

## Appendix D. Estimation of Pumping

Of the 19 high-capacity irrigation wells pumped during 2006 (fig. 14), 14 wells were equipped with flow meters, and pumping was estimated for the remaining 5 wells (see Pumping of Groundwater). These data and agricultural records were examined to estimate pumping at each well for 1966–2006 (fig. 13).

The USGS deployed inline turbine-type flow meters on 12 irrigation wells to measure irrigation water use for the 2006 irrigation season (fig. 14). The irrigation season occurs from April to September. The 12 flow meters, plus 2 owner-installed flow meters, measured an estimated 88 percent of the total irrigation water use (table D1). The 14 measured wells accounted for 74 percent of irrigation wells in the basin. Total measured discharge was 652 acre-ft and for individual wells ranged from 4 to 120 acre-ft with the average being 47 acre-ft. This water was applied to 741 acres, 86 percent of groundwater-irrigated acres in the Mosier basin. The application rate ranged from 0.14 to 1.86 ft/yr, with the average being 0.88 ft/yr.

To estimate 2006 water use for the five wells without an installed flow meter, coefficients were calculated from wells with flow meters (table D1), using the measured water applied, number of acres irrigated, and the type of irrigation system. The coefficients apply to the dominant crop (cherry orchards). The wells to be estimated had only two configurations of irrigation systems: Drip and micro spray used in conjunction or micro spray only. For these two irrigation methods, coefficients were developed:

Drip and micro-spray irrigation used in conjunction = 0.85 ft of water applied/acre.

Micro-spray only = 1.00 ft of water applied/acre.

These coefficients were used to estimate the remaining 12 percent of the total irrigation water use. Estimated well discharges ranged from 5 to 29 acre-ft with the average being 17 acre-ft. Aggregate unmeasured water use for the 2006 irrigation season totaled 86 acre-ft. This water was applied to 118 acres, 14 percent of groundwater-irrigated acres in the Mosier Basin (table D1).

**Table D1.** Irrigation well pumping in the Mosier, Oregon, study area, 2006.

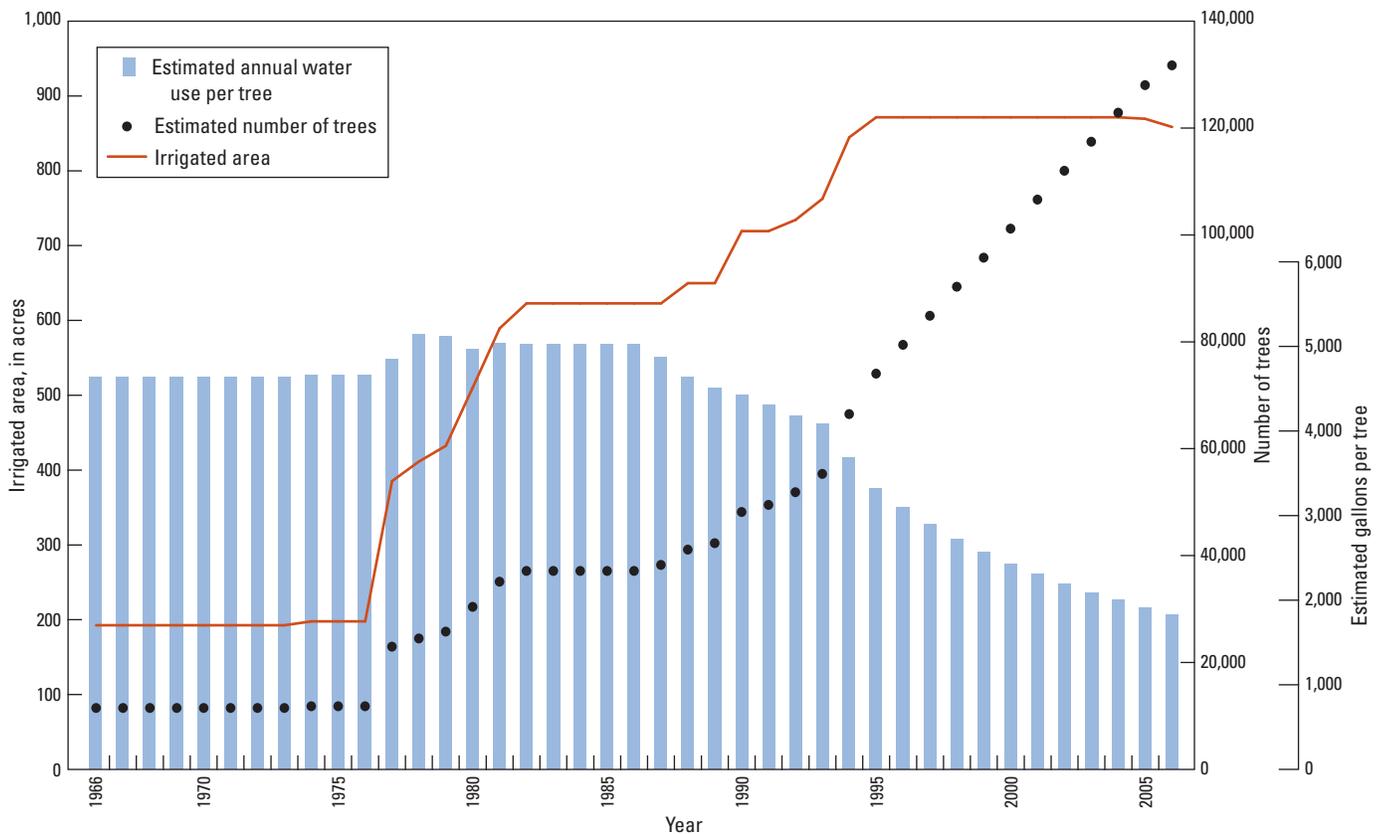
[Alternating shading shows relationship between wells pumped and the associated areas irrigated. **Abbreviations:** USGS, U.S. Geological Survey]

Farm	Site identification No.	Station name	Measurement method	2006 groundwater pumped (acre-feet)	2006 area irrigated on each farm (acres)	2006 application rate by farm (acre-feet per year)
A	454031121224001	02N/11E-12AAD1	Estimated	5.4	5.4	1.00
B	454029121225201	02.00N/11.00E-12ADB01	Owner flowmeter	3.7	27.0	0.14
C	454013121225902	02.00N/11.00E-12DAB02	USGS flowmeter	79.0	79.0	1.00
D	453943121224901	02.00N/11.00E-13AAD01	USGS flowmeter	57.0	82.0	0.70
E	454055121203401	02N/12E-05DCB1	Estimated	17.8	21.0	0.85
F	454057121220301	02.00N/12.00E-06CAD01	Owner flowmeter	12.8	15.0	0.85
A	454052121223301	02.00N/12.00E-06CCB03	Estimated	28.6	33.6	0.85
G	454032121213501	02N/12E-07AAC1	USGS flowmeter	60.6		
	454032121215601	02.00N/12.00E-07BAD01	USGS flowmeter	67.5		
		<b>Farm total:</b>		128.0	134.0	0.96
H	454032121213101	02N/12E-07AAC2	USGS flowmeter	37.2		
	454032121212001	02.00N/12.00E-07AAD01	USGS flowmeter	21.4		
		<b>Farm total:</b>		58.6	78.0	0.75
I	454020121211901	02.00N/12.00E-07ADD01	USGS flowmeter	14.2	27.0	0.53
J	454020121223401	02N/12E-07BCC1	USGS flowmeter	35.5	60.0	0.59
K	454011121223901	02.00N/12.00E-07CBB01	Estimated	17.0	40.8	0.42
L	454008121215101	02.00N/12.00E-07DBC01	USGS flowmeter	46.0	24.7	1.86
M	454004121211801	02.00N/12.00E-07DDA01	USGS flowmeter	53.0	39.4	1.35
K	453949121220301	02N/12E-18BAB1	USGS flowmeter	119.6		
	453942121221501	02N/12E-18BBD1	USGS flowmeter	44.9		
		<b>Farm total:</b>		164.5	174.0	0.95
N	453921121213101	02N/12E-18DAB1	Estimated	17.3	17.3	1.00
		<b>Total:</b>		738.5	858.2	

For 1966–2006, annual irrigation water use was assumed constant for each fully established farm (except for minor fluctuations as reported in owner accounts). Increases in total irrigation pumpage during this period (fig. 13) correspond to the establishment of new farms. This assumption is supported by the water use estimates of Lite and Grondin (1988) and those collected by USGS in 2006. Lite and Grondin determined irrigation water use for 1986 was 570 acre-ft applied to 550 acres, and USGS estimated that for 2006, 566 acre-ft of water was applied to 621 acres on the same farms. The increase in acreage supplied by the nearly equivalent pumpage corresponds to improvements in irrigation and other agricultural practices that have resulted in increased tree density and lower water use per tree (fig. D1). Irrigated acreage for 2006 was estimated using the Oregon Water Resource Department’s Water Rights Information System (WRIS) (Oregon Water Resources Department, 2006), Farm Service Agency Common Land Unit (CLU) GIS maps (data provided by James Bishop, County Executive Director, Farm Service Agency, U.S. Department of Agriculture, written commun., 2006), aerial photography, and owner accounts. The

fraction of acreage irrigated by micro spray, impact sprinkler, and drip irrigation methods was determined from discussions with owners and site visits.

Water use by tree estimates for mature cherry trees in nearby The Dalles, Oregon, are 1,250–2,500 gal per tree per yr for drip irrigation, 4,300 gallons per tree per year for micro spray irrigation, and 6,000 gallons per tree per year for impact sprinkler irrigation (J.P. le Roux, , IRRINET LLC, written commun., 2008). These rates compared favorably with Mosier per tree rates computed by dividing the total estimated irrigation pumping by the estimated total acreage irrigated and the estimated average cherry trees per acre for Wasco County (U.S. Department of Agriculture, 2006). Rates ranged from an average of about 5,000 gallons per tree per year in 1986 to 1,800 gallons per tree per year in 2006, which corresponds to the historical shift from less efficient to more efficient irrigation methods. Because USDA average tree density estimates were only available for 1986, 1993, and 2006, figure D1 was constructed by linearly interpolating tree density between these periods.



**Figure D1.** Irrigated acreage, estimated number of fruit trees, and estimated consumptive use per tree, 1966–2006, in the Mosier, Oregon, study area.

The city of Mosier provided the USGS with meter readings for the primary public-supply well and water-use estimates for the backup public-supply well for 1989–2006. In 2006, the combined pumpage was 90 acre-ft (figs. 13 and 14). Prior to 1989 public-supply water use was estimated by the USGS based on 1989 water use and population.

Self-supplied domestic water use was estimated based on a number of assumptions about the population and per capita water-use behavior. Residences were identified using tax lot data. Additional residences were identified where known locations of self-supplied domestic wells existed. A total of 485 residences were identified. It was assumed that all residences had one self-supplied domestic well. Using the 2000 Census data for Wasco County, the average household was calculated at 2.5 persons (U.S. Census Bureau, 2004). To estimate the water use per capita per day public-supply water use in the city of Mosier was analyzed. Computed water use by city residents was an average of 210 gallons per person per day. City water use tended to be seasonal, using 30 percent of the yearly total from October 15 to April 15 and 70 percent from April 15 to October 15. To calculate self-supplied domestic water use it was assumed that rural residents used water at the same rate as city residents and with the same seasonality. All water use from October 15 to April 15 was assumed to be non-consumptive, returning as groundwater

recharge through septic systems. From April 15 to October 15 it was assumed the same amount (30 percent) was used as in-house use with the balance (40 percent) used consumptively for property irrigation. Defining the coefficient of consumptive use as the percentage of water used consumptively, consumptive water use per well was calculated as:

$$Q = (P)(W)(365 \text{ days})(C), \quad (\text{D.1})$$

where

- P is estimated average household population per residence (2.5 persons),
- W is assumed average water use (210 gallons per person per day), and
- C is coefficient of consumptive groundwater use (40 percent)

During April 15 through October 15, each well was estimated to use 76,650 gal/yr (approximately 0.24 acre-ft). Consumptive water use was assigned to each well for years starting from the date it was drilled. Where no drill date is available, the well was assigned a construction date from the average date of neighboring wells. The aggregate self-supplied domestic water use for 2006 was estimated at 114 acre-ft (fig. 13).