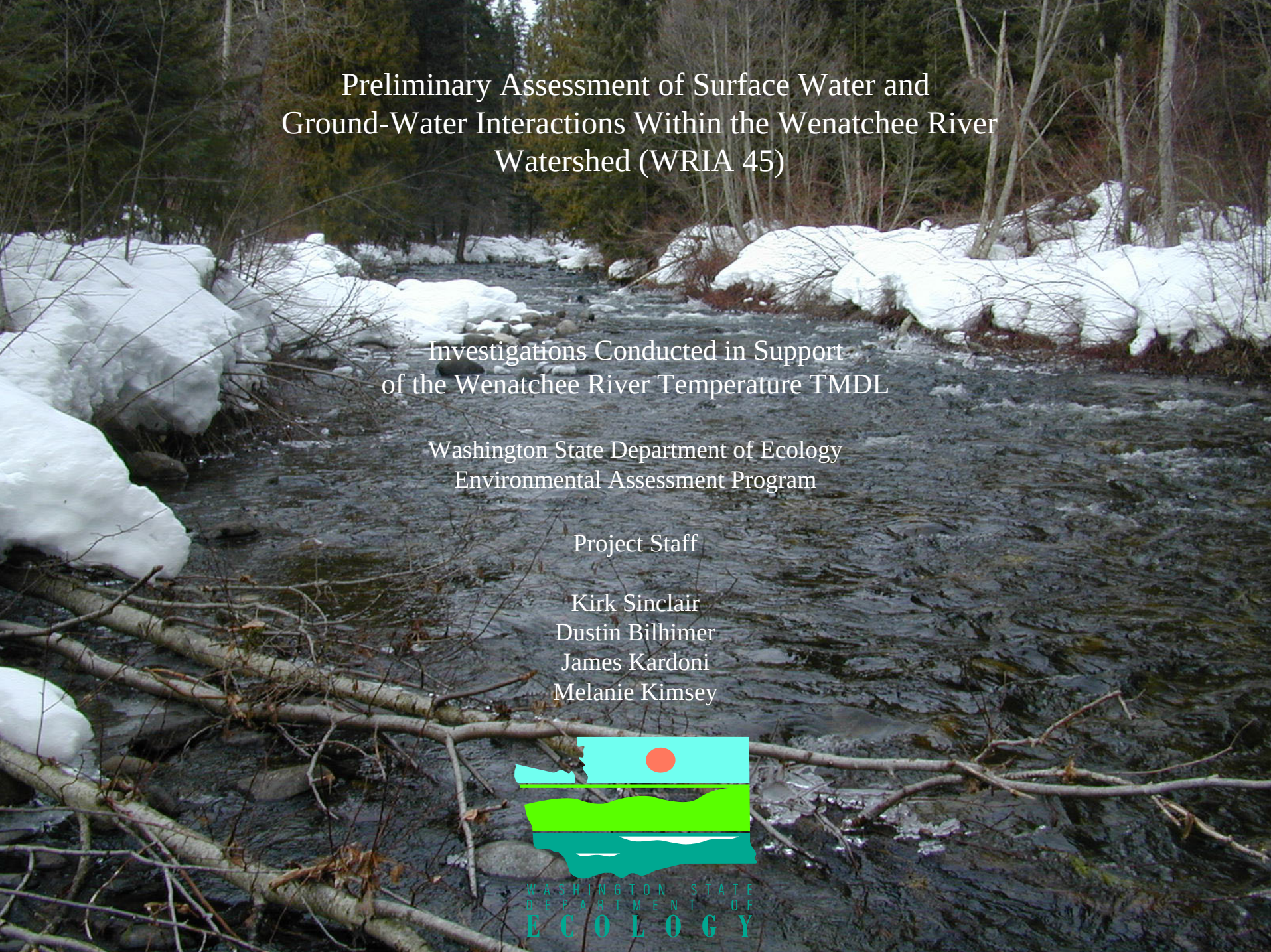

Preliminary Assessment of Surface Water and Ground-Water Interactions Within the Wenatchee River Watershed (WRIA 45)

Investigations Conducted in Support
of the Wenatchee River Temperature TMDL

Washington State Department of Ecology
Environmental Assessment Program

Project Staff

Kirk Sinclair
Dustin Bilhimer
James Kardoni
Melanie Kimsey

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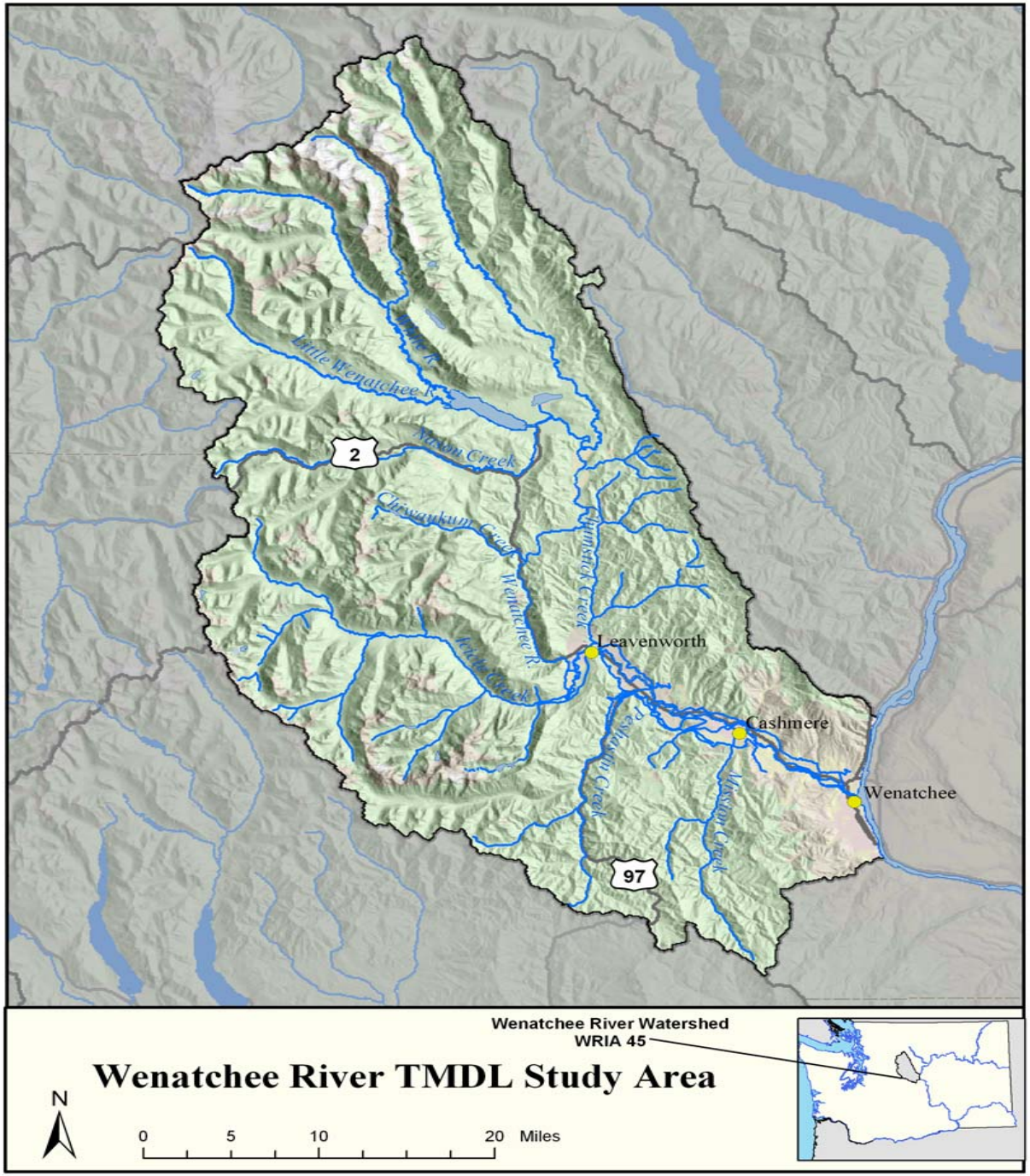
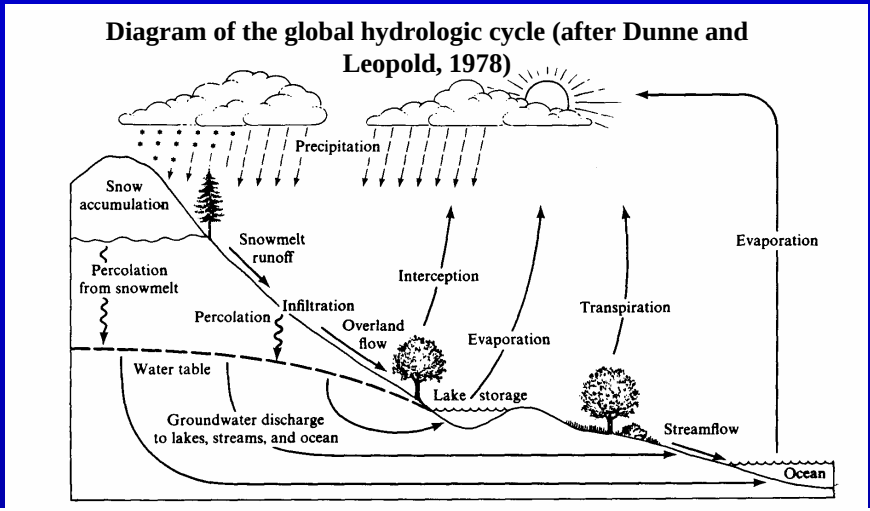

Wenatchee River Watershed
WRIA 45
Wenatchee River TMDL Study Area
N
0
5
10
20 Miles
Little Wenatchee R.
White R.
Nason Creek
Chiwawakum Creek
Wenatchee R.
Icicle Creek
Chumstick Creek
Peshastin Creek
Mission Creek
Leavenworth
Cashmere
Wenatchee
2
97

Temperature TMDL - Model Data Requirements

		MODEL		Collection By		
	PARAMETER	HeatSource	Qual2K			Ecology
Flow	discharge - tributary		x			x
	discharge (upstream & downstream)		x			x
	flow regression constants		x			
	flow velocity		x			x
	groundwater inflow rate/discharge		x			x
	travel time		x			
General	calendar day/date	x	x	All Data Collected Primarly from USGS or GIS Maps		
	duration of simulation	x	x			
	elevation - downstrean	x	x			
	elevation - upstream	x	x			
	elevation/altitude	x	x			
	latitude	x	x			
	longitude	x	x			
	time zone	x				
Physical	channel azimuth/stream aspect	x				
	cross-sectional area	x	x			x
	Manning's n value	x	x			
	percent bedrock	x				
	reach length	x				
	stream bank slope	x				
	stream bed slope	x				
	width - bankfull	x				
	width - stream	x				
Temperature	temperature - ground					
	temperature - groundwater					
	temperature - water downstream					
	temperatures - water upstream					
	temperature - air					
	thermal gradient					
Vegetation	% forest cover on each side	x				
	canopy-shading coefficient/veg density	x				
	diameter of shade-tree crowns	x				
	distance to shading vegetation	x				
	topographic shade angle	x				
	vegetation height	x				
	vegetation shade angle	x				
	vegetation width	x				
Weather	relative humidity					
	% possible sun/cloud cover					
	solar radiation					
	temperature - air					
	wind speed/velocity					



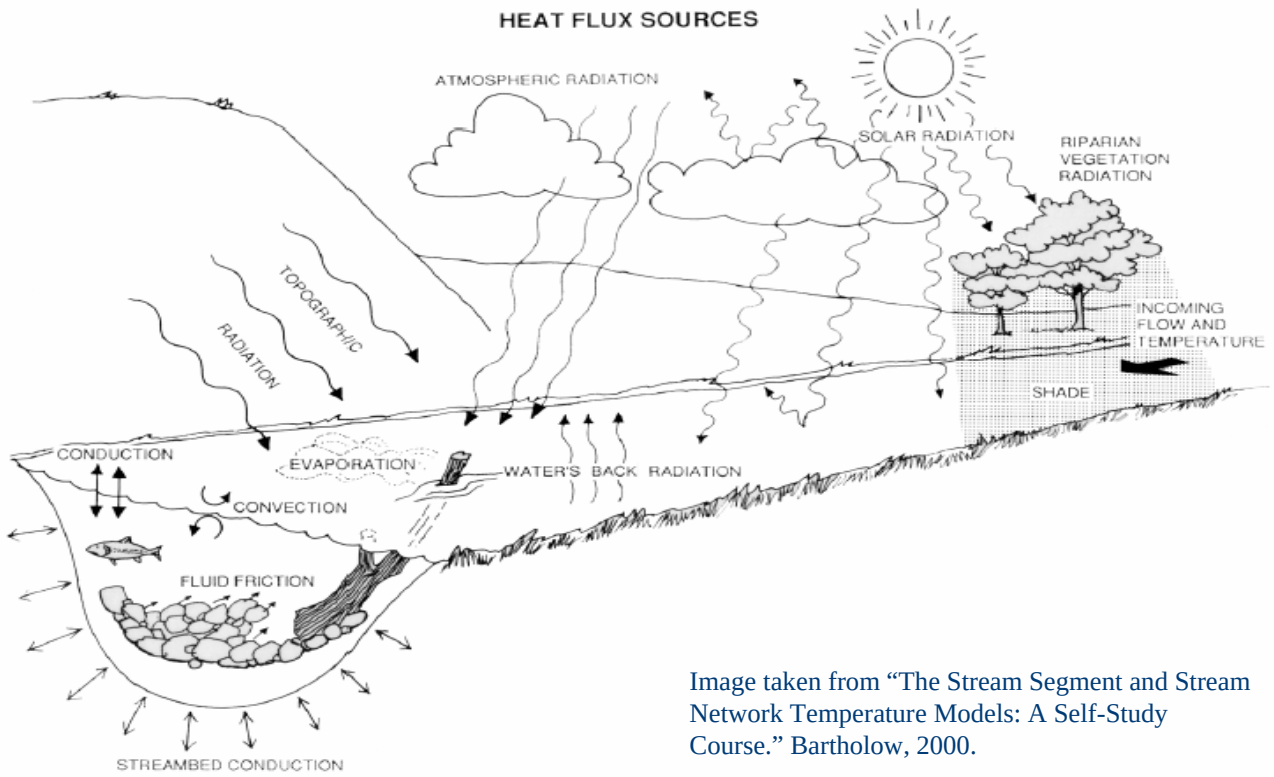
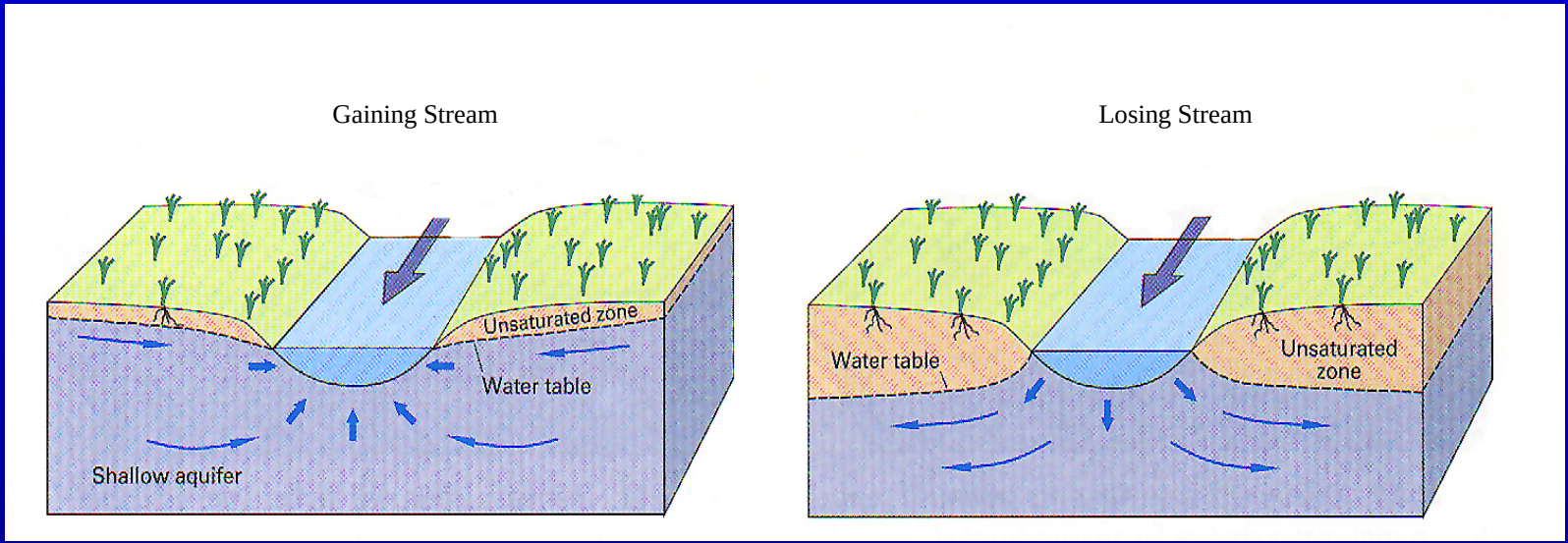
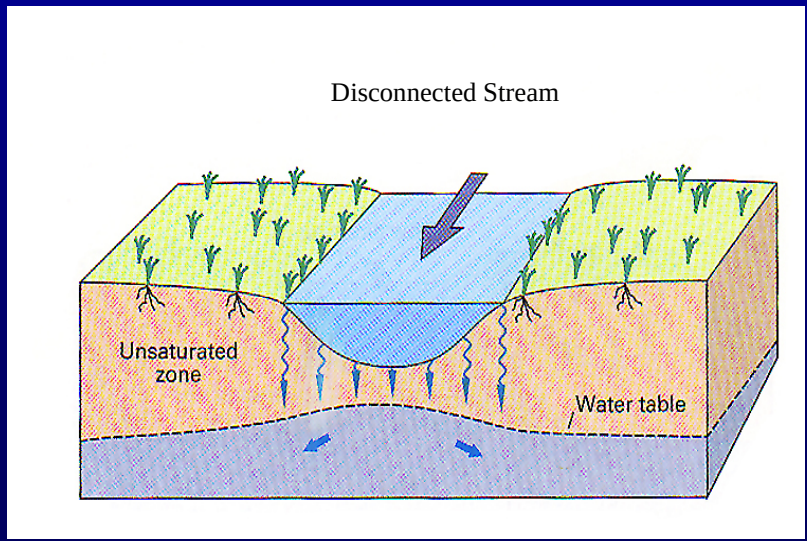


Image taken from "The Stream Segment and Stream Network Temperature Models: A Self-Study Course." Bartholow, 2000.

Schematic depiction of stream and ground-water interchange within gaining, losing, and disconnected stream reaches (after Winter, 1998)





Study Objectives

- To evaluate and describe the timing, volume, and distribution of surface water and groundwater interchange for selected stream reaches within the Wenatchee River watershed.
- To provide a better understanding of the regional hydrogeologic framework within which this interaction occurs.
- To characterize the temperature and chemical quality of the ground water that naturally discharges to area streams.

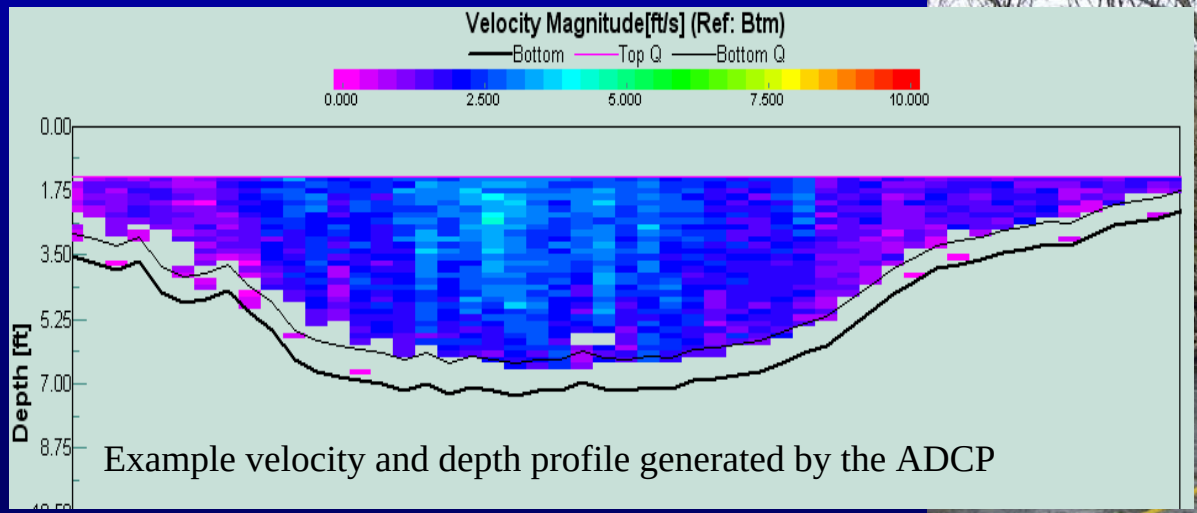
Study Approach

- **Refine our understanding of the study area hydrogeology -** to develop a better understanding of regional/local groundwater movement within the Wenatchee watershed.
- **Conduct stream seepage surveys -** to verify gaining and losing reaches and to determine reach specific magnitudes of groundwater/surface water exchange.
- **Conduct in-stream piezometer surveys -** to define in-stream hydraulic gradients and groundwater temperatures/water quality at specific points within the watershed.

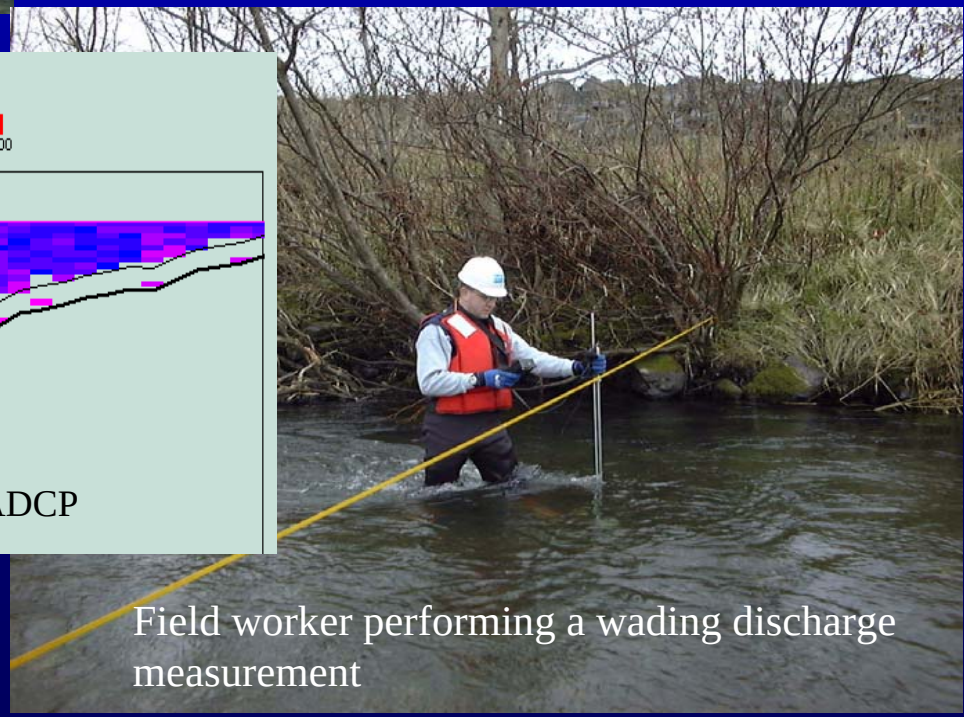
Seepage-run surveys

Seepage studies were conducted along each of the study area streams during base-flow conditions in order to estimate the net volume of water exchanged between area streams and groundwater within discrete stream reaches.

Setting up the acoustic Doppler current profiler (ADCP) to measure discharge of the Wenatchee River.



Example velocity and depth profile generated by the ADCP

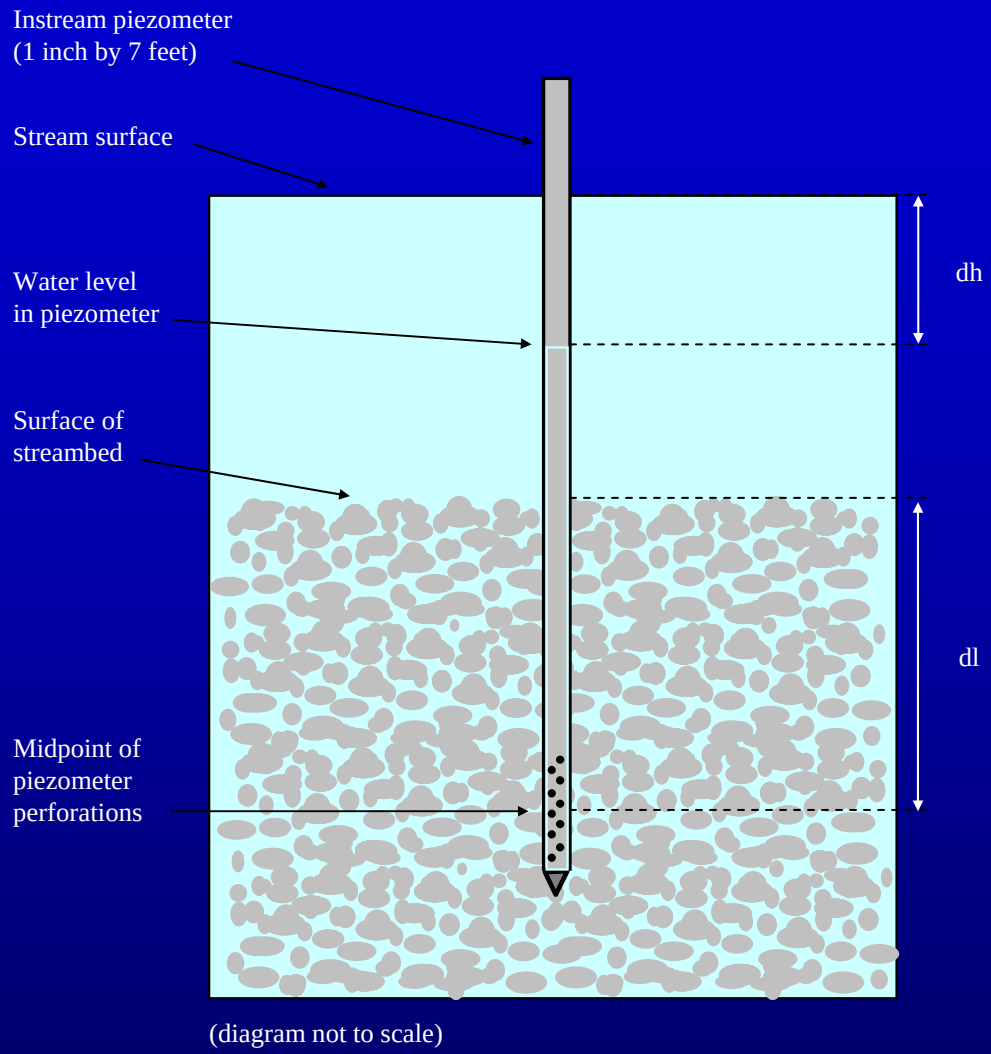


Field worker performing a wading discharge measurement

Study Approach

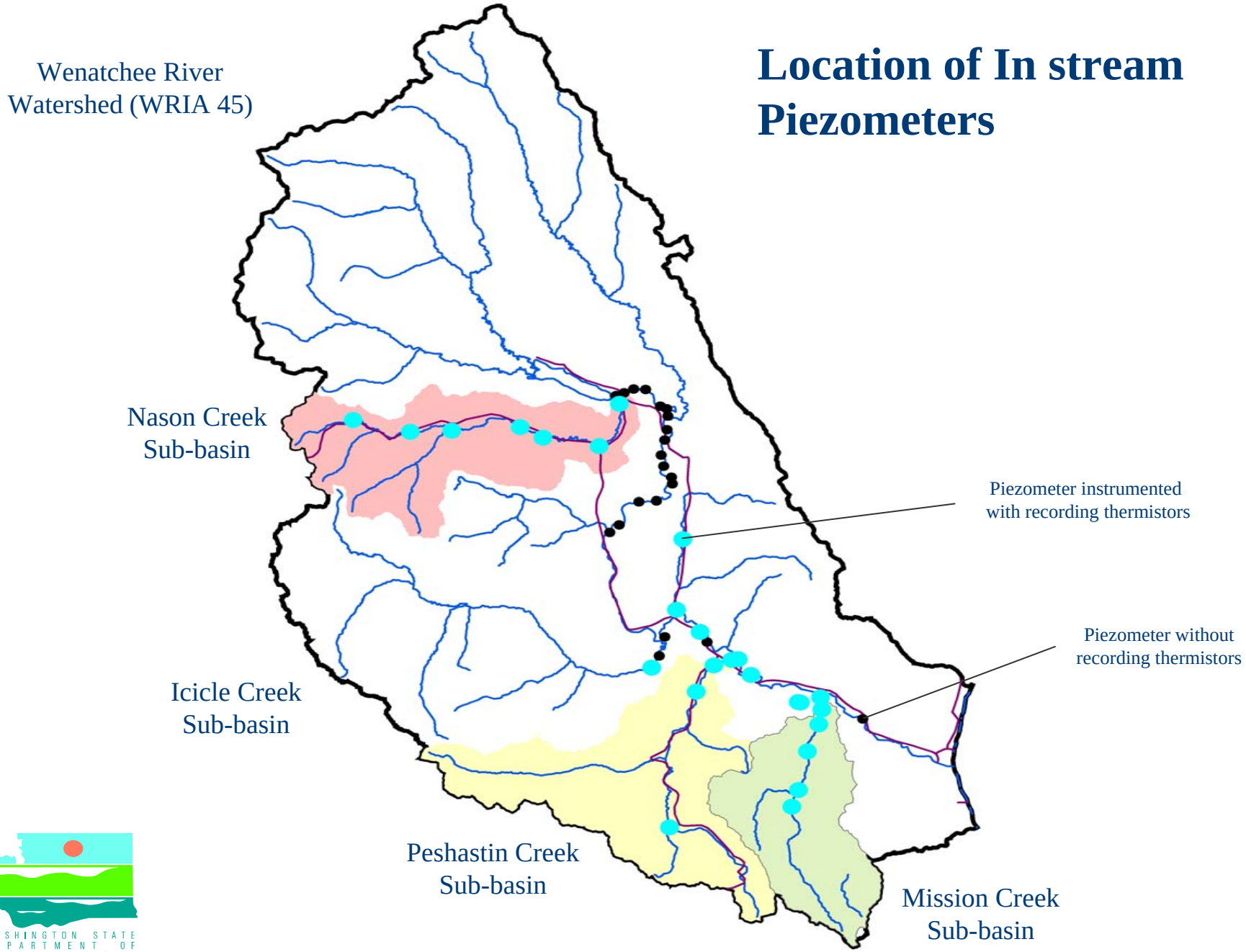
In stream Piezometer Surveys

Instream wells (piezometers) were installed at 54 sites along the main stem Wenatchee River and selected tributaries. The piezometers were monitored monthly over a period of 12 to 18 months to define hydraulic gradient
relationships between area streams and groundwater



Schematic of a typical instream piezometer

Location of In stream Piezometers



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In-stream Piezometer Installation, Development, and Sampling

Installing a piezometer

Piezometer development

Sampling a piezometer

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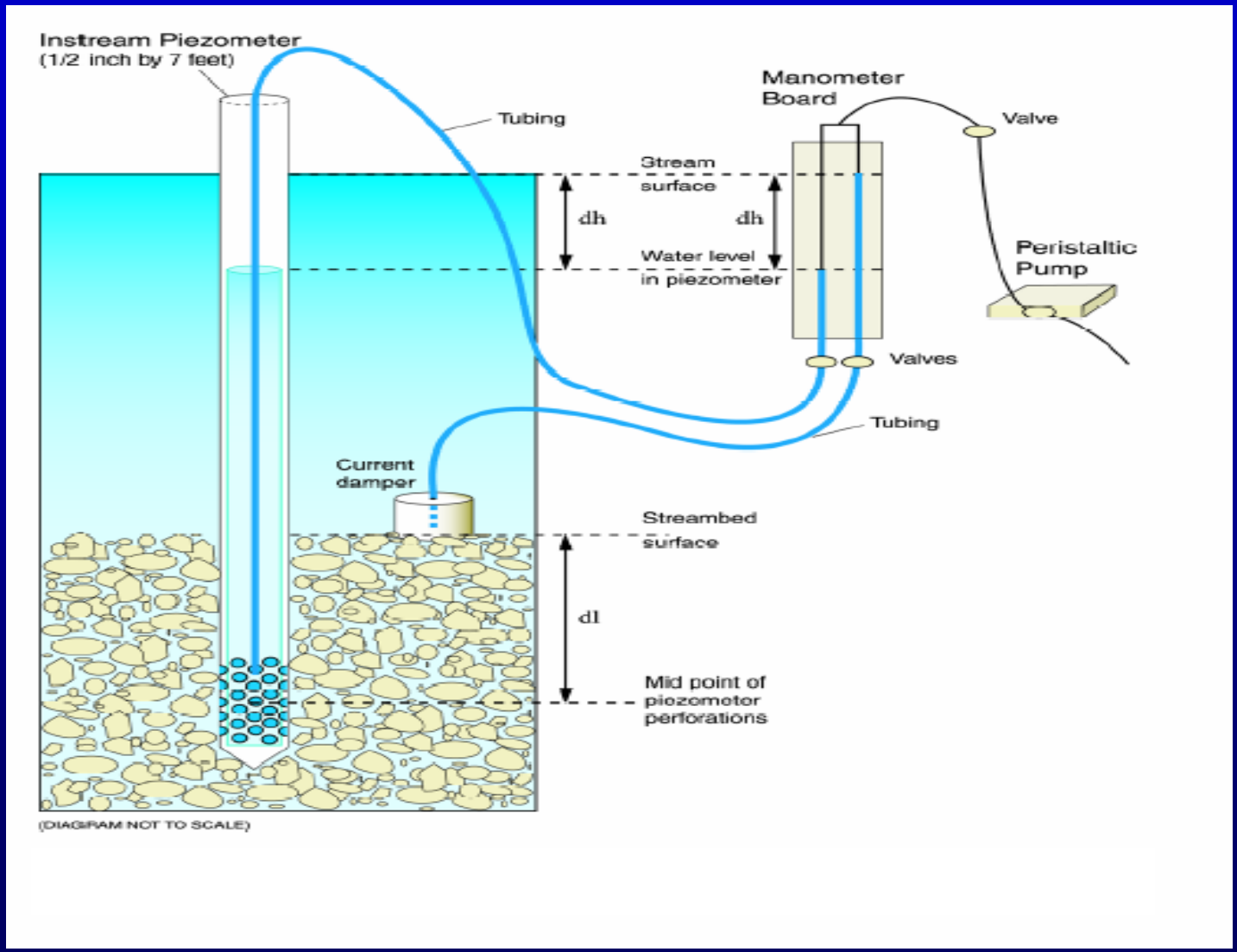
Installing Temperature data-loggers

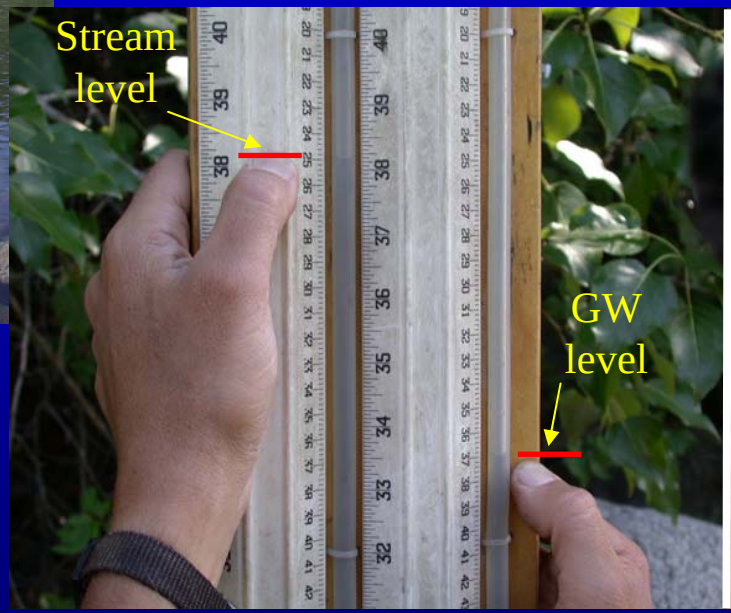
In 2003 recording thermistors were installed at three different depths within selected piezometers. The thermistors were used to measure and record water temperatures at 30 minute intervals throughout the summer.

Schematic showing how a manometer board was used to measure the in-stream hydraulic gradient (dh/dl) at piezometer sites

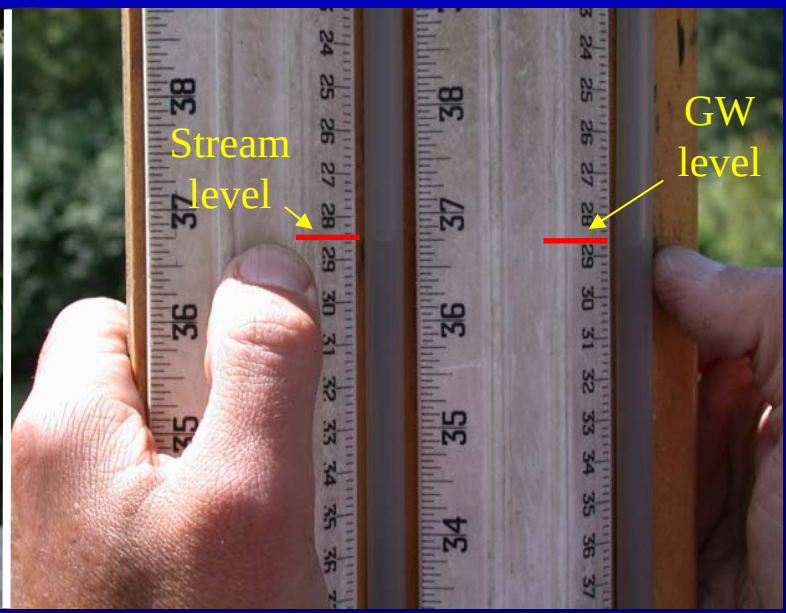


Using a manometer board to measure hydraulic heads

Close-up of Manometer board

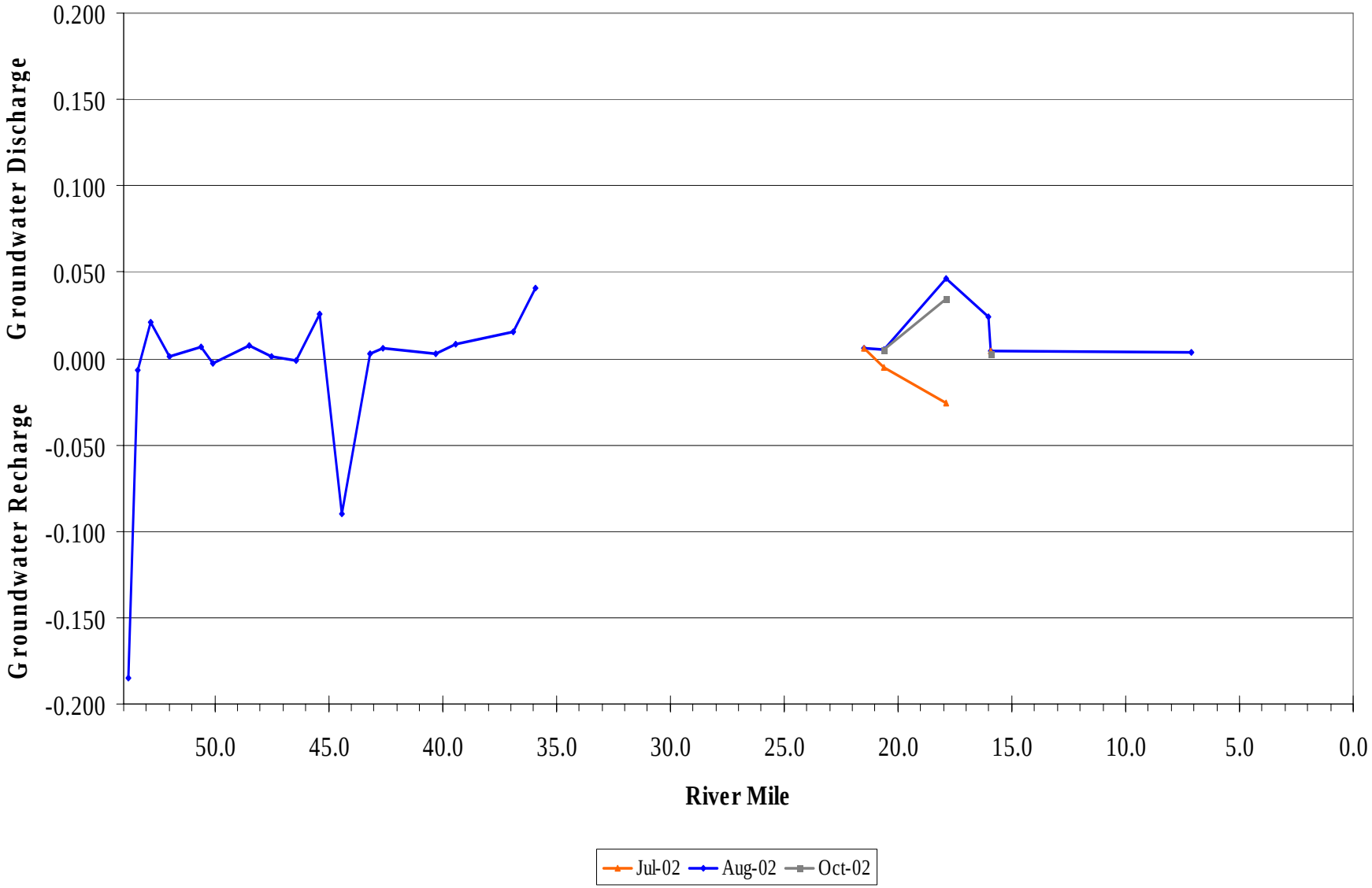


In this example the stream level (head) is greater than the GW level, indicating that surface water is recharging groundwater at this location.

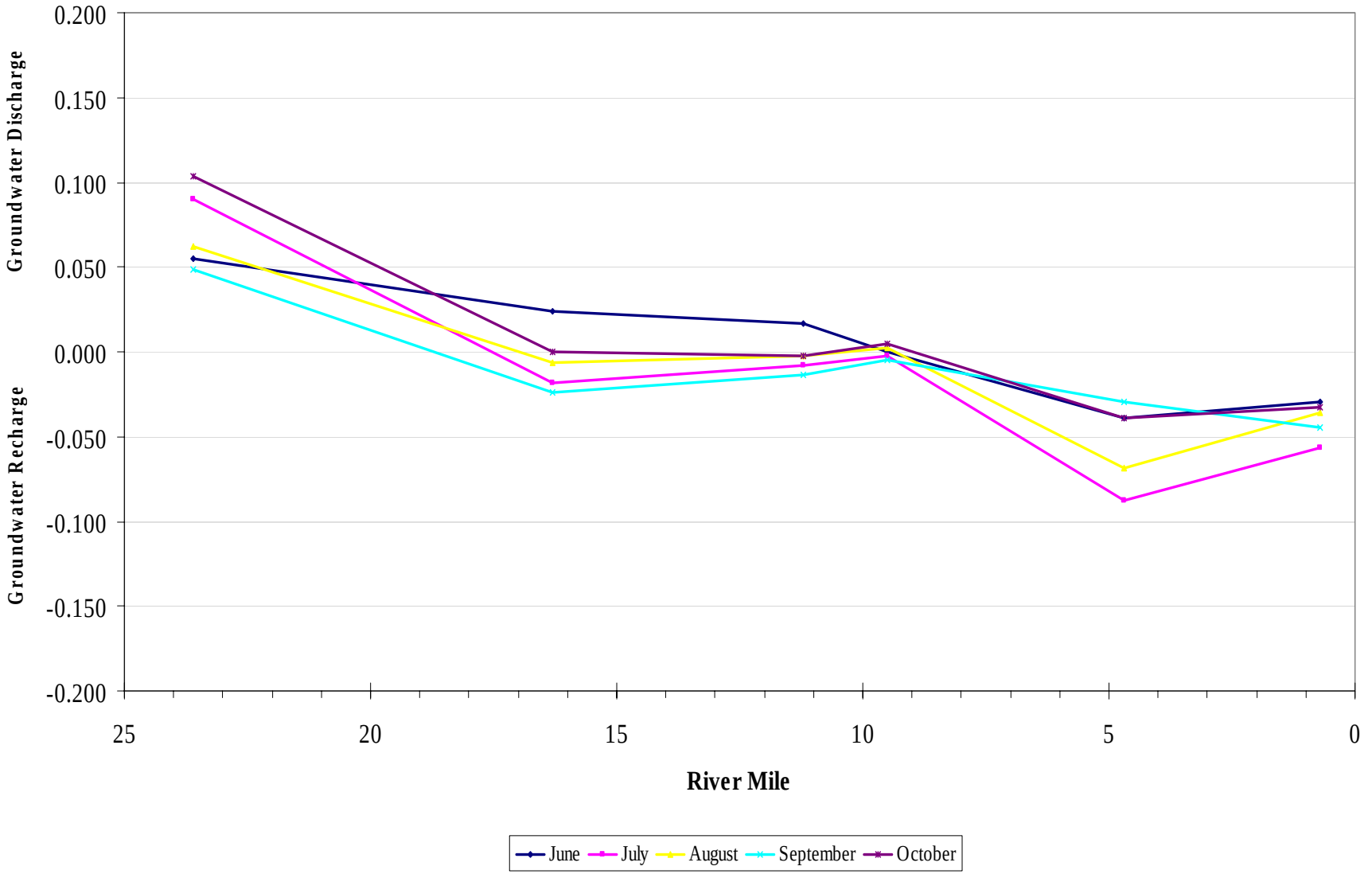


In this example the stream and ground water levels (heads) are similar, which suggests that little exchange occurs between SW and GW at this location.

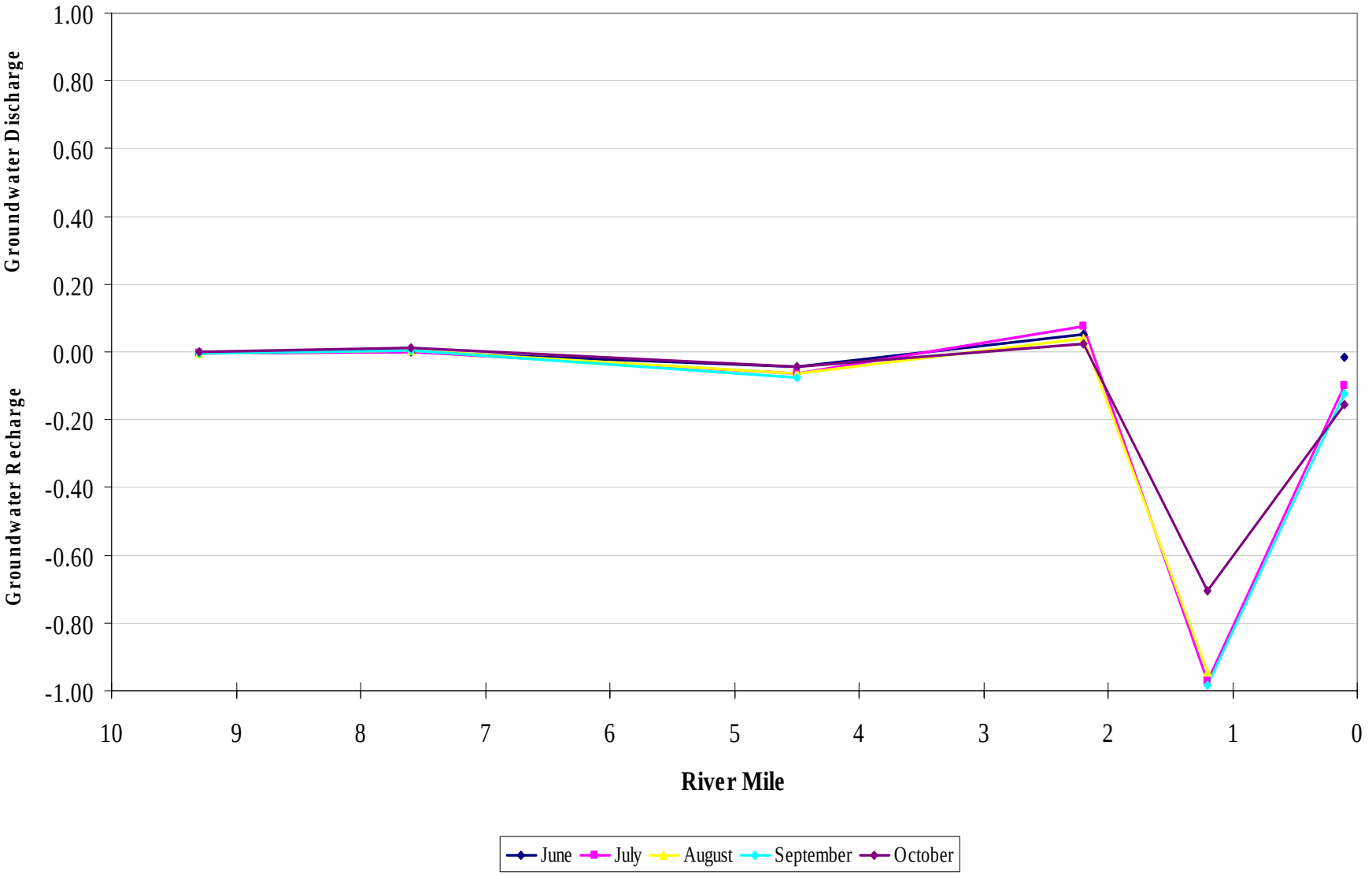
Vertical Hydraulic Gradient Between the Mainstem Wenatchee River and Near-Surface Groundwater at Monitored Instream Piezometer Sites, Aug-Oct 2002



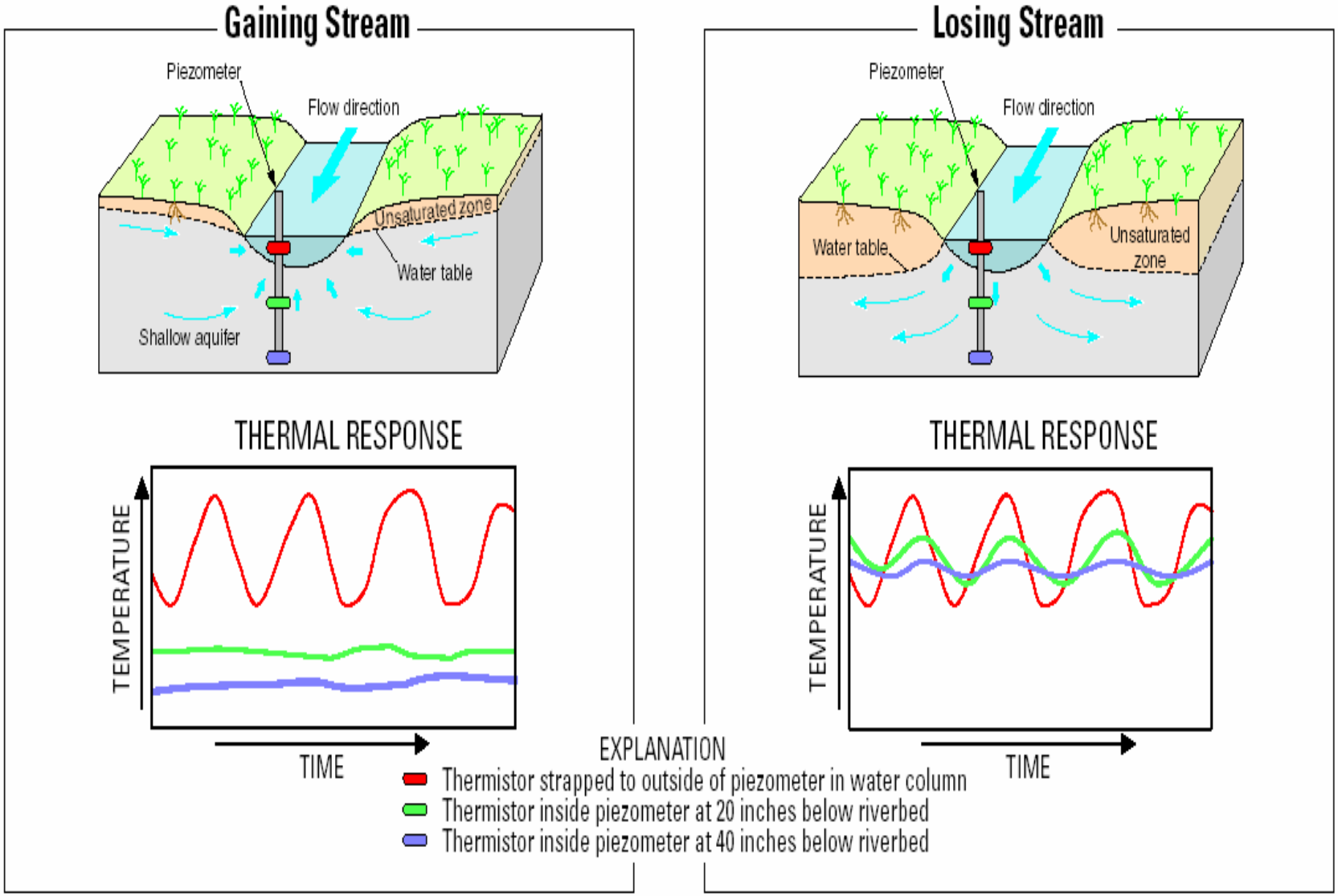
Vertical Hydraulic Gradient Between Nason Creek and Near-Surface Groundwater at Monitored Instream Piezometer Sites, June-Oct 2003



Vertical Hydraulic Gradient Between Mission Creek and Near-Surface Groundwater at Instream Piezometer Sites, June-Oct 2003

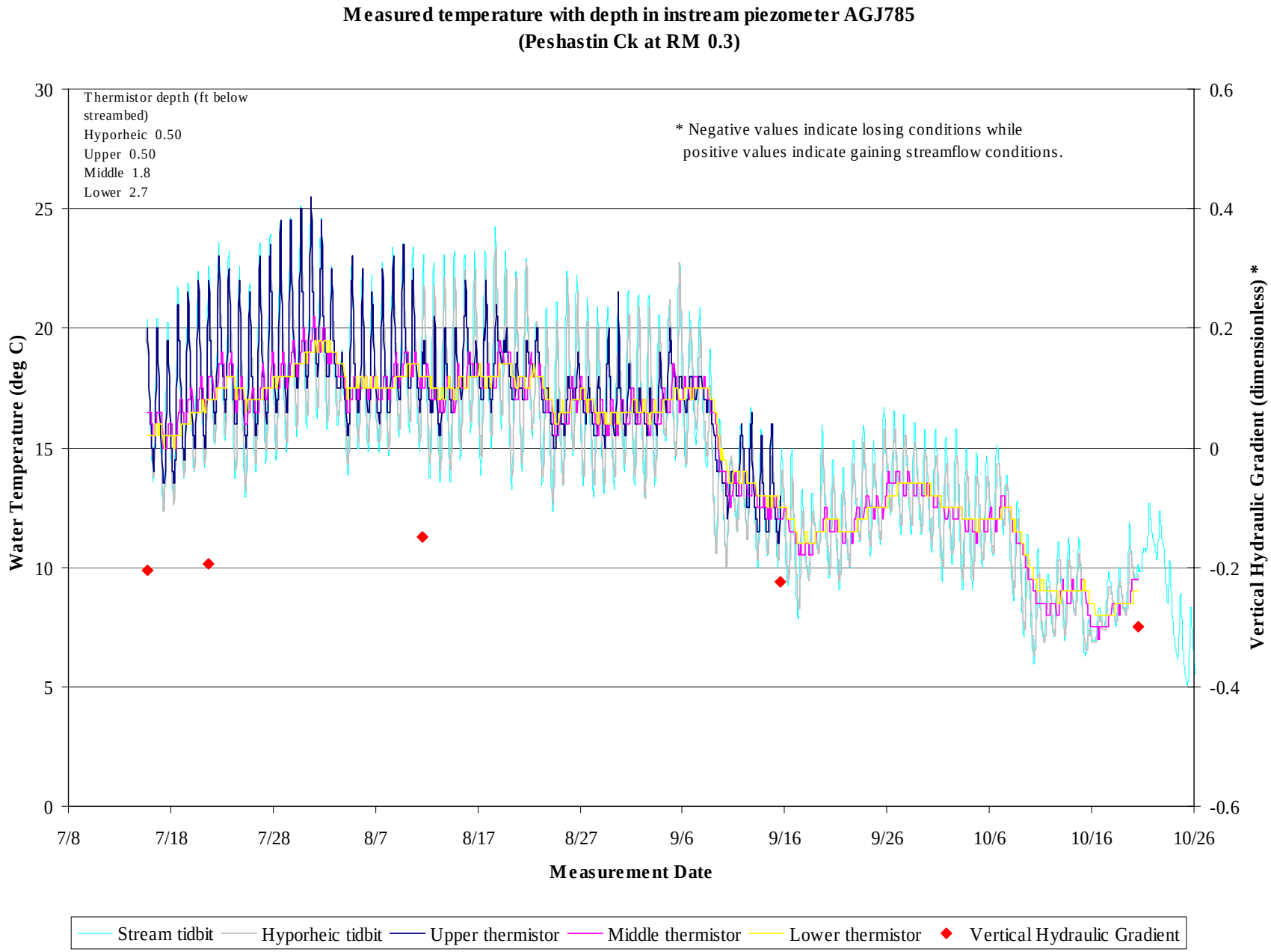


Conceptual surface- and ground-water relations and thermal response for representative gaining reaches and losing reaches

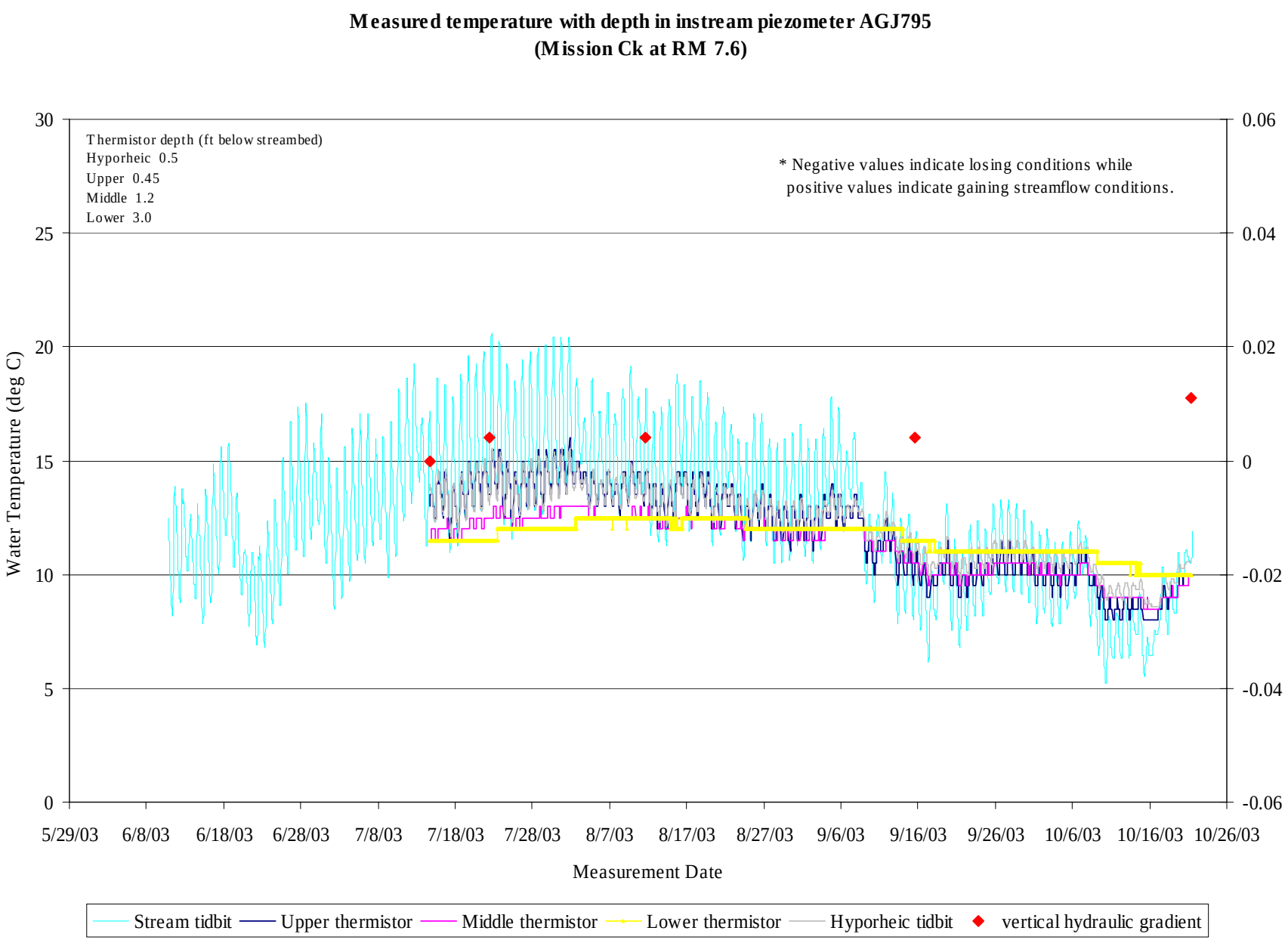


After Simonds, et al 2003

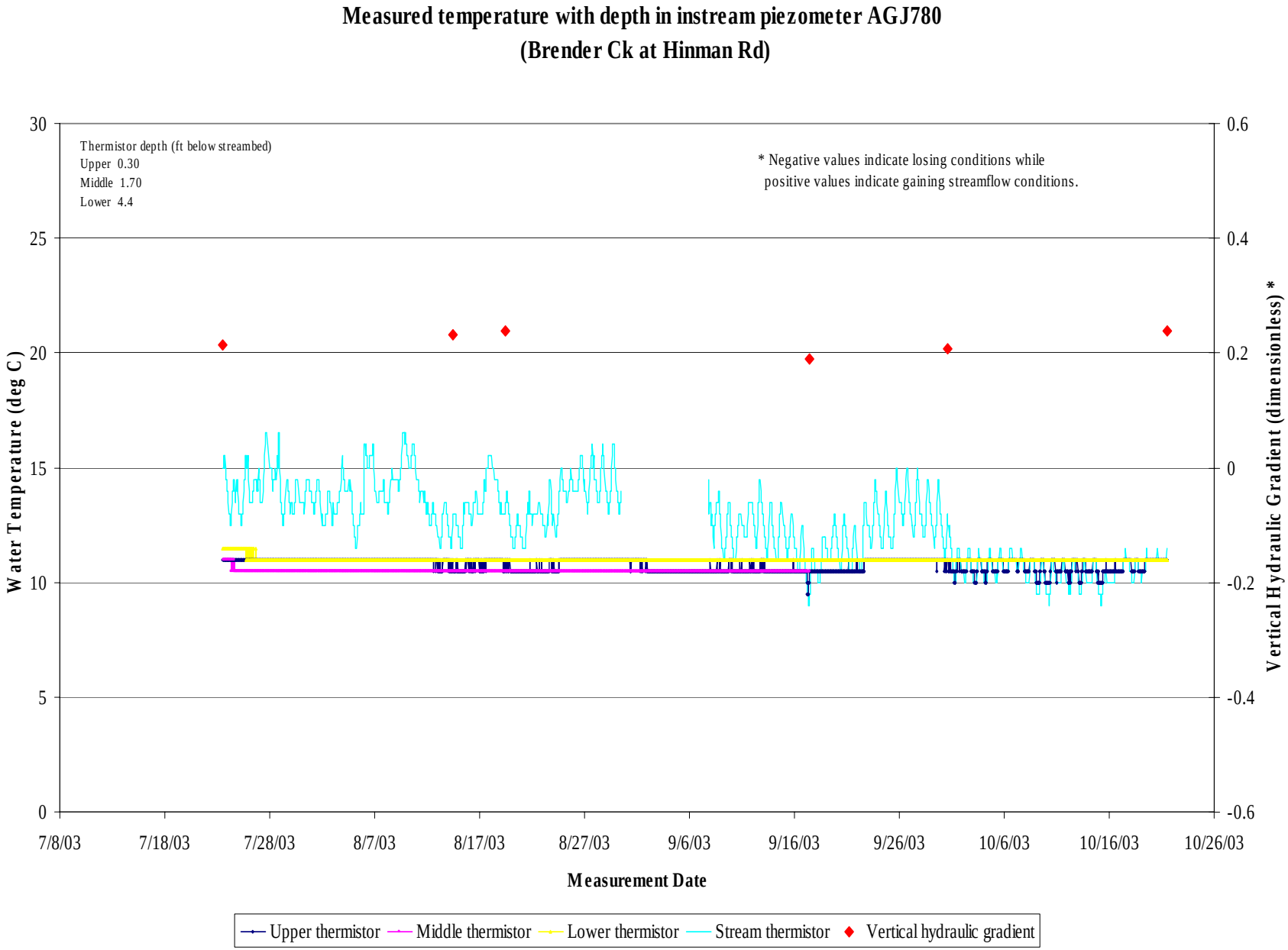
Thermal response for a “strongly losing” stream reach



Thermal response for a “moderately gaining” stream reach



Thermal response for a “strongly gaining” stream reach



In Summary

- The Wenatchee River exhibits interspersed gaining and losing stream reaches throughout it's length.
- Some piezometers showed significant seasonal variability in hydraulic gradients with a few sites transitioning between gaining and losing conditions and vice versa.
- Stream seepage assessments in combination with in-stream piezometer and thermistor "nests" provide a robust and economical method for assessing and quantifying stream aquifer interactions.

Project Resources and References

Wenatchee TMDL Quality Assurance Plans

Year 1: http://www.ecy.wa.gov/biblio/0203069.html

Year 2: http://www.ecy.wa.gov/biblio/0303106.html

Access to Project Data

Ecology's Environmental Information Management System:
http://www.ecy.wa.gov/services/as/iip/eim/

Useful Reference

Heat as a tool for studying the movement of ground water near streams,
USGS circular 1260: http://pubs.water.usgs.gov/circ1260/

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