoring sites, with successful piezometer installations, were losing creek water to groundwater during the September to October 2008 period of monitoring.

The piezometer study was intended to obtain additional information on the interaction between creek water flow and groundwater. A limitation of the study is that the monitoring period covered is a relatively short period of time during one water year. Additional data collection will be required to develop a more comprehensive understanding of interactions between surface water and groundwater in these creeks.

Sincerely yours,
AMEC Geomatrix, Inc.



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Attachments:
Tables 1 to 6
Figures 1 to 3



Lee Duncan, Chelan County Natural Resource Department
February 13, 2009
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REFERENCES

- AMEC (AMEC Geomatrix, Inc.), 2008, Quality Assurance Project Plan – Groundwater-Surface Water Interactions along Chumstick Creek and Mission Creek in WRIA 45, Chelan County, Washington: Chelan County Natural Resources Department, Wenatchee, Washington.
- Geomatrix (Geomatrix Consultants, Inc.), 2007a, Current Water Use Characterization and Monitoring Needs, Chumstick Creek Subwatershed, Wenatchee Watershed Water Resource Technical Assistance, Chelan County, Washington: Chelan County Natural Resources Department, Wenatchee, Washington.
- Geomatrix, 2007b, Current Water Use Characterization and Monitoring Needs, Mission Creek Subwatershed, Wenatchee Watershed Water Resource Technical Assistance, Chelan County, Washington: Chelan County Natural Resources Department, Wenatchee, Washington.
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- Winter, T.C., LaBaugh, J.W., and Rosenberry, D.O., 1988, The design and use of a hydraulic potentiometer for direct measurement of differences in hydraulic head between groundwater and surface water: *Limnology and Oceanography*, v. 33, p. 1209-1214.
- WWPU (Wenatchee Watershed Planning Unit), 2006, Final Wenatchee Watershed Management Plan: Chelan County Natural Resource Department, Wenatchee, Washington.

TABLES

TABLE 1
PIEZOMETER LOCATIONS IN THE CHUMSTICK CREEK SUBWATERSHED
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

Station		Well Tag ID	Install Date	Coordinates ¹		Development Date	Screen Depth Below Creek Bed (ft)
Name	ID			N	E		
Chumstick Ck below Eagle Ck	CC-1	BAE656	8/28/08	227740	1686467	9/5/08	3.90 to 4.68
Chumstick Ck above Eagle Ck	CC-4	BAE655	8/28/08	228874	1686998	9/5/08	3.90 to 4.68
Chumstick Ck below Spromberg	CC-5	BAE663	8/20/08	232913	1686457	9/5/08	3.90 to 4.68
Chumstick Ck above Spromberg	CC-6	BAE668	8/20/08	235232	1686448	9/5/08	3.90 to 4.68
Chumstick Ck below Sunitsch Ck	CC-7	BAE667	8/20/08	242129	1687626	9/5/08	3.90 to 4.68
Chumstick Ck above Sunitsch Canyon	CC-8	BAE664	8/20/08	253093	1688282	9/5/08	3.90 to 4.68
Chumstick Ck above Little Chumstick	CC-10	BAE652	8/28/08	261538	1689870	9/5/08	3.90 to 4.68
Eagle Ck above Bjork Canyon	EC-2	BAE653	8/28/08	233659	1701532	9/5/08	3.90 to 4.68
Eagle Ck below Van Ck	EC-3	BAE654	8/28/08	239146	1710746	9/5/08	3.90 to 4.68

Note(s)

1. Washington State Plane NAD83

TABLE 2
PIEZOMETER LOCATIONS IN THE MISSION CREEK SUBWATERSHED
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

Station		Well Tag ID	Install Date	Coordinates ¹		Development Date	Screen Depth Below Creek Bed (ft)
Name	ID			N	E		
Mission Ck below Yaksum Ck	MC-1	BAE665	8/19/08	183130	1728541	8/28/08	3.28 to 4.06
Mission Ck above Yaksum Ck	MC-2	BAE666	8/19/08	180886	1728474	8/28/08	3.90 to 4.68
Mission Ck below Tripp Ck	MC-3	BAE662	8/19/08	178972	1727402	8/28/08	3.90 to 4.68
Mission Ck above Tripp Ck	MC-4	BAE661	8/19/08	177937	1726896	8/28/08	2.60 to 3.38
Mission Ck above Sand Ck	MC-5	BAE659	8/19/08	155024	1720790	8/29/08	2.03 to 2.81
Mission Ck below Sand Ck	MC-6	BAE660	8/19/08	157912	1721688	8/29/08	3.90 to 4.68
Mission Ck below Crow Canyon	MC-7	BAE658	8/19/08	145157	1722745	8/29/08	3.36 to 4.14
East fork of Mission Ck above Crow Canyon	MC-8	BAE657	8/19/08	143461	1723578	8/29/08	3.90 to 4.68

Note(s)

1. Washington State Plane NAD83

TABLE 3
CHUMSTICK CREEK – COMPARISON OF WATER QUALITY DATA IN PIEZOMETER AND CREEK
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

Station		Well Tag ID	Install Date	Coordinates ¹		Development Date	Piezometer Data			Creek Data		
Name	ID			N	E		Temp (°C)	Spec. Cond. (uS/cm)	DO (mg/L)	Temp (°C)	Spec. Cond. (uS/cm)	DO (mg/L)
Chumstick Ck below Eagle Ck	CC-1	BAE656	8/28/08	227740	1686467	9/5/08	No water in creek or piezometer					
Chumstick Ck above Eagle Ck	CC-4	BAE655	8/28/08	228874	1686998	9/5/08	No water in creek or piezometer					
Chumstick Ck below Spromberg	CC-5	BAE663	8/20/08	232913	1686457	9/5/08	19.6	230	6.7	12.2	228	9.56
Chumstick Ck above Spromberg	CC-6	BAE668	8/20/08	235232	1686448	9/5/08	16.3	265	6.79	12.4	240	8.05
Chumstick Ck below Sunitsch Ck	CC-7	BAE667	8/20/08	242129	1687626	9/5/08	15.7	245	6.89	14.1	244	8.13
Chumstick Ck above Sunitsch Canyon	CC-8	BAE664	8/20/08	253093	1688282	9/5/08	14.1	283	6.62	12.9	242	7.44
Chumstick Ck above Little Chumstick	CC-10	BAE652	8/28/08	261538	1689870	9/5/08	14.9	271	7.4	12.6	243	8.1
Eagle Ck above Bjork Canyon	EC-2	BAE653	8/28/08	233659	1701532	9/5/08	14.5	240	6.5	9.9	345.7	10.7
Eagle Ck below Van Ck	EC-3	BAE654	8/28/08	239146	1710746	9/5/08	18.8	589	5.46	11.8	456	8.41

Note(s)

1. Washington State Plane NAD83

TABLE 4
MISSION CREEK – COMPARISON OF WATER QUALITY DATA IN PIEZOMETER AND CREEK
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

Station		Well Tag ID	Install Date	Coordinates ¹		Development Date	Piezometer Data			Creek Data		
Name	ID			N	E		Temp (°C)	Spec. Cond. (uS/cm)	DO (mg/L)	Temp (°C)	Spec. Cond. (uS/cm)	DO (mg/L)
Mission Ck below Yaksum Ck	MC-1	BAE665	8/19/08	183130	1728541	8/28/08	16.4	148.3	6.33	15.3	132.9	9.74
Mission Ck above Yaksum Ck	MC-2	BAE666	8/19/08	180886	1728474	8/28/08	15.5	427.8	7.93	15.1	405.4	4.17
Mission Ck below Tripp Ck	MC-3	BAE662	8/19/08	178972	1727402	8/28/08	No water in creek or piezometer					
Mission Ck above Tripp Ck	MC-4	BAE661	8/19/08	177937	1726896	8/28/08	17.6	285.4	7.86	17.7	282.9	8.59
Mission Ck above Sand Ck	MC-5	BAE659	8/19/08	155024	1720790	8/29/08	14.7	180.9	5.9	13.8	172.3	9.95
Mission Ck below Sand Ck	MC-6	BAE660	8/19/08	157912	1721688	8/29/08	17.3	NA	8.62	14.3	194.3	9.82
Mission Ck below Crow Canyon	MC-7	BAE658	8/19/08	145157	1722745	8/29/08	13.1	166.6	8.18	12.4	164.1	10.16
East fork of Mission Ck above Crow Canyon	MC-8	BAE657	8/19/08	143461	1723578	8/29/08	12.5	291.7	7.99	11	NA	10.64

Note(s)

1. Washington State Plane NAD83

Abbreviation(s)

NA – Not available

TABLE 5
HYDRAULIC GRADIENT DATA FOR THE CHUMSTICK CREEK SUBWATERSHED
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

Station		Date	Manometer Reading (cm)		Height Difference (cm)	Streambed to Middle of Screen (ft)	Vertical Gradient (ft/ft)	Gradient Type
Name	ID		Stream	Piezometer				
Chumstick Ck below Eagle Ck	CC-1	9/10/08	Creek dry					
		10/7/08	Creek dry					
		11/18/08	NA	NA				
Chumstick Ck above Eagle Ck	CC-4	8/27/08	Creek dry					
		9/10/08	Creek dry					
		10/16/08	79.3	8.3	-71	4.29	-0.543	Losing
		11/13/08	29.5	67.8	38.3	4.29	0.293	Gaining
Chumstick Ck below Spromberg	CC-5	8/27/08	NA	NA		4.29		
		9/10/08	93.8	97.2	3.4	4.29	0.026	Gaining
		10/7/08	80.1	83.9	3.8	4.29	0.029	Gaining
		11/18/08	Piezometer destroyed					
Chumstick Ck above Spromberg	CC-6	8/27/08	NA	NA		4.29		
		9/10/08	91.7	87.7	-4.0	4.29	-0.031	Losing
		10/7/08	58.6	54.7	-3.9	4.29	-0.030	Losing
		11/18/08	53.8	52.4	-1.4	4.29	-0.011	Losing
Chumstick Ck below Sunitsch Ck	CC-7	8/27/08	NA	NA		4.29		
		9/10/08	79.3	75.9	-3.4	4.29	-0.026	Losing
		10/7/08	78.6	75.1	-3.5	4.29	-0.027	Losing
		11/18/08	51.1	49.5	-1.6	4.29	-0.012	Losing
Chumstick Ck above Sunitsch Canyon	CC-8	8/27/08	NA	NA		4.29		
		9/10/08	82.8	85.7	2.9	4.29	0.022	Gaining
		10/7/08	85.1	80.5	-4.6	4.29	-0.035	Losing
		11/18/08	47.2	49.8	2.6	4.29	0.020	Gaining

TABLE 5
HYDRAULIC GRADIENT DATA FOR THE CHUMSTICK CREEK SUBWATERSHED
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

Station		Date	Manometer Reading (cm)		Height Difference (cm)	Streambed to Middle of Screen (ft)	Vertical Gradient (ft/ft)	Gradient Type
Name	ID		Stream	Piezometer				
Chumstick Ck above Little Chumstick	CC-10	8/27/08	NA	NA		4.29		
		9/10/08	47.4	52.6	5.2	4.29	0.040	Gaining
		10/7/08	71	73.2	2.2	4.29	0.017	Gaining
		11/18/08	59.8	63.4	3.6	4.29	0.028	Gaining
Eagle Ck above Bjork Canyon	EC-2	8/27/08	NA	NA				
		9/10/08	83.9	98.3	14.4	4.29	0.110	Gaining
		10/7/08	74.7	91.2	16.5	4.29	0.126	Gaining
		11/13/08	58.3	43	-15.3	4.29	-0.117	Losing
Eagle Ck below Van Ck	EC-3	8/27/08	NA	NA		4.29		
		9/10/08	88.8	70	-18.8	4.29	-0.144	Losing
		10/7/08	88	72.8	-15.2	4.29	-0.116	Losing
		11/13/08	11.6	3.3	-8.3	4.29	-0.063	Losing

TABLE 6
HYDRAULIC GRADIENT DATA FOR THE MISSION CREEK SUBWATERSHED
 Groundwater–Surface Water Interactions
 along Chumstick Creek and Mission Creek in WRIA 45
 Chelan County, Washington

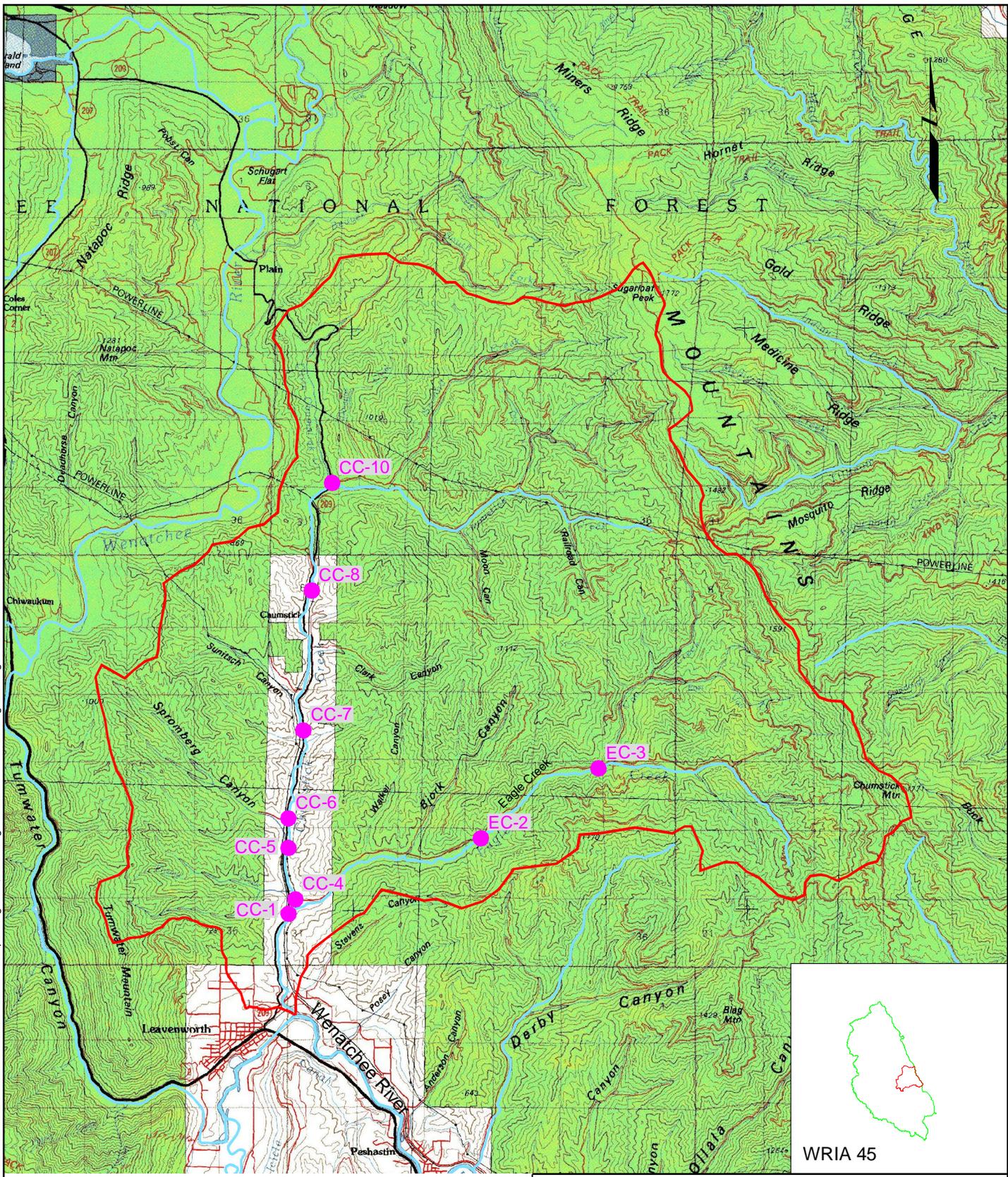
Station		Date	Manometer Reading (cm)		Height Difference (cm)	Streambed to Middle of Screen (ft)	Vertical Gradient (ft/ft)	Gradient Type
Name	ID		Stream	Piezometer				
Mission Ck below Yaksum Ck	MC-1	9/4/08	81.8	56.3	-25.5	3.67	-0.228	Losing
		10/9/08	84.2	49.4	-34.8	3.67	-0.311	Losing
Mission Ck above Yaksum Ck	MC-2	10/9/08	68.3	72.1	3.8	4.29	0.029	Gaining
Mission Ck below Tripp Ck	MC-3	10/9/08	NA	NA		4.29		
Mission Ck above Tripp Ck	MC-4	10/9/08	72	72.1	0.1	2.99	0.001	Gaining
Mission Ck above Sand Ck	MC-5	9/3/08	104.4	83.3	-21.1	2.42	-0.286	Losing
		10/8/08	99.1	70.8	-28.3	2.42	-0.384	Losing
Mission Ck below Sand Ck	MC-6	9/3/08	87.1	77	-10.1	4.29	-0.077	Losing
		10/8/08	78.2	68.6	-9.6	4.29	-0.073	Losing
Mission Ck below Crow Canyon	MC-7	9/3/08	98.5	68.4	-30.1	3.75	-0.263	Losing
		10/8/08	82.3	50.6	-31.7	3.75	-0.277	Losing
East fork of Mission Ck above Crow Canyon	MC-8	9/3/08	103.5	102.5	-1.0	4.29	-0.008	Losing
		10/8/08	65.5	64.7	-0.8	4.29	-0.006	Losing

Abbreviation(s)

NA – Not available

FIGURES

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- Piezometer Location
- Chumstick Creek Subwatershed

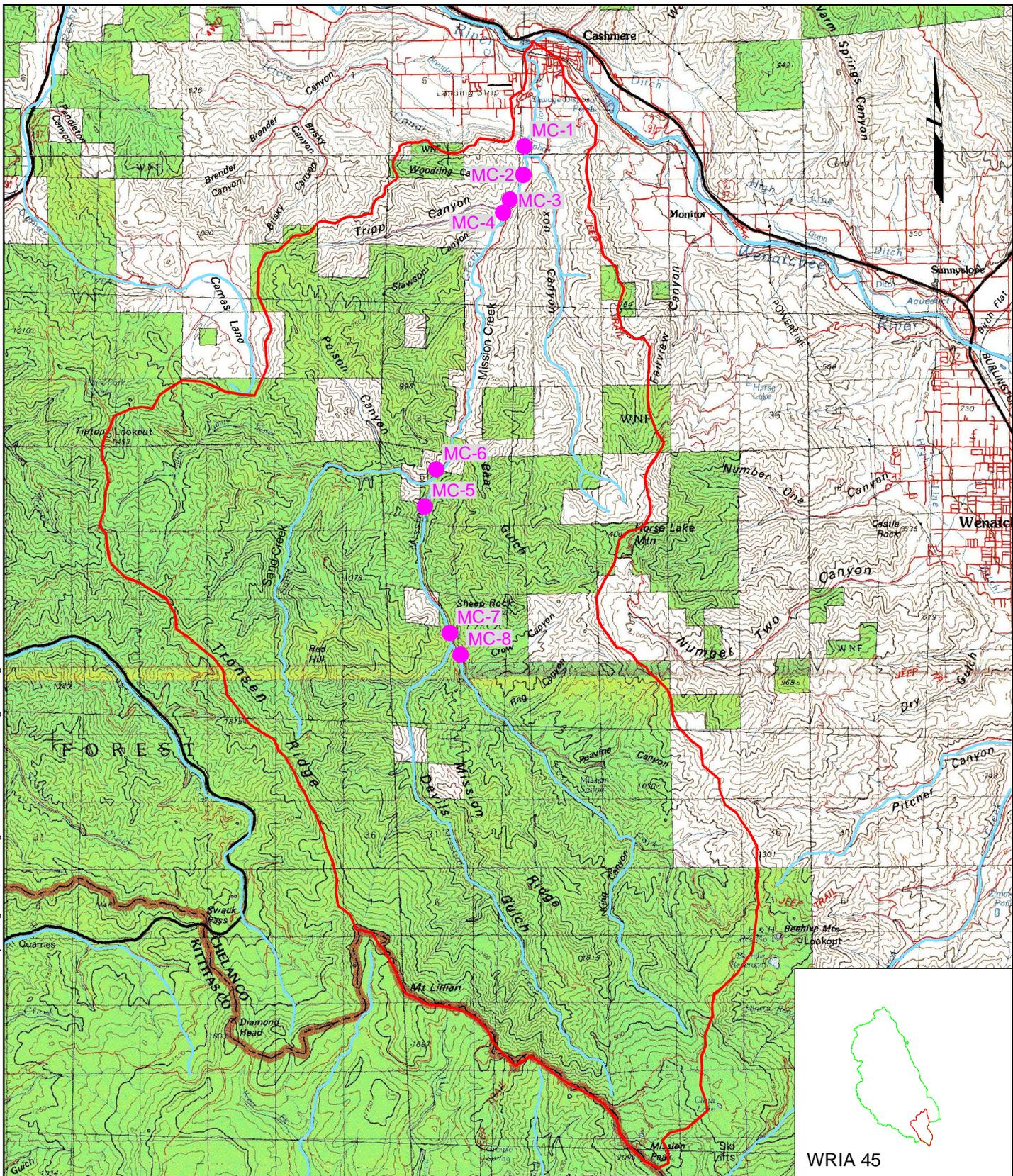


PIEZOMETER LOCATIONS
 Chumstick Creek Subwatershed
 Wenatchee Watershed Water Resource
 Technical Assistance
 Chelan County, Washington

By: GSM	Date: 2/12/2009	Project No. 12817.001
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AMEC Geomatrix	Figure 1
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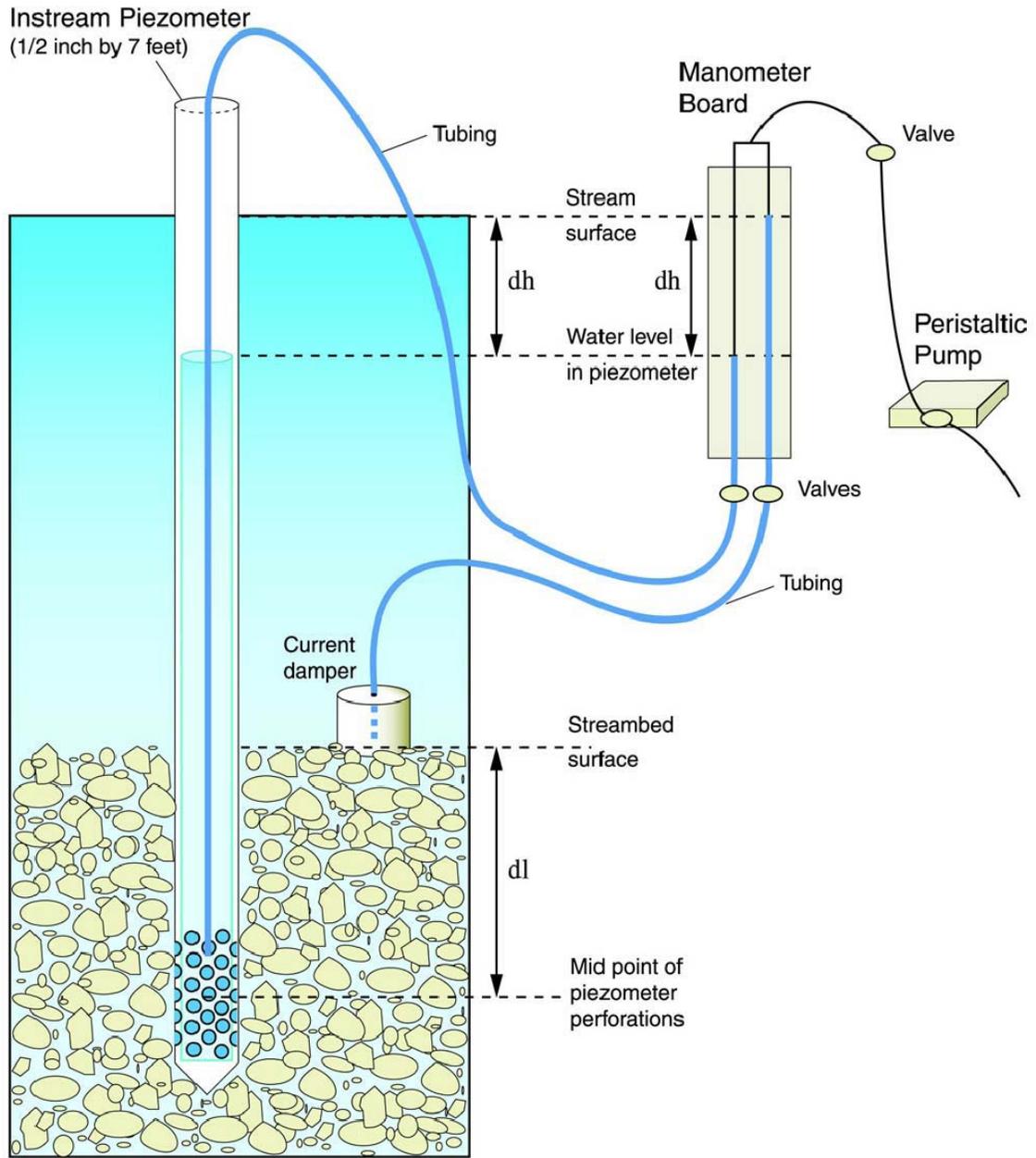
- Piezometer Location
- Mission Creek Subwatershed



PIEZOMETER LOCATIONS
 Mission Creek Subwatershed
 Wenatchee Watershed Water Resource
 Technical Assistance
 Chelan County, Washington

By: GSM	Date: 2/12/2009	Project No. 12817.001
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AMEC Geomatrix	Figure 2
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Notes:

1. Diagram from Simonds and Sinclair (2002)
2. Diagram Not to Scale

MANOMETER BOARD MEASUREMENT DESIGN
 Wenatchee Watershed Water Resource
 Technical Assistance
 Chelan County, Washington

By: APS	Date: 07/10/08	Project No. 12817.000
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AMEC Geomatrix

Figure **3**