WATER AND NUTRIENT BALANCES FOR THE TWIN FALLS IRRIGATION TRACT

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ABSTRACT

Surface water return flow from the 202,500 acre Twin Falls irrigation tract to the Snake River has been measured since 2005 to identify changes in water, salt and nutrient balances as conservation practices have been implemented. Irrigation water diverted from the Snake River was the main hydrologic input to this watershed, supplying 73% of the water in 2005 and 83% in 2006. Approximately 50% of the total water input was potentially used by crops and 35 to 40% returned to the Snake River. Two years of monitoring have shown that water quality has improved since similar monitoring took place from 1968 to 1971. Net loss of suspended sediment was 196 lb acre^{-1} in 2005 and 9 lb acre^{-1} in 2006 compared to 410 lb acre^{-1} during the 1971 irrigation season. Net loss of nitrate-N decreased from 30 lb acre^{-1} in 1969 to 9 to 13 lb acre^{-1} in 2005 and 2006.

INTRODUCTION

Monitoring on the Twin Falls irrigation tract was initiated in 2005 to assess the effectiveness of conservation practices in an irrigated watershed as part of the Conservation Effects Assessment Project (CEAP), a national effort by NRCS and ARS to quantify impacts of implemented conservation practices. The Twin Falls irrigation tract is a 202,500 acre watershed located along the Snake River in southern Idaho. The Twin Falls Canal Company diverts water from the Snake River and delivers it to farms through 112 miles of main canals and over 990 miles of smaller channels and laterals. Water is typically diverted from mid-April to late-October.

Runoff from furrow irrigated fields and unused irrigation water collect in surface drains that flow back to the Snake River if the water cannot be diverted to other fields. Subsurface drains also contribute flow to surface drains, which continue to flow after the irrigation season.

Earlier studies showed that the Twin Falls Irrigation tract had a net loss of sediment, nitrate, and soluble salts, and a net gain of soluble phosphorus when the Twin Falls tract was about 95% surface irrigated. The net loss of 2141 lb acre^{-1} soluble salt (Carter et al., 1971) was a good indication for the sustainability of this irrigated watershed, but the net losses of 30 lb acre^{-1} nitrate-N (Carter et al., 1971) and 410 lb acre^{-1} of sediment (Carter et al., 1974) were a concern. The purpose of this paper is to compare the earlier water, salt and nutrient balances with current data when the Twin Falls irrigation tract is approximately 35% sprinkler irrigated.

MATERIALS AND METHODS

Monitoring sites for calculating water and nutrient balances are categorized as primary, secondary, or tertiary sites. Primary sites have data loggers recording water depth and automatic water samplers collecting time-composite water samples (0.2 L (0.75 gal.) sub-sample every 5 h in 2 L (0.5 gal) bottles). The three or four 2 L composite samples from each primary site are combined into a weekly composite sample during sample processing. The 5 h interval was chosen so samples were not collected at the same time each day. Secondary sites also have data loggers recording flow but a 2 L water sample is only collected once per week. Tertiary sites have less flow than primary or secondary sites so flow rate is manually measured once per week when 2 L water samples are collected. Flow rates at primary and secondary sites are measured with weirs or calculated from stage-discharge relationships. Flow rates at tertiary sites are measured by recording water depth from a staff gage on a weir or from a weir stick on a concrete structure.

Crop areas and irrigation methods for the entire Twin Falls tract were estimated by a single field survey each year of one randomly chosen section within each of the 17 townships in the tract. Total area surveyed was 10,900 acres or about 5% of the total land area in the Twin Falls tract. The relative area of each crop type identified by the driving survey was multiplied by the total area of the irrigation district to determine the total area of each crop. Potential crop water use was calculated by multiplying crop areas by the potential water use for each crop calculated by AgriMet (USBR, 2007) for the Kimberly, ID site. Non-growing season evapotranspiration (ET) was calculated using bare soil ET calculated by Allen and Robison (2007).

All return flow monitoring sites were visited weekly while water was flowing to collect water samples and measure flow rate or download flow data. Water samples were refrigerated until processed the day after collection. During sample processing, samples were stirred for 1 to 2 min before measuring pH and electrical conductivity (EC). A 50 ml aliquot was taken for total nitrogen (N) and phosphorus (P) analysis. A second 20 ml aliquot was filtered (0.45 micron) and analyzed for dissolved nutrients and salts. A third aliquot was used to determine sediment concentration by filtering a known volume (approximately 100 ml) through 0.45 micron filter paper and weighing the dried filter paper.

The filtered water sample was analyzed by inductively coupled plasma-optical emission spectroscopy (ICP-OES) for P, K, Ca, Mg, Na, Al, Fe, Mn, Zn, and S concentrations, and by flow injection analysis (FIA) for NO_3-N, NH_4-N, and Cl concentrations. An aliquot (~25 ml) of the unfiltered water sample was digested with a Kjeldahl procedure (USEPA, 1983) and analyzed by ICP-OES for total P and by FIA for NH_4-N for total N.

The volume of flow at each site was calculated for each sample interval. This volume was multiplied by parameter concentrations from laboratory analysis to calculate mass loads. Loads were summed over appropriate intervals (e.g. yearly or monthly) to determine net input or output of a parameter. Flow-weighted concentrations were calculated by dividing the mass load for a time period by the total flow volume for the same period. Soluble salt concentration was calculated by multiplying EC ($\mu S\ cm^{-1}$) by 0.64.

RESULTS AND DISCUSSION

Annual water balances and salt and nutrient loads were calculated from May to April rather than the traditional October to September water year because our monitoring began in May 2005. Water balances for the first two years of monitoring are shown in table 1. Above normal precipitation in 2005 contributed 24% of the total water input compared to 14% in 2006. Irrigation water flowing in the Twin Falls Canal Company (TFCC) Main Canal was the main hydrologic input to the watershed, supplying 73% of the water in 2005 and 83% in 2006. Less water was diverted in 2005 due to above normal precipitation in the spring and limited irrigation water supply due to drought. More water was diverted in the 1969 water year (88 in.) and the Main Canal contributed 89% of the total input (Carter et al., 1971).

Approximately half of the total water input to the watershed was used by crops and non-growing season ET. Annual irrigation return flow was 26 in. in 2005 and 30 in. in 2006, or 37%

and 43%, respectively, of the total input to the irrigation tract. About 25% to 30% of the measured return flow occurred during the non-irrigation season as a result of subsurface drainage. The positive water balance accounts for all measurement and calculation errors, the quantity of water lost through evaporation or seepage from irrigation canals, and deep percolation that did not flow to subsurface drainage.

Alost 80% of the return flow was measured at primary sites (data loggers and automatic samplers). The increase in flow at tertiary sites in 2006 occurred because two tertiary sites were added and one primary site was temporarily converted to two tertiary sites while the TFCC constructed new water quality ponds in 2006.

The Twin Falls irrigation tract still had a net loss of suspended sediment in 2005 and 2006 (Table 2), although current losses are much less than the 410 lb acre^{-1} measured by Carter et al. (1974) during the 1971 irrigation season. Converting to sprinkler irrigation, installing sediment ponds, and using polyacrylamide all contribute to reduced sediment loads in return flow streams. The difference in net sediment losses between 2005 and 2006 was not due to differences in return flow sediment loads but much lower inflow sediment load in 2005 compared to 2006 (Table 2). Additional monitoring may show that annual net sediment loss is typically less than the 196 lb acre^{-1} measured in 2005. We also must assume that the 1971 water year was not an abnormal year when concluding that sediment loss has decreased.

Compared to 1971 data, both inflow and outflow sediment loads have decreased, which is noteworthy because Carter et al. (1974) only collected data from May to September. The net sediment loss from May to September 2005 was only 45 lb acre^{-1}. There was a net gain of 116 lb acre^{-1} of sediment for the same time period in 2006. The decreased outflow sediment loads correspond with decreased flow-weighted sediment concentrations for May to September: 300 mg L^{-1} in 1971, 130 mg L^{-1} in 2005, and 100 mg L^{-1} in 2006. Inflow sediment concentrations also seem to have decreased from 55 mg L^{-1} in 1971 to 29 mg L^{-1} in 2005 and 43 mg L^{-1} in 2006.

Current monitoring indicates a net increase in soluble salts in the watershed (table 2). Data from Carter et al. (1971) indicated that there was a net loss of 2141 lb acre^{-1} soluble salts from the Twin Falls tract in the 1969 water year, because soluble salt concentrations in subsurface drainage were more than twice the concentration of irrigation inflow. The effects of irrigation diversion and subsurface drainage on soluble salt concentrations are demonstrated in figure 1. Inflow salt concentration was higher during the irrigation season due to higher salt concentrations in the Snake River compared to Rock Creek. Outflow salt concentrations were greater after the irrigation season when subsurface drainage contributed almost all of the flow. The change from losing salts to retaining salts was possibly due to changes in irrigation practices that result in less deep percolation that ultimately becomes subsurface drainage. Also, Carter et al. (1971) considered that the unaccounted for balance of water was subsurface flow. Using that assumption with current data changes the net accumulation of soluble salts to a net loss of about 178 lb acre^{-1} each year, which is still much less than the loss measured by Carter et al. (1971), indicating that less water may be percolating through the soil and flowing to subsurface drainage.

Nitrate-N losses in 2005 and 2006 (Table 2) were less than half of loss in 1969 (30 lb acre^{-1} nitrate-N). Estimating the additional contribution to subsurface flow as was done by Carter et al. (1971) increases the nitrate-N loss to about 18 lb acre^{-1} for both 2005 and 2006. Decreased nitrate losses could result from less water percolating through the soil to subsurface drains or changes in other factors such as irrigation systems, fertilization practices, and crop types.

Dissolved P data indicate that there was a net gain of soluble P in the Twin Falls irrigation tract in 2005 and 2006 (Table 2), which means more dissolved P was removed from the Snake River than returned. The annual net gain varied among years but was always less than 1 lb $acre^{-1}$.

The first two years of monitoring on the Twin Falls irrigation tract indicate that water quality has improved since similar data were collected in 1968 to 1971. Exact cause-effect relationships have not been identified in this preliminary analysis, but a major change on agricultural land has been conversion from furrow irrigation to sprinkler irrigation.

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Table 1. Water balances for 2005 and 2006 for the Twin Falls Irrigation Tract.

		2005 (in.)	2006 (in.)
Inputs	Main Canal	52	57
	Rock Creek	2	2
	Total Surface Flow	54	59
	Precipitation	17	10
Total Input		71	69
Outputs	Primary	21	22
	Secondary	3	4
	Tertiary	1	3
	Total Surface Flow	26	29
	Crop Water Use	37	34
Total Output		63	63
Balance (total input – total output)		175	8

Table 2. Suspended sediment, soluble salts and nutrient balances for 2005 and 2006 for the Twin Falls irrigation tract.

	Suspended Sediment		Soluble Salts		Nitrate-N		Dissolved P	
	2005	2006	2005	2006	2005	2006	2005	2006
Inputs	($lb\ acre^{-1}$)							
Main Canal	271	454	2977	2897	0.5	0.1	0.78	0.41
Rock Creek	40	23	29	21	0.0	0.0	0.02	0.01
Total Input	311	477	3005	2919	0.5	0.1	0.79	0.42
Outputs								
Primary	449	345	1900	1999	8.3	10.4	0.32	0.24
Secondary	45	66	305	310	1.6	2.0	0.05	0.04
Tertiary	15	75	111	236	0.4	0.9	0.02	0.04
Total Output	509	486	2317	2546	10.3	13.2	0.39	0.32
Balance*	-198	-8	689	373	-9.8	-13.1	0.40	0.09

* Balance is total input minus total output.

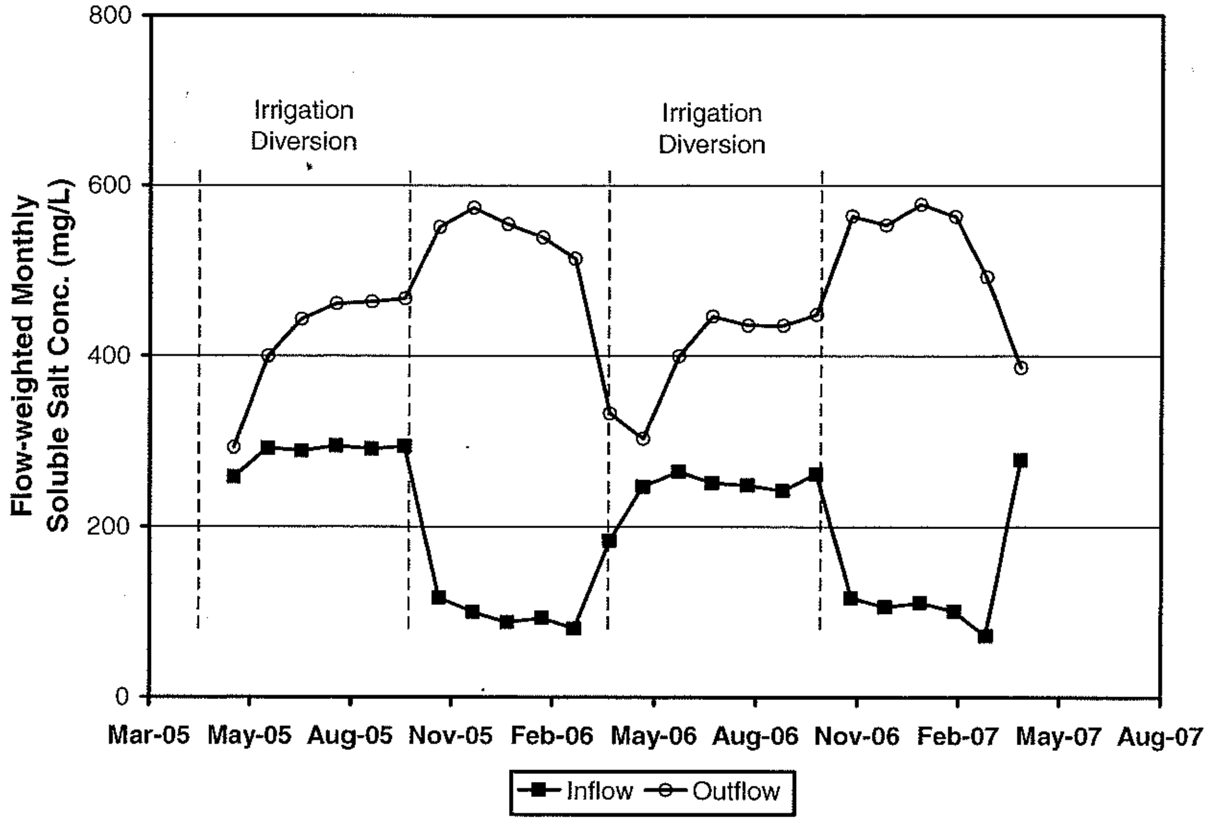

Figure 1. Flow-weighted average soluble salt concentrations in watershed inflow and outflow. Watershed inflow is the Main Canal and Rock Creek. Watershed outflow contains subsurface drainage that flows to surface drainage channels.