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SEEPAGE TESTS ON NO NAME CREEK, COLVILLE INDIAN RESERVATION, WASHINGTON, MAY 12-13, 1977

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METRIC CONVERSIONS

Multiply	By	To obtain
Feet (ft)	0.3048	meters (m)
Miles	1.609	kilometers (km)
Cubic feet per second (ft^3/s)	.02832	cubic meters per second (m^3/s)
Gallons per minute (gal/min)	3.785	liters per minute (L/min)

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ABSTRACT

To gain information for a water-management situation, a seepage test was performed on May 12-13, 1977, on a reach of No Name Creek on the Colville Indian Reservation in north-central Washington. On May 13 injection of a concentrated brine at the head of the test reach permitted chloride-concentration data to be combined with the discharge measurements made to define the pattern of gain and loss along the reach. Equations describing discharge and chloride mass balance were used to determine this pattern of gain and loss. The seepage tests showed that the streamflow gain of at least 0.58 ft^3/s from springflow contributions was offset by losses of at least 0.59 ft^3/s over the same reach.

INTRODUCTION

In July 1976, the United States District Court for the Eastern District of Washington entered a court order which required that a program of monitoring and hydrologic testing be implemented on No Name Creek basin in the Colville Indian Reservation of eastern Washington (fig. 1). The purpose of the testing was to ensure that a complex legal issue involving the Colville Confederated Tribes, Mr. Boyd Walton, Jr., Mr. William Boyd Walton, the State of Washington, and the United States of America, might be resolved in the light of a clear understanding of the basin's hydrology. Having been extended once, the study is presently scheduled to end in January 1978.

During the course of the testing program the Colville Tribe implemented development of the ground-water resource for irrigation and fish-rearing purposes. This involved bringing under irrigation most of the valley floor north of the test reach shown on figure 1, and the exportation of water from this same area to the lower reaches of the stream, for both irrigation and fishrearing.

Springs normally feed No Name Creek, and in the past its flow began near and (or) slightly above the permanent flume at the north end of the test reach. Heavy pumping of wells in the northern part of this small valley has caused water levels in the aquifer feeding the springs to decline, and as a result springflow has virtually ceased in this area.
Mr. Boyd Walton, Jr., diverts the natural streamflow from these and other springs down the valley for irrigation at the southern end of the test reach, and the Colville Tribe is using the stream channel to transmit their developed ground water to the lower part of the basin.

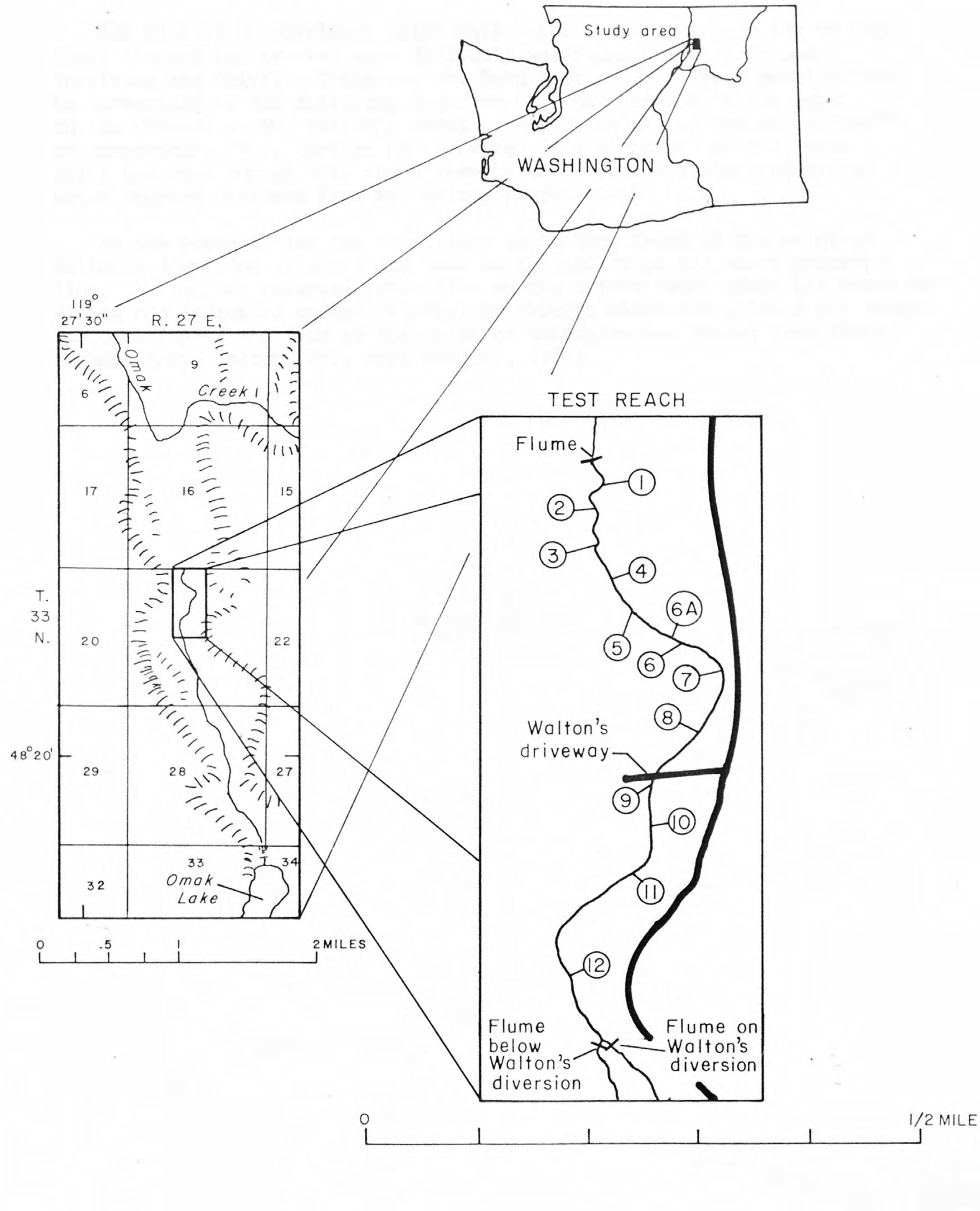

FIGURE 1.-- Locations of study reach on No Name Creek and data-collection sites.

The mixture of developed water with natural springflow in the No Name Creek channel has created some difficult water-management problems involving the Colville Tribe and Mr. Boyd Walton, Jr. These problems may be summarized by the following questions: "What portion of the water in the channel at Mr. Walton's point of diversion is natural springflow?", or conversely, "What portion of the water in the channel at that same point has been pumped into the stream by the Colville Tribe from ground-water sources upstream from Mr. Walton's property?"

At the present time the total flow in No Name Creek at the point of Walton's diversion is about the same as the inflow at his north property line. Walton has observed springflow on the stream banks along his reach of stream and indicated on May 6th that he thought about 250 gallons per minute (0.56 ft^3/s) of the flow at the point of diversion was coming from these springs (Boyd Walton, Jr., oral commun., 1977).

APPROACH

To resolve the question and provide the information necessary for the tribe to manage their resource, a seepage test was planned by the U.S. Geological Survey and executed on May 12th and 13th. This involved the following elements of work:

1. On May 12 experienced engineers and a geologist reconnoitered the stream from the north line of Mr. Walton's property to the point of diversion.

2. Measurements of streamflow were made at 12 sites along the reach to aid in selection of seepage test sites. Flags were used to mark the approximate locations of the sites at which measurements were made.

3. Background chloride concentrations were recorded at 4 of the 12 sites, and specific conductance and temperature were measured and recorded at each site and at one site just below the point of diversion.

4. Based on the 12 streamflow measurements, five sites were selected for the seepage test.

5. On May 13 and over the course of several hours, each of the five sites was visited and the flow was measured by four engineers highly experienced in surface-water hydrology. During this time the flow at the flume at the north property line remained constant.

6. Concurrently, a concentrated brine solution was introduced at the flume at Walton's north property line. The solution was injected at a constant rate (0.0009 ft^3/s) over a 27-minute period, and approximately halfway through the injection a dye slug was introduced to mark the center of the chloride injection in the stream water.

7. Samples of the stream water were collected above the flume, at the previous day's 12 measuring sites, and at the 5 selected measuring sites. A sample of the brine was collected and analyzed. Samples of the stream water were obtained from the center of the dye slug as it traveled downstream.

RESULTS

On the basis of the tests on May 12 it appeared that the streamflow diminished from 1.80 ft^3/s to 1.63 ft^3/s in the first 200 or so feet below the north line, then increased to 2.29 ft^3/s just above Walton's driveway, and then diminished once more to 1.79 ft^3/s at the diversion. From this set of measurements five stations were selected to document the changes in streamflow from the north property line to the point of diversion.

The results of the measurements are shown in table 1. The seepage test on May 13 showed the same pattern of loss and gain as that of May 12. The losses or gains can be more definitively stated on May 13, as the averaging of measurements made at exactly the same sections by four engineers gives more confidence in the precision of the value obtained. The method used was to first average the four measurements, cast out any measurement that differed from this average by more than 5 percent, and then average the remaining measurements.

Using these averaged flow measurements in concert with the chloride measurements, the gains and losses may be computed by using two equations.

First, the equation defining the flow between two measurement points:

$$Q_d = Q_u + Q_i - Q_o \qquad (1)$$

where Q_d = discharge at the downstream site,

Q_u = discharge at the upstream site,

Q_i = rate of inflow to the stream, and

Q_o = rate of outflow from the stream.

Second, the equation describing the mass balance of the chloride:

$$Q_dC_d = Q_uC_u - Q_oC_o + Q_iC_i \qquad (2)$$

where C_d = chloride concentration at downstream site,

C_u = chloride concentration at upstream site,

C_i = chloride concentration of the inflow to the stream, and

C_o = the chloride concentration of the outflow from the stream.

Assuming that C_o can be approximated as the average of the upstream and downstream concentration, equation 2 becomes

$$Q_dC_d = Q_uC_u - Q_o\left[\frac{C_u + C_d}{2}\right] + Q_iC_i \qquad (3)$$

Thus, between site 1 and site 4, equation 1 becomes

$$1.68 = 1.73 + Q_i - Q_o \; , \qquad (4)$$

$$\text{or} \quad Q_i = Q_o - 0.05 \; , \qquad (5)$$

and equation 3 becomes

$$1.68(41) = 1.73(44) - Q_o\left(\frac{44 + 41}{2}\right) + Q_i(1.9^{1/}) \; , \qquad (6)$$

$$\text{or} \quad 68.88 = 76.12 - Q_o(42.5) + Q_i(1.9) \; . \qquad (7)$$

Collecting terms,

$$Q_o = 0.17 + Q_i(0.045) \; , \qquad (8)$$

and substituting equation 5 into equation 8,

$$Q_o = 0.17 + 0.045\,Q_o - 0.002 \; . \qquad (9)$$

$$\text{Thus} \quad Q_o = 0.18 \; , \qquad (10)$$

and from equation 5,

$$Q_i = 0.18 - 0.05 \; , \qquad (11)$$

$$\text{or} \quad Q_i = 0.13 \; . \qquad (12)$$

1/ From station 2 on the previous day. A test of sensitivity was made by using the background chloride concentration of 3.3 mg/L on May 13, and the value of Q_o was changed by 0.01 ft^3/s.

Using this analytical method, the measurements of streamflow and chloride concentration showed the following pattern of gains and losses:

Reach	Gain	Loss	Net change
	(cubic feet per second)		
North line to site 1	--	--	[a] -0.09
Site 1 to site 4	0.13	0.18	- .05
Site 4 to site 6	.14	.03	.11
Site 6 to site 8	.28	.02	.26
Site 8 to site 11	.69*	.66*	.03
Site 11 to diversion	--	--	-.27

The effects of the large volume of water stored in the pond at Mr. Walton's driveway on the chloride concentration in the stream may not have stabilized, as the brine injection lasted for only 27 minutes, and the time required for complete mixing in the pond may have been that long or even somewhat longer. For this reason, the calculation of gains and losses using the chloride concentrations (values marked * in table above) are not considered to be representative for that reach below site 8.

The conclusions reached as a result of this seepage test are that springflow contribution of at least 0.58 ft^3/s (three computed values between sites 1 and 8 and the net contribution measured between sites 8 and 11) between Mr. Walton's north property line and his point of diversion are offset by losses of at least 0.59 ft^3/s (three computed values between sites 1 and 8 and the net losses measured between the north line and site 1, and site 11 and the diversion) over the same reach. If the gains and losses are to be defined with respect to their origin, it is reasonable to say that seepage and evaporation losses from the stream reduce the natural streamflow component and the developed ground-water component in proportion to their relative volumes.

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[a] The channel above the flume at the north line was ponded and precluded injection of brine above the flume, hence gains and losses could not be calculated between the north line and site 1.

Using this reasoning, the components of flow on May 13, 1977, can be tabulated as follows:

Point	Total flow	Developed water	Natural flow
	(cubic feet per second)		
North property line	1.82	1.82	0.00
Site 1	1.73	1.73	.00
Site 4	1.68	1.56	.12
Site 6	1.79	a/ 1.53*	.26
Site 8	2.05	1.52	.53
Site 11	2.08	1.52	.56
Diversion	1.81	1.32	.49

Note that from site 8 downstream the gains and losses are not separated as explained above; net gains are credited to natural flow entirely and net losses are apportioned to the two components.

From a strictly volumetric viewpoint, the minimum calculable natural streamflow on May 13, 1977, was 0.40 ft^3/s (gain from 1.68 ft^3/s at site 4 to 2.08 ft^3/s at site 11), and, by apportioning the loss between site 11 and the diversion, according to the relative volumes of natural flow and developed water, the natural-flow component at the diversion was 0.35 ft^3/s.

On May 15, the developed ground-water contribution was stopped for almost the entire day, and the flow at the diversion point decreased to 0.22 ft^3/s.

These data suggest that, as the streamflow decreases, the rate of loss does not decrease as quickly. This is not unusual, as most of the losses, in the lower reaches especially, are from evapotranspiration, and the surface area of the stream and the availability of stream water to rooted plants do not decrease rapidly with decline in flow. Thus, at this time of the year and under these stress conditions, when natural streamflow is the only flow, it sustains a heavier loss than when the developed ground waters are present to share the losses.

a/ Less than 0.005 ft^3/s of the 0.03 ft^3/s loss can be apportioned to the natural flow component.

TABLE 1.--Water-quality and discharge data

Station	Description	May 12, 1977				May 13, 1977		
		Discharge (ft³/s)	Temp. (°F)	Specific conductance (umhos)	Chloride (mg/L)	Discharge (ft³/s) Measured value	Discharge (ft³/s) Value used	Chloride (mg/L)
Flume at Walton's north line	Stream	1.80	51	190	1.9	[a]1.82	1.82	3.3
	Brine	--	--	--	--	--	--	75,500
1	At foot bridge, 150-200 ft below flume at north property line.	1.63	52	182	--	1.73 1.79 1.73 1.67	1.73	44
2	150 ft below site 1.	1.69	51.5	235	1.9	--	--	42
3	170 ft below site 2.	1.76	51.5	235	--	--	--	41
4	170 ft below site 3 and about 100 ft above a collapsed tree and some bank caving in the right bank.	1.68	51.5	235	--	1.72 1.71 [b]1.33 1.62	1.68	41
5	65 ft below an irrigation aqueduct, about 70 ft below the bank caving.	2.02	51.5	235	--	--	--	40
6	Near power pole 270 ft below an aqueduct. On May 13 site moved upstream about 50 ft to better measuring section.	1.66	52	230	--	1.79 1.71 [b]1.87 1.50	1.79	38
7	About 600 ft above Walton's driveway.	1.99	52	235	--	--	--	34
8	At the entrance to Walton's duck pond at driveway. About 260 ft above driveway.	2.29	51	240	1.5	2.09 2.01 [b]2.22 2.06	2.05	33
9	50 ft below Walton's driveway.	1.94	53	240	--	--	--	27
10	At fence corner on right bank about 250 ft below driveway.	2.15	55	250	--	--	--	26
11	At staff gage about 500 ft below driveway.	1.84	53	250	--	2.05 2.11 2.18 1.98	2.08	24
12	At bridge about 300 ft above Walton's diversion.	1.72	--	--	--	--	--	25
	Walton's diversion	.06				[a].32	1.81	
	Stream below diversion	1.73	54	255	2.3	[a]1.49		
Point of diversion	Total flow	1.79				1.81		

[a]Flume measurement.

[b]Not used in average because it differed by more than 5 percent of the average of four measurements.