Water Quality Improvements in RSBOJC Irrigation Return Waterways, 1997-2008

Roza-Sunnyside Board of Joint Control

March 2009







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Preface

This document was written by Marie Zuroske to highlight the RSBOJC report, "Water Quality Conditions in Irrigation Waterways within the Roza and Sunnyside Valley Irrigation Districts, Lower Yakima Valley, Washington, 1997-2008." Charts have been simplified; often only a few of the constituents or sites are shown. Implication statements which are not found in the technical report have been added to encourage future discussions. The technical report is available from Sunnyside Valley Irrigation District (509-837-6980 or http://www.svid.org/) or Roza Irrigation District (509-837-5141 or http://www.roza.org/).

To improve readability, the use of technical terms has been minimized. In this summary:

Suspended solids= total suspended solids
Nitrate = nitrate+nitrite as N
Bacteria = fecal coliform
Phosphorus= total phosphorus
Flow = instantaneous discharge
Typical = the median value
Organic nitrogen+ammonia = total Kjeldahl nitrogen.

Acknowledgements

Without support from landowners within our districts, RSBOJC would not have been able to develop or effectively implement a water quality improvement policy and monitoring program. Without financial support from the U.S. Bureau of Reclamation's Pacific Northwest Laboratory, the number of samples analyzed each year would be drastically reduced.

Cover photographs: *Left to right, top row, Sulphur Creek Wasteway, Granger Drain, (next row) Joint Drain 51.4, Spring Creek Wasteway, Snipes Creek Wasteway, (next row) three sub-drains within the Granger Drain system (Joint Drain 32.0, DR 2, and Joint Drain 27.5).*

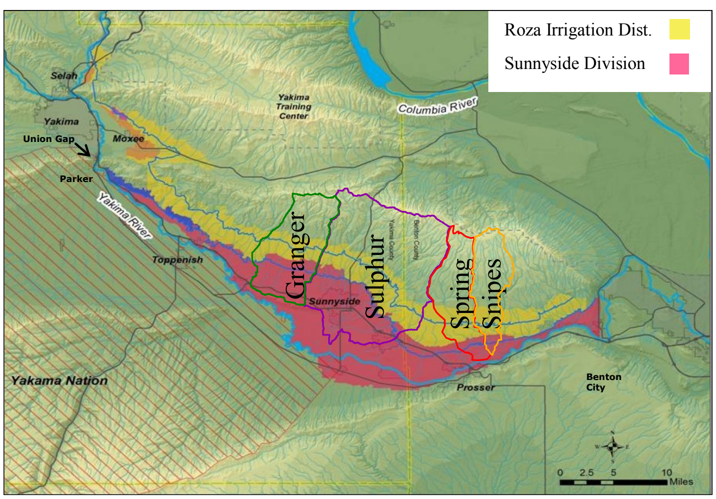
Introduction

The Roza-Sunnyside Board of Joint Control (RSBOJC) was formed in 1996 to address overlapping responsibilities of the Roza and Sunnyside Valley irrigation districts, including water quality of irrigation return flows. During summer months, because much of the water in the lower Yakima River consists of irrigation return flows, the water quality of the return flows can strongly influence the quality of the water in the river. In 1997, RSBOJC developed a water quality improvement program, established an accredited in-house laboratory, and began long-term sampling of the waterways. The first 12 years of RSBOJC's water quality data were used to answer three key questions:

- How did conditions change over the 12-year period?
- What factors strongly influenced water quality in the waterways?
- What can we learn from the data to help guide future efforts?

The data analysis focused on four waterways — Granger Drain, Sulphur Creek Wasteway, Spring Creek Wasteway, and Snipes Creek Wasteway — which were identified in 1995 as major contributors of suspended solids (dirt in water) in the Department of Ecology's clean-up plan for the lower Yakima River. For ease of reference, these waterways will be referred to as Granger, Sulphur, Spring, and Snipes.

As a result of their different functions, during the irrigation season, water in Sulphur, Spring and Snipes consists primarily of tailwater, operational spill, and groundwater, while in Granger it consists primarily of tailwater and groundwater. During the non-irrigation season all four waterways contain primarily groundwater.



Terms

Groundwater in these drainage basins is generally derived from irrigation water not consumed by crops, nor lost to evaporation or surface run-off.

Tailwater is irrigation water collected at the bottom end ('tail') of a field, which is then usually returned to irrigation drains.

Wasteways return canal water to the river from routine canal or lateral operations (termed 'operational spill') needed to maintain water levels in different portions of the delivery system or during emergencies such as breaks in the canal or lateral.

Waterways, as used in this report, are drains and/or wasteways.

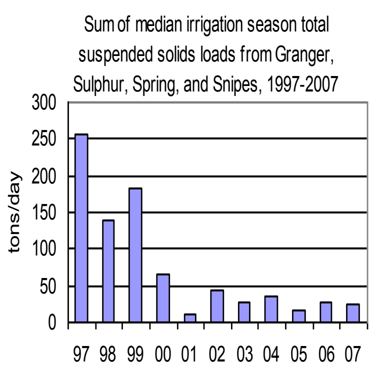
From 1997 to 2008, droughts occurred in 2001 and 2005 due to low snowpack in the Cascade Mountains, which reduced the amount of irrigation water available during the dry summer months. Precipitation is not a significant source of water for crops or to recharge groundwater in this area: the average precipitation during these 12 years was 2.1 inches during the irrigation season (April 1 to mid-October) and 5.1 inches during the non-irrigation season (mid-October to March 31). The seasonal average and maximum air temperatures varied no more than 3.5º F between years.

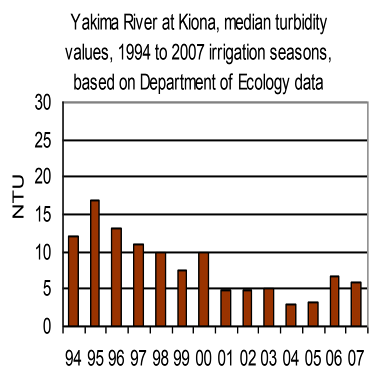
Changes Over Time

How Much Did Conditions Improve During the Irrigation Seasons? Substantially. Typical concentrations of suspended solids, phosphorus, bacteria, and organic nitrogen+ammonia in most waterways decreased by 42 to 90% between 1997 and 2008. Nearly all loads and yields decreased significantly.

During the 1997 irrigation season, the typical cumulative load (amount) of suspended solids coming from all four waterways was 254 tons per day, which decreased quickly and substantially to less than 50 tons per day from 2001 to 2007. In drought years such as 2001 and 2005, loads often decrease. But after 2000, loads remained low even in non-drought years.

The decreased loads coming from the waterways corresponded to decreased turbidity (a measure of water clarity) in the Yakima River at Kiona, downstream of the waterways, where the Department of Ecology samples the Yakima River on a monthly basis. The typical turbidity during the irrigation season declined by 14 Nephelometric Turbidity Units (NTU) from 1995 to 2005.





Environmental Excellence Award

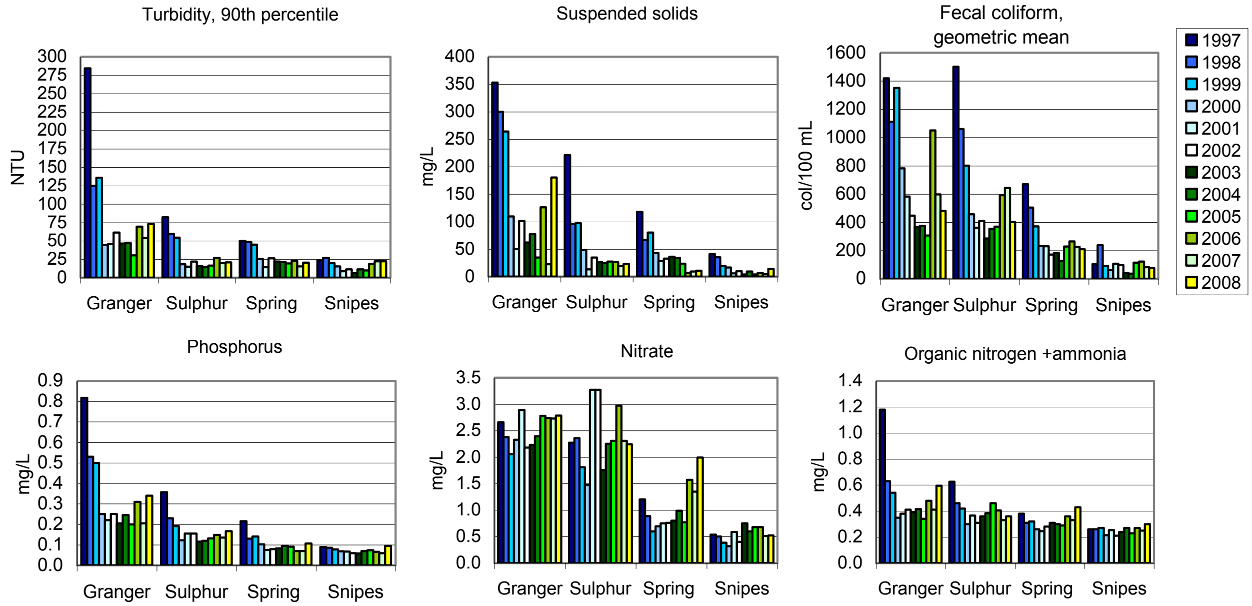
In 2000, the Roza and Sunnyside Valley irrigation districts received an environmental excellence award from the Department of Ecology for improvements in water quality in RSBOJC irrigation return waterways that enter the lower Yakima River.

Concentrations and loads of bacteria, phosphorus, and organic nitrogen+ammonia also decreased substantially from 1997 to 2000 in Granger, Sulphur, and Spring. Most of the decreases that occurred in Snipes were too small to be considered significant. Between 1997 and 2008, the typical turbidity in Granger Drain decreased by more than 200 NTU (74% decline), bacteria in Sulphur decreased by 1,100 colonies per 100 milliliters (73% decline), and suspended solids in Spring decreased by 107 milligrams per liter (90% decline). Most decreases in loads were also substantial.

From 2000 to 2008 the rate of improvement slowed; in some cases conditions slightly worsened, although improvements in irrigation practices continued. Despite the slowing rate of improvement, trends during the irrigation seasons from 1997 to 2008 were significantly downward for suspended solids, phosphorus, organic nitrogen+ammonia and discharge in Granger and Sulphur.

Implication: The improvements from 1997 to 2000 were significant by any measure — environmental, statistical, or societal. While concentrations remained low, the decreased rates of improvement from 2000 to 2008 are a concern.

Typical concentrations during the irrigation season (except turbidity, which are the worst 10 percent values)

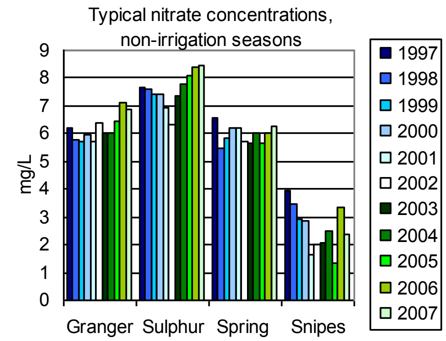


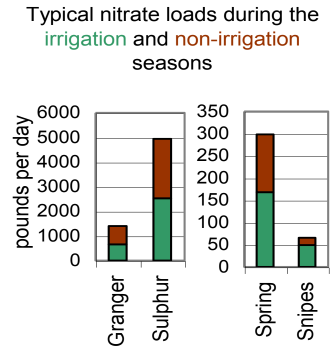
Differences between 1997 and 2008							
Concentrations (median values, unless otherwise noted)							
	Turbidity (NTU), 90th percentile	Total suspended solids (mg/L)	Total phosphorus (mg/L)	Total Kjeldahl nitrogen (mg/L)	Nitrate + nitrite (mg/L)	Fecal coliform (col/100 mL), geo mean	Discharge (cfs)
Granger	-212	-173	-0.477	-0.59	0.13	-937	-11
Sulphur	-61	-198	-0.191	-0.27	-0.03	-1098	-171
Spring	-30	-107	-0.109	0.05	0.80	-461	-41
Snipes	-1	-27	0.01	0.04	-0.02	-28	-20
Loads (median values)							
		tons/day	lb/day	lb/day	lb/day	million col/sec	
Granger	n/a	-39.5	-185	-225	-50	-18	n/a
Sulphur	n/a	-164	-415	-501	-2340	-116	n/a
Spring	n/a	-13.8	-38	-47	-159	-7	n/a
Snipes	n/a	-2.8	-11	-17	-76	-1	n/a
Percent differences between 1997 and 2008							
Concentrations (median values, unless otherwise noted)							
Granger	-74	-49	-58	-50	5	-66	-17
Sulphur	-75	-90	-54	-42	-1	-73	-52
Spring	-60	-91	-51	13	66	-69	-75
Snipes	-5	-65	6	15	-3	-27	-40
Loads (median values)							
Granger	n/a	-61	-65	-58	-6	-70	n/a
Sulphur	n/a	-96	-71	-59	-56	-85	n/a
Spring	n/a	-97	-85	-62	-51	-89	n/a
Snipes	n/a	-70	-46	-27	-55	-77	n/a

Negative values in yellow cells indicate a decrease between years; positive values in blue cells indicate an increase. Grey font indicates insignificant differences -- relative percent differences (not shown) were less than the uncertainty in the field replicate samples. When differences between concentrations were insignificant, the differences between the corresponding loads were also considered insignificant.

What did not improve? Nitrate concentrations in three of the four waterways.

Nitrate concentrations decreased during the non-irrigation season only in Snipes. Why did nitrate behave differently than the other constituents? The major source of nitrate in these waterways is groundwater, not overland flows. How do we know that? Except in Snipes, nitrate loads (pounds per day) were nearly constant year-round. If runoff from farms was a significant source of nitrate, the load during the irrigation season would significantly increase. It did not, except in Snipes. The reason Snipes acts differently than the other waterways (in this and other ways) is unknown but may be related to its connectedness to groundwater.



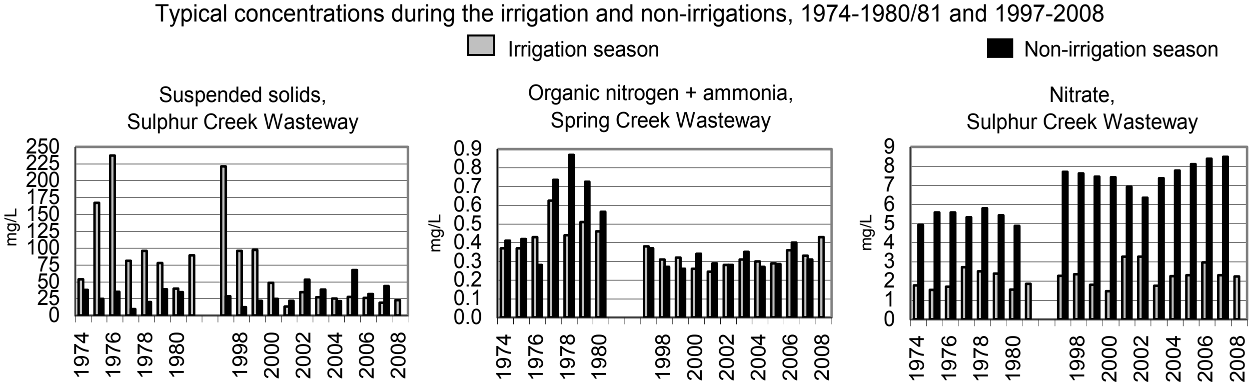


Implication: The intensive effort to reduce erosion in irrigated areas has not yet changed nitrate concentrations in groundwater. There are at least two possible reasons: (1) the irrigation improvements were more effective in reducing run-off than leaching; and/or (2) some of the nitrate in groundwater is decades old which would be unaffected by current changes in irrigation practices.

Were the high concentrations in 1997 to 1999 a fluke? No. Most were comparable to conditions from 1974 to 1981.

To determine whether conditions during 1997-99 were not typical, conditions during 1974-81 (based on data for the same four waterways from an EPA database) were evaluated. During the irrigation seasons, typical concentrations during 1997-99 were similar to those during 1974-81, while the 2000-08 concentrations were generally lower than 1974-81. During the non-irrigation seasons, most conditions were comparable between sets of years. One exception was the concentration of nitrate in Sulphur which was highest in most recent years, at least in part due to lower flows in recent years compared to the late 1970's.

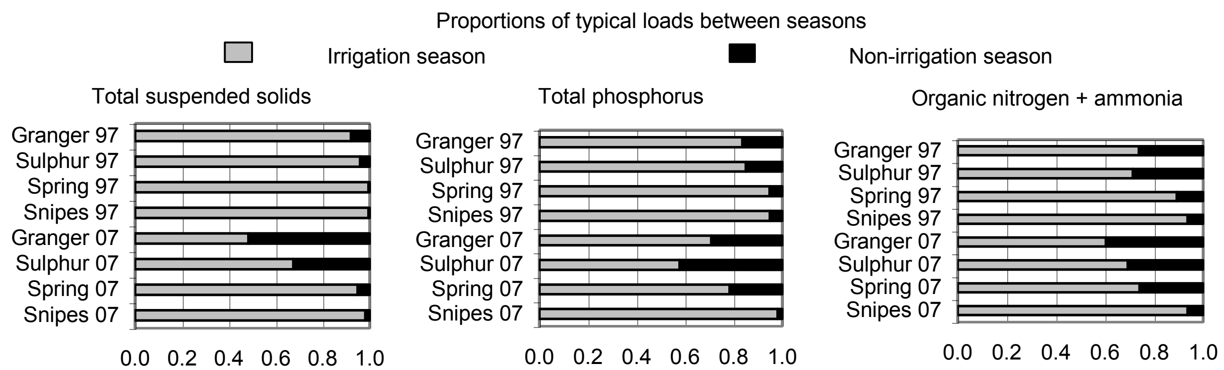
Typical concentrations during the irrigation and non-irrigations, 1974-1980/81 and 1997-2008

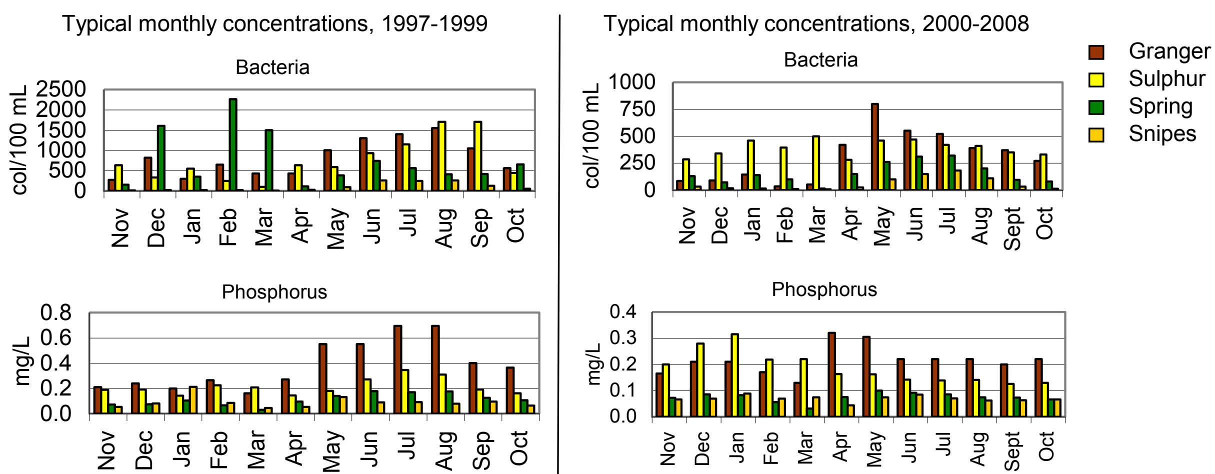


Implication: Conditions during 1997-99 were generally comparable to 1974-81; thus, the improved conditions during 2000-08 were a significant change, not an artifact of unusually high values during 1997-99.

Did the Relationship between the Irrigation and Non-irrigation Seasons Change? Yes, in some cases the relative contributions during the non-irrigation season increased over time.

The relative importance of the irrigation and non-irrigation seasons was estimated by comparing the typical loads during the irrigation and non-irrigation seasons relative to their sums in 1997 and 2007. In 1997, in each waterway the non-irrigation season load of suspended solids was less than one-tenth of the sum. However, in 2007, in Sulphur and Granger, the non-irrigation season load of suspended solids was roughly one-third and one-half of the summed loads and the phosphorus non-irrigation season load was roughly one-third of the summed loads. Why did proportions change? Concentrations decreased during the irrigation seasons, and in certain cases in Sulphur, increased during the non-irrigation seasons (see charts of monthly values, below). Additionally, except in Granger, flow decreased between years by different amounts.





Note different scales between 1997-1999 charts and 2000-2008 charts.

It does not make intuitive sense that such high proportions of suspended solids and phosphorus were contributed during the non-irrigation season in recent years, considering the average rainfall was 5.1 inches during the winter while a common amount of irrigation water applied in the summer was 36 inches. Other transport mechanisms (such as direct piping) may be at work. Also, we also do not know how much influence transport of these constituents during the irrigation season may have on the non-irrigation conditions.

One example of the possible interconnectedness between irrigation and non-irrigation seasons was seen in the Sulphur basin. A mass balance during the non-irrigation season suggested 9 tons of suspended solids, 32 pounds of phosphorus, and 137 pounds of organic nitrogen+ ammonia were typically deposited in the main channel on each day during the winter, which likely would have been resuspended when water velocity increased at the beginning of each irrigation season, unless removed by drain maintenance (dredging).

Implication: The potential effectiveness of continued emphasis on improving irrigation practices to improve water quality cannot be assessed without a better understanding of the interconnectedness between irrigation and non-irrigation season conditions.

Factors Influencing Water Quality

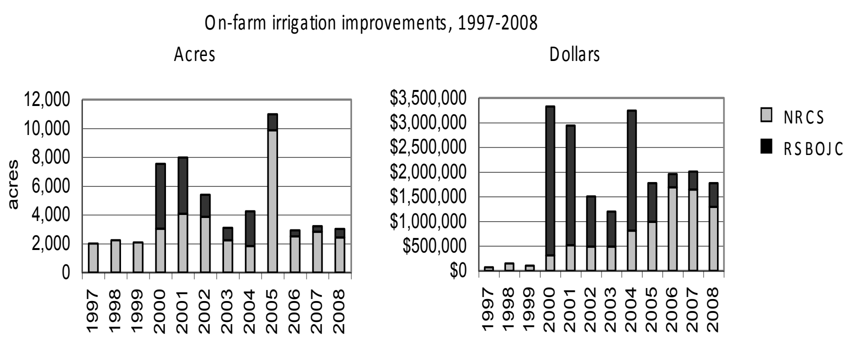
Several factors that influence water quality were assessed: precipitation, canal water quality, on-farm irrigation practices, water availability, crop types, and basin characteristics.

Which factor could best account for the magnitude of the improvements observed? Improvements in on-farm irrigation practices.

Of the factors evaluated, the one which could best account for the size of the decreases from 1997 to 2000 was improvements in irrigation practices which decreased erosion in irrigated areas. Irrigation-induced erosion is *the* dominant transport process that carries dirt from the fields to the waterways during the summer. Between 1997 and 2000, there were no major changes in precipitation amounts, drain maintenance protocols, canal operation, or general land use (which remained intensive irrigated agriculture).

Did the rate of improvements in on-farm irrigation practices correspond to the rate of water quality improvements? No. The rates of change did not correspond.

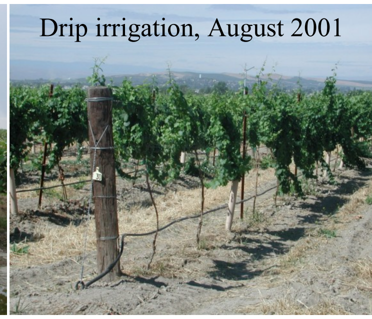
Despite the well-known link between irrigation practices and water quality, the rate of partially publicly-funded irrigation improvements did not correspond to the rate of water quality improvements between years. Possible reasons include the amount of unfunded and untracked irrigation improvements by landowners, varying effectiveness of the same practice on different fields (converting from furrow to sprinkler on five percent slopes would produce larger improvements than on one percent slopes, all else being equal), diminishing returns common to many environmental improvements, and the general complexity between conservation efforts and their effects on water quality in watersheds with diverse cropping and irrigation practices.

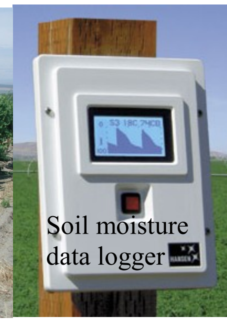


The increase in Natural Resources Conservation Service (NRCS) cost-share dollars over the years was not a reflection of the level of interest by landowners but rather the amount of funds available. In nearly every year, more landowners applied for cost-share than funding was available.

A substantial level of effort was needed to improve water quality in the waterways. From 1997 to 2008, growers used $20,067,033 of public funds for low-interest loans or cost-share (the grower shares in the cost of the project) to improve irrigation practices on roughly 34,700 acres throughout the lower valley. Growers spent substantial but unknown amounts of their own funds to improve practices without government involvement.


Rill (furrow) irrigation, June 2002


Drip irrigation, August 2001

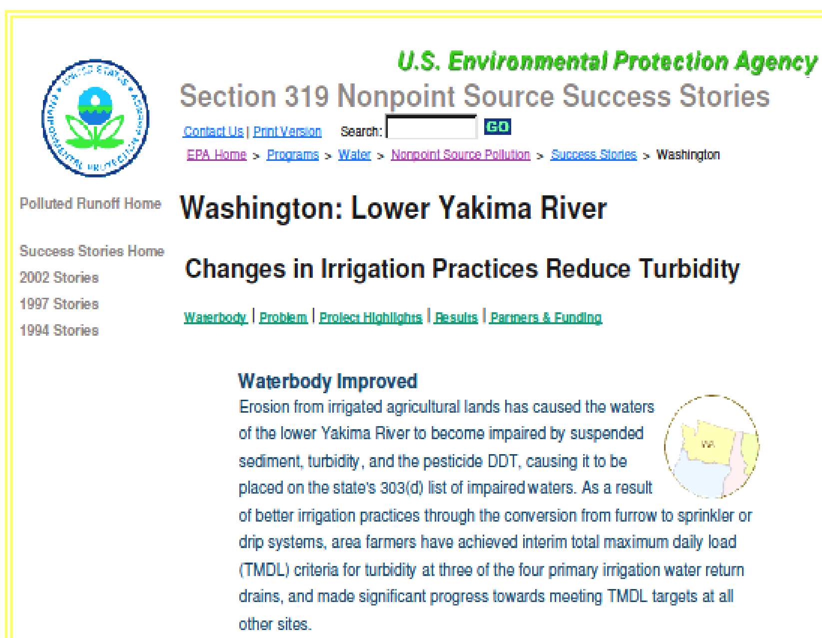

Soil moisture data logger


Center pivot, April 2002

Why did growers choose to improve their irrigation practices? Many factors potentially influenced their decisions during these years, including but not limited to:

(1) availability of cost-share funds and low-interest loans;
(2) an increasing number of pressurized laterals, which enabled some growers to install sprinkler systems without expensive pumps;
(3) the Roza-Sunnyside Board of Joint Control's water quality policy, which reduced water deliveries to fields from which highly turbid runoff repeatedly occurred;
(4) the passage of the state's Dairy Nutrient Management Act in 1998, which required dairies to develop nutrient management plans and resulted in partial funding of improved irrigation and nutrient management practices on dairies;
(5) decades of technical assistance from the Natural Resources Conservation Service, Washington State University Cooperation Extension, and local conservation districts; and
(6) peer pressure.

Implication: Successful water quality improvements can be very expensive. With decreasing rates of return, how much effort and money are landowners and taxpayers willing and able to spend to continue improvements — for example, to reach the Granger turbidity and fecal coliform goals?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Washington: Lower Yakima River

Changes in Irrigation Practices Reduce Turbidity

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Waterbody Improved

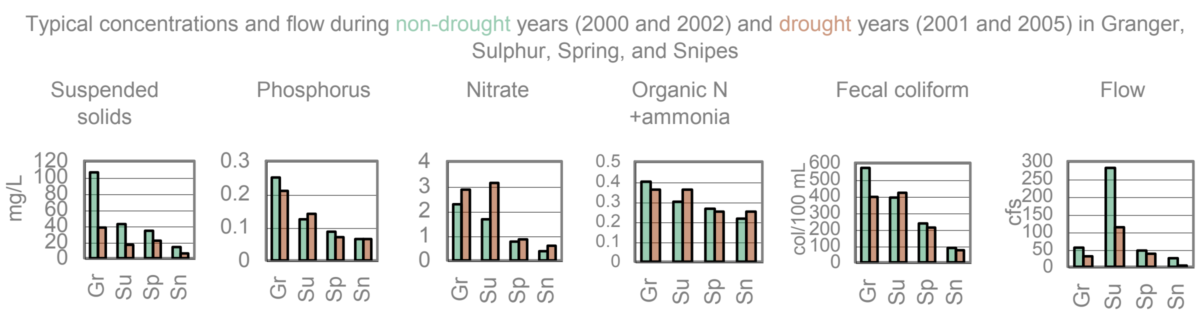
Erosion from irrigated agricultural lands has caused the waters of the lower Yakima River to become impaired by suspended sediment, turbidity, and the pesticide DDT, causing it to be placed on the state's 303(d) list of impaired waters. As a result of better irrigation practices through the conversion from furrow to sprinkler or drip systems, area farmers have achieved interim total maximum daily load (TMDL) criteria for turbidity at three of the four primary irrigation water return drains, and made significant progress towards meeting TMDL targets at all other sites.

Did water availability influence water quality in the waterways? Yes, although in sometimes unexpected ways.

Water availability changed substantially for two reasons during a few of these years: drought and improvements in the efficiency of the delivery system.

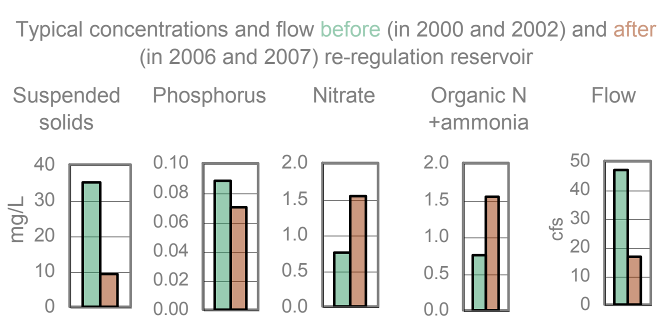
Drought

In drought years, nitrate concentrations would be expected to increase due to less dilution from canal spill water while sediment-related constituents would be expected to decrease due to less runoff from farms. Indeed, in most waterways, typical concentrations of suspended solids were lower in drought than in non-drought years. Unexpectedly, typical concentrations of phosphorus, organic nitrogen+ammonia and bacteria were similar in drought and non-drought years in most waterways. Nitrate concentrations increased, although not significantly in Spring or Snipes.



Canal Efficiency

After a re-regulation reservoir was installed in 2005 to improve the delivery efficiency of the Sunnyside Canal, the amount of canal water released into Spring decreased substantially, as intended. Concentrations of suspended solids and phosphorus subsequently decreased, likely due to less in-channel movement of deposited materials – water velocities would have slowed considerably when typical flows decreased from 47 cubic feet per second (cfs) before the reservoir to 17 cfs after the reservoir. In contrast, the increased concentrations of nitrate after the reservoir was likely due to decreased dilution from the canal water of the groundwater in the waterway. All irrigation season loads decreased, even nitrate, because the decrease in flow was so substantial.



Implication: When a re-regulation reservoir is completed in future years to decrease spills into Sulphur, we may see a similar outcome on a larger scale — decreased concentrations of sediment-related constituents, increased concentrations of water-soluble constituents, and decreased loads of all constituents. Decreased loads would be good news for the Yakima River.

Did differences in water quality between waterways correspond to differences in drainage basin characteristics? *During the irrigation season, no. During the non-irrigation season, yes.*

Irrigation season

During the irrigation season, when most constituents are transported via irrigation water, crop types, soils, slopes, and related factors might be expected to relate to differences between the waterways. Spring and Snipes had larger percentages of drip irrigation, fewer dairies, and steeper slopes. Sulphur and Granger had similar soils and slopes; Sulphur had more grapes and Granger had more corn; Granger had proportionally more irrigated acres owned by dairies (29%) and Sulphur had fewer (12%) although the number of dairies in each were similar.

Drainage	% of total watershed under irrigation	Dominant substrate in drain	Drain gradient (%)	Major crops in 2000 (varies between years)	Number of dairies (1998-2003 data)	Dominant irrigation system in 2000 (varies between years)	Soils	Susp. solids yields	Bacteria yields	Phosphorus yields	Nitrate yields
Granger	66	Silt, sand	0.3	27% tree fruit, 25% corn, 19% pasture, 11% grapes	20	54% sprinkler, 41% rill, 5% drip	90% silt loam (irrigated portion)	H	M	M	M
Sulphur	48	Silt, sand	0.3	25% pasture, 23% grapes, 17% tree fruit, 11% corn	24	48% sprinkler, 40% rill, 3% drip	57% silt loam, 20% fine sandy loam (irrigated portion)	H	H	H	H
Spring	40	Gravel, cobble	0.9	33% grapes, 27% tree fruit, 17% pasture, 14% hops	2	29% rill, 51% sprinkler, 21% drip	87% high permeability deposits, 13% basalt	H	M	M	M
Snipes	25	Gravel, cobble	1.0		0		80% high permeability deposits, 20% basalt	M	M	M	L

Yields were ranked highest (H), mid-range (M), and lowest (L). Yields that had similar ranges for a given parameter, for all irrigation seasons from 1997 to 2008, are indicated with the same color.

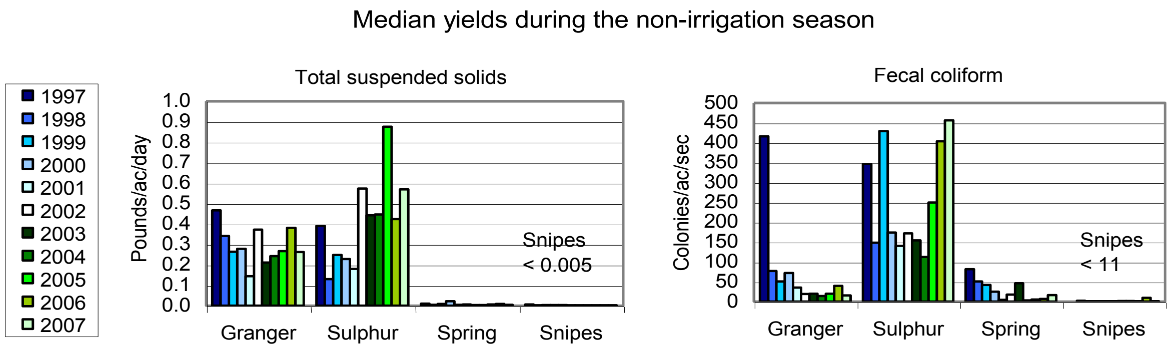
Despite differences in basin characteristics, irrigation season yields of fecal coliform, phosphorus, nitrate, and organic nitrogen+ammonia were comparable in Spring and Granger. Yields of suspended solids were comparable in Granger, Sulphur and Spring. Sulphur had higher yields of bacteria, phosphorus, and nitrate, even though it shared several similar characteristics with Granger — irrigation types, soils, number of dairies, slopes, and type of substrate in the bottom of the waterways.

Yields

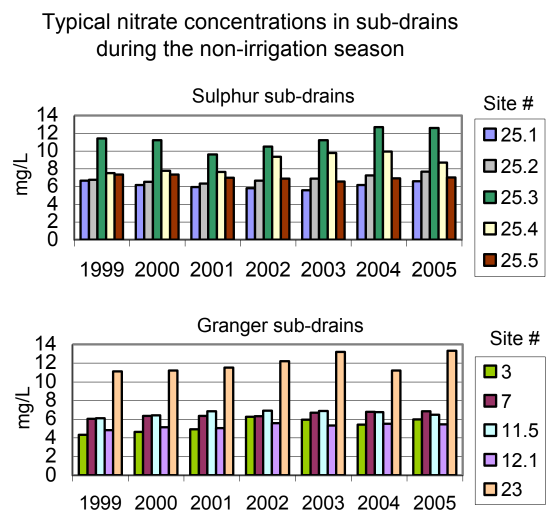
When comparing drainage areas of different sizes, yields are useful because they are the amount (usually in pounds) of a substance coming from a drainage area on a *per irrigated acre* basis.

Non-irrigation season

During the non-irrigation seasons, yields of water and all constituents from Spring and Snipes were substantially lower than from Granger and Sulphur. Why? The primary known transport mechanisms during these months are stormwater runoff, bedload movement within the waterways, and groundwater seeping into the waterways. How could those processes differ in the different drainages?



The potential influence of stormwater was likely largest in Sulphur and Granger, with urban areas of about 4,500 and 500 acres, respectively, while there were no urban areas in Spring or Snipes. The dominant types of substrate in the drain were fines (mud) in Sulphur and Granger and gravel and cobble in Spring and Snipes. Smaller substrate would allow bedload movement at lower water velocities in Sulphur and Granger than in Spring or Snipes. Spring and Snipes had more basalt on or near the surface of the land than Granger or Sulphur drainage areas, possibly decreasing the connectivity of the drain to shallow groundwater. Snipes had the lowest proportion of irrigated acres within its drainage area, likely responsible for it having the smallest ratio of typical irrigation-to-nonirrigation flow values.

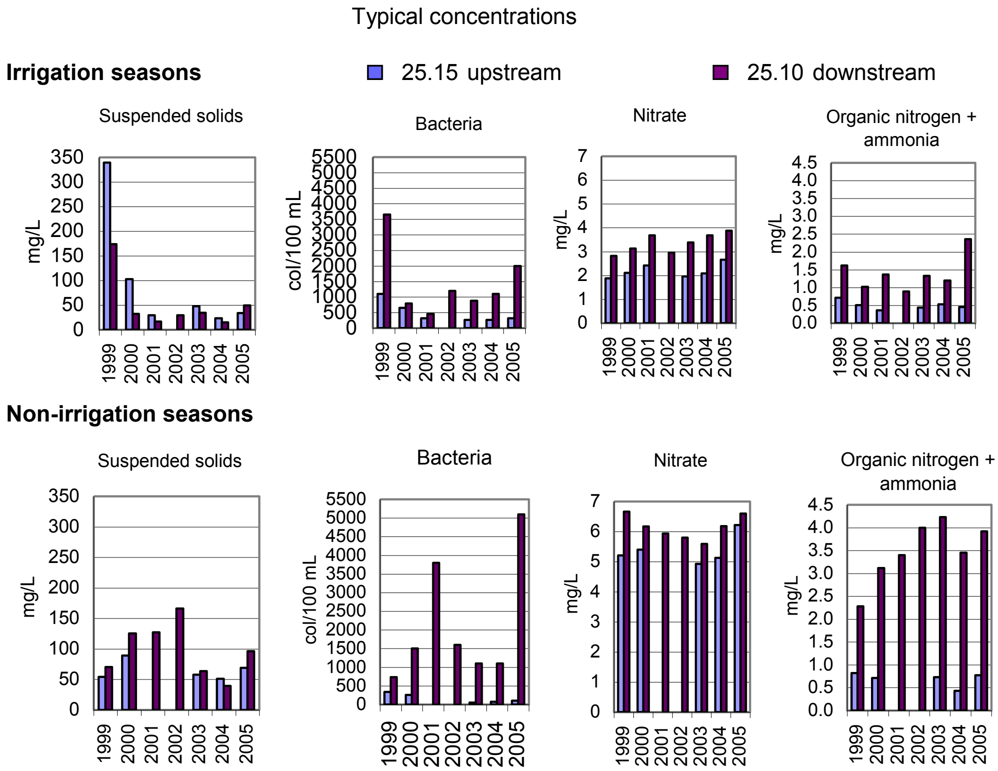


Granger and Sulphur drainage areas were more similar than different and non-irrigation seasonal yields of bacteria, phosphorus, organic nitrogen+ammonia, and water were similar in their sub-drains. The reason for especially high nitrate concentrations in one each of the Sulphur and Granger sub-drains is unknown but may be related to the depth of the sub-drains.

Implication: Differences between drainage basin characteristics related poorly to differences in water quality in the waterways during the irrigation season, despite many studies in other areas which have found basin characteristics are important factors. Perhaps the complexity of crops and irrigation practices in these drainages masks patterns that would otherwise be reflected in the data. During the non-irrigation season, differences in land use (urban vs. agricultural) and basin characteristics (drain substrate, soil permeability, proportion of watershed under irrigation) may explain some differences between waterways.

Did the urban area influence water quality? Yes. There was a marked difference in water quality upstream and downstream of the City of Sunnyside. The specific sources are unknown.

Joint Drain (JD) 33.4 begins in irrigated cropland above the Sunnyside Canal and enters Sulphur a few miles downstream of the City of Sunnyside. RSBOJC sampled JD 33.4 at sites upstream (site 25.15) and downstream (site 25.10) of the city from 1999 to 2005. Between these two sites are three small irrigation return drains, storm drains which discharge to JD 33.4, and two permitted wastewater treatment facilities. Typical concentrations of nutrients and bacteria increased substantially between the upstream and downstream sites.



Concentrations at site 25.10 (downstream of the City of Sunnyside) were high enough to substantially affect conditions at the mouth of Sulphur. Concentrations of bacteria, nitrate, organic nitrogen+ammonia, and discharge were higher in Sulphur than the other waterways during the non-irrigation season, but when site 25.10 was removed from consideration, the concentrations of most constituents in Granger and Sulphur sub-basins became comparable.

Implication: We have work to do. We need to better understand what influences water quality in Joint Drain 33.4. The number and diversity of inputs to the drain (smaller irrigation return drains, storm water drains, effluent from permitted wastewater treatment facilities, and illegal septic system connections) plus the overlapping legal jurisdictions (irrigation district, city, county, and state) make investigative work a significant challenge.

Broader Context

How Did Conditions Compare to Regulatory Standards and to Other Watersheds? Most regulatory criteria were not met. Compared to other watersheds, these waterways had similar yields of suspended solids but often higher yields of nutrients.

Despite significant decreases in bacteria concentrations in three of the waterways from 1997 to 2008, none of the waterways met state standards during the irrigation season nor, in most cases, the non-irrigation season. Concentrations in Snipes were significantly less than other waterways and may be useful to illustrate the potential for improvement in the other waterways. Dissolved oxygen concentrations and pH values routinely and frequently exceeded state standards, even during winter months when algal and plant growth rates are typically reduced, suggesting limits on the ability of these waterways to meet state standards during warmer summer months. The Department of Ecology's clean-up goal for turbidity, 25 NTU in 90 percent of the samples, was met in three of the four waterways.

From 2000 through 2008, yields (pounds per irrigated acre per day) of suspended solids were similar to other irrigated areas. Nutrient yields were generally on the high end of the range for Granger and Sulphur. Phosphorus yields in Spring and Snipes were, in a few years, slightly less than from undeveloped basins throughout the U.S. – remarkable in an irrigated area.

Implication: As we improve our understanding of how these systems work, we can share our knowledge with regulatory and interested agencies to encourage decisions based on the most current data available. Internally, as we continue to learn in future years, we may be able to apply what we learn about Spring and Snipes to Granger and Sulphur.

Can These Data be Used as Indicators of Soil and Water Conservation Efforts? With caution, yes, for yields of suspended solids and nutrients. But not yet for estimating suspended solids entering and leaving the drainage areas.

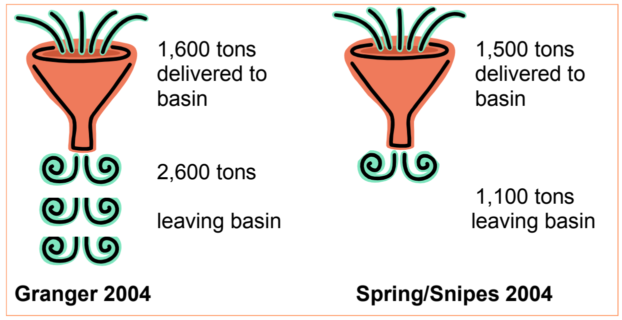
Changes in yields

Extrapolating the range of median suspended solids yields (0.2 to 2.5 lb/ac/day) during 2000-08 in Sulphur to the entire irrigation season results in a rough estimate of 40 to 500 lb/ac for the entire irrigation season – substantially less than the 1.9 tons/ac (3,800 lb/ac) reported for the 1976 irrigation season in Sulphur by Boucher and Fretwell, 1982. Extrapolating the nitrate and phosphorus median yields resulted in rough estimates for the irrigation season of 6 to 14 lb/ac nitrate and 0.4 to 1.4 lb/ac phosphorus — very similar to the yields reported for the 1976 irrigation season of about 14 lb/ac nitrate and 2.4 lb/ac.

Implication: When all other factors remain unchanged, a decrease in suspended solids yields in an irrigated area should reflect decreased erosion. However, changes that affect water movement in the waterways (such as piping, rip rapping, dredging, etc.) can also affect yields by changing how deposited sediment moves within a waterway. These changes were not assessed in this report, so we need to be cautious in using changes in yields to indicate success.

Load balance

When comparing the suspended solids load delivered to these drainage basins in canal water during the 2000 and 2004 irrigation seasons against the load in the waterways, in Granger and Sulphur more load left the basins than entered, while in Spring/Snipes less load left the basin than entered the basin. Although concentrations of suspended solids in the canal water were low, the sheer volume of water delivered to farms for irrigation resulted in significant amounts of dirt coming into the basins.



Unfortunately, the above calculations are based on assumptions for which the uncertainty cannot be estimated. Without an estimate of uncertainty, it would be premature to determine the significance of the results.

Implication: If this roughly estimated mass balance is later determined to be accurate using other methods, the net gain of suspended solids in the Spring/Snipes drainage basin could be a strong indicator of successful conservation practices.

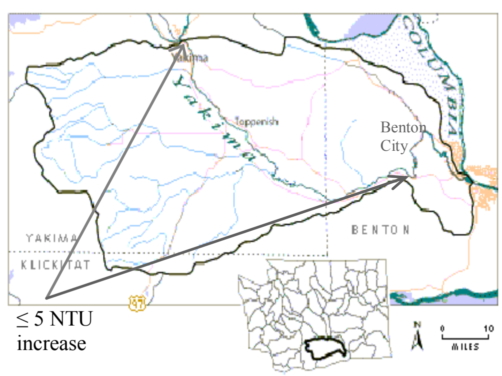
Influence on the Yakima River

The influence of irrigation return waterways on Yakima River has been assessed by multiple agencies since the 1970's. This report did not attempt to summarize all of their efforts but did attempt to provide a larger context to the RSBOJC data collected from 1997 to 2008, focusing on suspended solids, bacteria, nutrients, and temperature.

Were the improvements in the waterways reflected in the river? Improvements in suspended solids in the waterways were reflected in the river. Improvements in phosphorus were not reflected. Improvements in bacteria could not be estimated with existing data.

Suspended solids

A 1995 Department of Ecology study found Granger, Sulphur, Spring, and Snipes were major sources of suspended solids to the lower Yakima River. Eight years later, in 2003, the department found the river met the turbidity clean-up goal of no more than a 5 NTU increase between the City of Yakima and Benton City from late June (after snowmelt ended) through October. Further, when considering all of the 2003 data, no significant difference between the two sites was found. The amount (pounds per day) of suspended solids in the river at Benton City was substantially less than in 1995, which the department attributed to improved irrigation practices.



Implication: Given the presence of roughly 390 square miles of irrigated crops and more than 16 irrigation waterways entering the river between the City*

of Yakima and Benton City, the lack of difference in turbidity in the Yakima River between these two locations is a visible measure of progress. Between these cities, however, is a roughly 25-mile section of river with a low gradient and slow-moving water during the summer, resulting in some of the suspended solids being deposited on the riverbed before reaching Benton City. So an even better indicator of success is the decrease in the amount (load) of suspended solids between years at the same site (Benton City) during similar flow conditions.

* The 390 mi^2 estimate is the sum of irrigated acres in the Roza Irrigation District, Sunnyside Division, and Wapato Irrigation Project.

Bacteria

The Yakima River at Kiona met state fecal coliform standards from 2000 to 2007; however, since this site is many miles downstream of the four waterways, its use as an indicator of the impact of the waterways — especially Sulphur and Granger — is limited.

When USGS sampled the Yakima Basin for fecal coliform in 1999 and 2000, variability between field replicates was so high that for differences to be meaningful, they had to differ by an order of magnitude. Neither of the two sites with significant increases from July 1988 to August 1999 were downstream of these four waterways. And there were no significant differences between August 1999 and EPA data from July-September 1972-85.

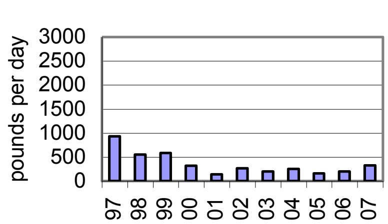
Implication: The degree that these four waterways influence bacterial concentrations in the river cannot be assessed with available data, in part due to sampling locations and in part due to extreme variability in concentrations from samples taken at the same place within a week.

Nutrients

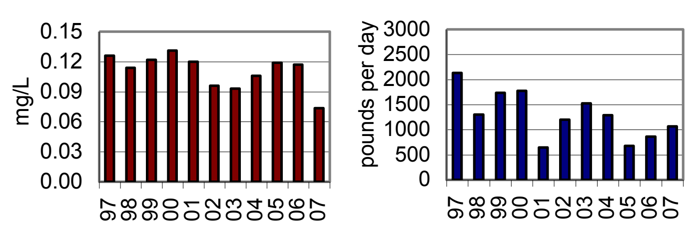
As with turbidity and suspended solids, the amount of phosphorus coming from the waterways was compared against conditions in the Yakima River near Benton City. Nitrate was not evaluated since concentrations did not follow a downward trend and organic nitrogen+ammonia was not evaluated because the Department of Ecology does not analyze for that constituent.

The 46-85% decline in the amount (load) of phosphorus coming from the waterways was not similar to patterns of changing phosphorus concentrations or loads at Kiona (near Benton City) but a general decrease over the years did occur in the river.

Sum of typical irrigation season phosphorus loads from 4 waterways, 1997-2007 (RSBOJC data)



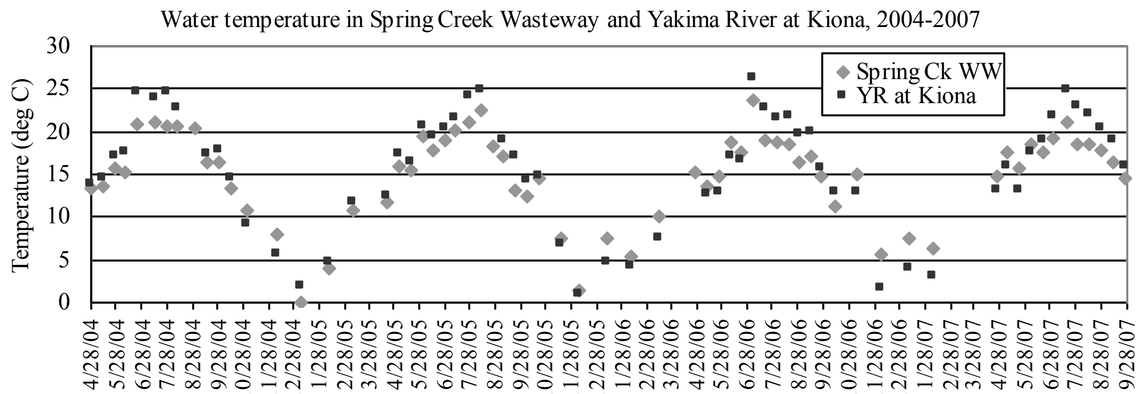
Yakima River at Kiona, typical total irrigation season phosphorus concentrations and loads, 1994-2007 (Dept. of Ecology data).



Implication: We need to better understand the diverse factors which influence phosphorus in the river in order to develop effective strategies to reduce concentrations in the river.

Was water in the waterways warmer or cooler than the river? Cooler in the summer and warmer in the winter.

From 2004 through 2007, Spring and Snipes were generally cooler than the Yakima River in summer and warmer than the river in winter. Based on flux calculations, the degree to which the temperature difference influenced the river was slight (less than four percent, in 90 percent of the data).



Implication: Cooler water from these two waterways may provide benefits to the river on a microhabitat-scale but not on a reach scale.

Conclusions

Over $20,000,000 of public funds and an unknown amount of private funds were spent to improve water quality in waterways in the lower Yakima Valley from 1997 to 2008. The improvements in turbidity were declared a partial success on a national and state level. With the decreasing rates of return observed after 2000, what effort will be needed to continue improvements, for example to reach the turbidity and fecal coliform goals for Granger Drain? More funding? More time? Different approaches? Our understanding of these data does not yet provide answers to these questions. Without a technical basis for decision-making, policy makers will rely instead on other types of information — economic, competing priorities, regulatory settings, etc.

Although these data did not generate a list of specific actions needed to continue improving water quality, a great deal was learned from the first twelve years of data, including quantifiable indicators of success, a better understanding of our impact on these waterways, and specific questions to ask in the future which may help answer the policy questions, above.

Indicators of improvements in water quality and conservation efforts included:
(a) Substantial and significant decreases in concentrations, loads, and yields of most constituents in most waterways during the first twelve years of data collection.
(b) Order-of-magnitude decreases in yields of suspended solids in Sulphur Creek Wasteway between 1976 and 2000-08.

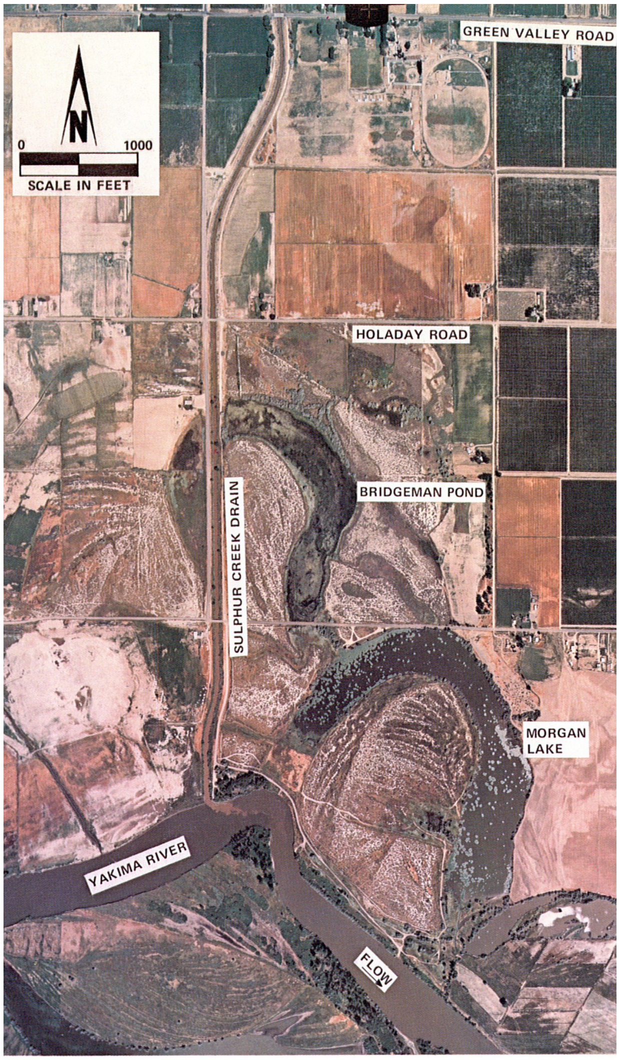
(c) Phosphorus yields in a few years in Spring and Snipes that were slightly less than yields from undeveloped basin in the U.S.
(d) The turbidity goal set by the Department of Ecology was met in three out of four waterways.
(e) Suspended solids loads and turbidity in the lower Yakima River decreased.

Indicators suggesting further work is needed included:
(a) The intensive effort to reduce erosion in irrigated areas likely has not yet resulted in decreased nitrate concentrations in groundwater, if concentrations in the waterways reflect changes in concentrations in groundwater.
(b) The rate of improvement in surface water quality decreased from 2000 to 2008 compared to 1997 to 2000.
(c) The turbidity and bacteria goals set by the Department of Ecology for Granger Drain were not met.
(d) Nitrogen yields were generally high-to-moderate compared with other watersheds.
(e) Unexplained increases of phosphorus, organic nitrogen+ammonia, and bacteria downstream of the Sunnyside urban area need further investigation.

Differences and similarities between drainage basin characteristics related poorly to differences in water quality in the waterways during the irrigation season. During the non-irrigation season, differences in land use (urban vs. agricultural) and basin characteristics (drain substrate, soil permeability, proportion of watershed under irrigation) may explain some of the differences between waterways.

Future efforts to improve water quality may benefit from a better understanding of the factors which result in generally better water quality in Snipes, the factors influencing spatial variability in nitrate concentrations, ways to minimize the effects of the urban area, and the relationship between irrigation and non-irrigation season conditions.

As we continue to improve our understanding of the complexities of these systems, it will become increasingly important to keep current conditions in perspective with the not-so-distant past. It may also help to remember the reasons earlier efforts were successful: the grassroots involvement of farmers with diverse backgrounds (farms of varying size representing the wide range of commodities produced in the lower valley), the cooperation between many organizations, funding availability, and the political will to proceed against difficult odds.



July 1974
From "Agricultural Return Flow Management in the State of Washington," CH2M Hill.

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For more information, contact Elaine Brouillard, RSBOJC water quality specialist, (509) 837-6980.