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Water Quality in the Central Columbia Plateau

Washington and Idaho, 1992–95

U.S. Department of the Interior
U.S. Geological Survey

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FOR ADDITIONAL INFORMATION ON THE NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) PROGRAM:

Central Columbia Plateau Study Unit contact:

District Chief
U.S. Geological Survey
Water Resources Division
1201 Pacific Ave., Suite 600
Tacoma WA 98402
Phone: (253) 428-3600

NAWQA Program contact:

Chief, NAWQA Program
U.S. Geological Survey
Water Resources Division
12201 Sunrise Valley Drive, M.S. 413
Reston VA 20192

Information on the NAWQA Program is also available on the Internet via the World Wide Web.

The Central Columbia Plateau Study Unit's Home Page is:
http://water.usgs.gov/lookup/get?wawater/ccpt/
Email: nawqa_ccpt_wa@usgs.gov

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Front cover: Rolling hills near Pullman, Washington. The Palouse basin is almost entirely cropped in wheat and other dry-farmed grains. Strip cropping (alternating bands of different crops or fallow) is a best management practice (BMP) designed to reduce soil erosion. *(Photograph © by Phil Schofield. Used with permission)*

Back cover: Front cover photograph and a second photograph, looking south from where I-90 crosses the Columbia River, showing the mouth of Crab Creek, and irrigated circles on both the Royal Slope in front of the Saddle Mountains and on the Wahluke Slope beyond. *(Second photograph by Dennis Cline, U.S. Geological Survey)*

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Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992–95

By Alex K. Williamson, Mark D. Munn, Sarah J. Ryker, Richard J. Wagner, James C. Ebbert, and Ann M. Vanderpool

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A contribution of the National Water-Quality Assessment (NAWQA) Program

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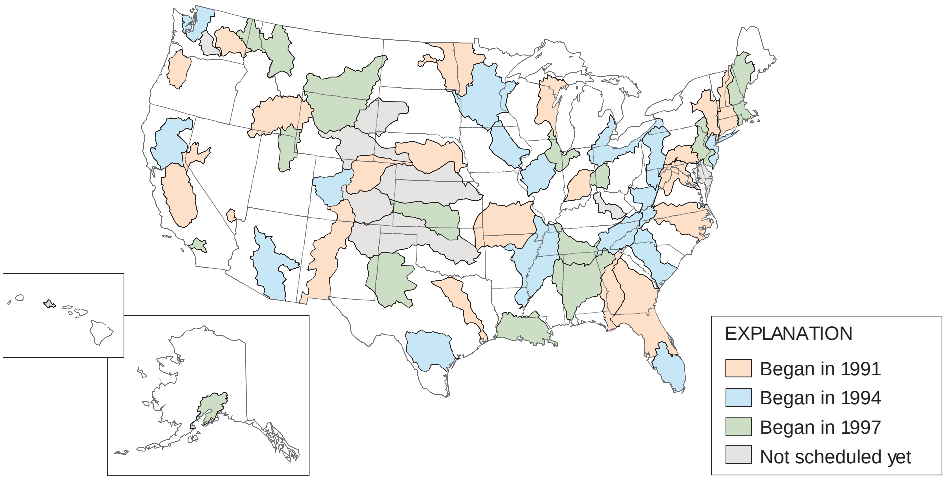
Numbers in [ ] refer to References. Words in *italics* are defined in the Glossary.



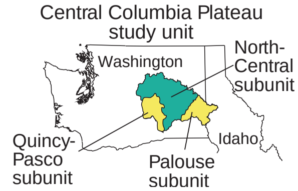
Knowledge of the quality of the Nation's streams and aquifers is important because of the implications to human and aquatic health and because of the significant costs associated with decisions involving land and water management, conservation, and regulation. In 1991, the U.S. Congress appropriated funds for the U.S. Geological Survey (USGS) to begin the National Water-Quality Assessment (NAWQA) Program to help meet the continuing need for sound, scientific information on the areal extent of the water-quality problems, how these problems are changing with time, and an understanding of the effects of human actions and natural factors on water quality conditions.

The NAWQA Program is assessing the water-quality conditions of more than 50 of the Nation's largest river basins and aquifers, known as Study Units. Collectively, these Study Units cover about one-half of the United States and include sources of drinking water used by about 70 percent of the U.S. population. Comprehensive assessments of about one-third of the Study Units are ongoing at a given time. Each Study Unit is scheduled to be revisited every decade to evaluate changes in water-quality conditions. NAWQA assessments rely heavily on existing information collected by the USGS and many other agencies as well as the use of nationally consistent study designs and methods of sampling and analysis. Such consistency simultaneously provides information about the status and trends in water-quality conditions in a particular stream or aquifer and, more importantly, provides the basis to make comparisons among watersheds and improve our understanding of the factors that affect water-quality conditions regionally and nationally.

This report is intended to summarize major findings that emerged between 1992 and 1995 from the water-quality assessment of the Central Columbia Plateau Study Unit and to relate these findings to water-quality issues of regional and national concern. The information is primarily intended for those who are involved in water-resource management. Indeed, this report addresses many of the concerns raised by regulators, water-utility managers, industry representatives, and other scientists, engineers, public officials, and members of stakeholder groups who provided advice and input to the USGS during this NAWQA Study-Unit investigation. Yet, the information contained here may also interest those who simply wish to know more about the quality of water in the rivers and aquifers in the area where they live.

Robert M. Hirsch, Chief Hydrologist

GROUND WATER: Ground water, the main source of drinking water, is substantially affected by agricultural practices.



Concentrations of nitrate in many wells exceed the drinking water standard (p. 6–8).

- Nitrate concentrations in about 20 percent of all wells exceed the drinking water standard, which is the U.S. Environmental Protection Agency maximum contaminant level (MCL). The highest exceedance rates occur where fertilizer use and irrigation are greatest.
- The primary source of nitrate in ground water is agricultural fertilizers. Other sources include cattle feedlots, food processing plants, septic tanks, and wastewater discharges.
- Nitrate concentrations are generally highest in shallow wells in irrigated areas, including many domestic wells and shallow public supply wells.
- Nitrate concentrations in shallow wells are among the highest in the Nation (p. 22).

Pesticides are frequently detected, although generally at concentrations below drinking water criteria (p. 10–11).

- Pesticides were detected in 60 percent of shallow wells and 46 percent of deeper public supply wells.
- Concentrations of only three pesticides exceed the MCL or a health advisory: dieldrin, EDB, and 1,2-dichloropropane. These pesticides have been discontinued from use, and the exceedances occur in only 2 percent of the wells.
- Herbicides were detected most often, especially atrazine and its breakdown products. However, no concentrations of an herbicide exceed MCLs or health advisories.
- Shallow wells in irrigated agricultural areas of the Quincy-Pasco subunit have the most pesticide detections and the largest number of different pesticides detected per well. Pesticide detections also correlate with elevated nitrate concentrations.
- In the Palouse subunit, none of the commonly used pesticides were detected in ground water, although 10 were detected in surface water.
- Sixty-four percent of public supply wells with detections of pesticides contain more than one detectable pesticide. The human health significance of very low concentrations of several pesticides is uncertain because drinking water standards do not exist for 40 percent of the pesticides detected or for occurrences of multiple pesticides.
- Pesticides were detected more frequently than the national average, with the exception of those in shallow ground water associated with dryland farming (p. 22).

Radon, a naturally occurring gas, is not increased by agricultural practices. Neither radon nor trace elements are a major concern in the Central Columbia Plateau.

Is ground-water quality improving?

Improvements from best management practices (BMPs) take decades or longer to be seen.

- However, as a result of fertilizer use leveling off since 1985, nitrate concentrations may be beginning to level off in some areas. In many areas, concentrations continue to rise.

It is difficult to determine trends for pesticides because there are not enough data, but the patterns of detection may give some clues (p. 10).

- The newer pesticides, which are less persistent in the environment than the discontinued ones, were not detected at concentrations above MCLs or health advisories. EDB, discontinued in the late 1970s, was detected more frequently in deeper wells, possibly indicating that it is moving down into deeper ground water. This is another indication that ground-water quality improvements take decades or longer.
- Concentrations of nitrate and pesticides are generally similar in shallow ground water and in surface water at base flow, which occurs in winter. Trends in pesticides in ground water are most cost effectively monitored by sampling surface water at base flow, though sampling very shallow wells gives the most current picture of ground-water quality (p. 13).

SURFACE WATER: The health of the aquatic ecosystems is substantially affected by agricultural practices and, in a few streams, by wastewater discharges.

Eutrophication, caused by high concentrations of nutrients, is degrading streams (p. 17, 18).

- Eutrophication results in excessive plant growth, sometimes reducing dissolved oxygen below levels that some fish species require.
- Improving the health of aquatic ecosystems may require reducing nitrate concentrations in ground water. At one site in the Quincy-Pasco subunit, over 60 percent of the nitrogen comes from ground water (p. 13).

Sediment erosion and runoff are degrading streams (p. 14–15, 19).

- In most streams, sediment loading has reduced instream habitat needed by fish and other aquatic life (p. 19). Moreover, eroded soil particles carry pesticides that accumulate in streambeds and also in fish tissue.
- Concentrations of some long-banned but persistent organochlorine pesticides (such as DDT) or total PCBs exceed environmental guidelines for streambed sediment at 22 percent of the sites sampled.
- However, concentrations of trace elements are not elevated above naturally occurring levels in soils.

Riparian (streamside) habitat has been seriously reduced, and present-day agricultural practices limit natural recovery of the vegetation (p. 19).

- Loss of riparian habitat causes stream temperatures to increase and stream banks to become more unstable, and thus more likely to erode. Increased temperatures and sediment in streams can alter resident fish communities.
- Grazing practices also contribute to erosion of destabilized stream banks.

Concentrations of agricultural pesticides occasionally exceed criteria for the protection of aquatic life in several streams (p. 12).

- Highest concentrations and exceedances of freshwater-chronic criteria generally occur within a month or two of pesticide application.
- Most exceedances of freshwater-chronic criteria are for currently used organophosphate insecticides.
- Carp in a small lake in the Quincy-Pasco subunit showed nervous system abnormalities, possibly indicating exposure to organophosphate insecticides; long-term effects are uncertain (p. 19).

Is surface-water quality improving?

Soil erosion is decreasing as a result of best management practices (BMPs) (p. 14–15).

- Changing from furrow to sprinkler irrigation is reducing the loss of soil from irrigated cropland in the Quincy- Pasco subunit.
- Soil erosion from irrigated cropland and DDT concentrations in sediment and fish correlate with the percentage of furrow-irrigated land, so changing to sprinklers also improves sediment quality.
- Improved farming practices may have reduced soil erosion from dry-farmed cropland in the Palouse subunit.

Although concentrations of nutrients are commonly still increasing, at some sites they have decreased slightly or begun to level off (p. 9, 17).

Rich grasslands and forested canyons inspired 19th-century cattle ranchers to make the Central Columbia Plateau their home. As overgrazing devalued the land for ranching, farming became more important. Today it is an area of national agricultural importance and home to about 300,000 people. The region is one of the Nation's top two producers of potatoes and wheat, is a significant producer of apples and many other crops, and supports much rangeland grazing.

The Study Unit was divided into three subunits on the basis of hydrologic and geologic differences affecting land and water use (see p. 24–25). Thick *loess* and moderate precipitation allow for dryland farming in the Palouse subunit, while the Columbia Basin Irrigation Project has made the Quincy-Pasco subunit also productive for farming. The North-Central subunit supports rangeland grazing and, where conditions allow, irrigated and dryland farming.

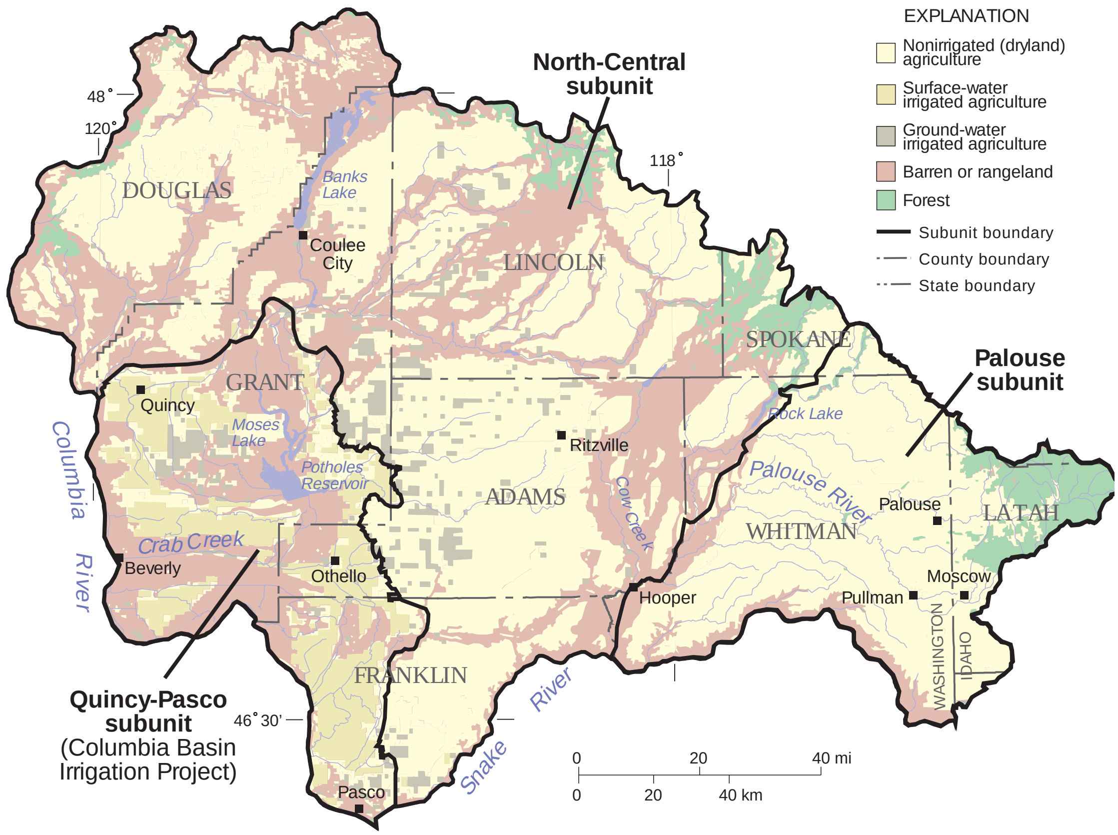


Figure 1. Most of the land in the Central Columbia Plateau is used for agriculture.

Table 1. Summary of subunit characteristics [mi^2, square mile; %, percent]

	Quincy-Pasco subunit (2,500 mi^2)	North-Central subunit (8,100 mi^2)	Palouse subunit (2,500 mi^2)
Total cropland[a] **Major crops**[b] (approximate percentage of total cropland)	896,000 acres alfalfa (30%) wheat (20%) field crops (15%) corn (11%) potatoes (10%) orchard (7%)	3,210,000 acres cereal grains (wheat, barley, oats) (93%)	1,260,000 acres cereal grains (78%) field crops (19%)
Hydrology	Controlled during irrigation season (Mar.–Oct.) Nearly all surface water is canals and agricultural drains Storm runoff is rare	Intermittent streams with few disconnected perennial stream segments	Perennial streams in larger basins
Major point and localized nonpoint sources of pollutants	Feedlots, pesticide handling areas Land-applied food-processing effluent Land-applied wastewater-treatment effluent	Some feedlots	Wastewater-treatment effluent discharged to streams
Surficial geology **Topography**	Varied thickness of sediments over basalt Nearly flat basins between bluffs	0-20 feet of loess over basalt Channeled scablands	5-100 feet of loess over basalt Rolling hills
Water table change, 1950 to present	Rise of 50 to 500 feet	Decline of more than 150 feet in some locations	Slightly declining

[a] [1]; [b] [2, 3]

The climate is arid to semiarid

The arid to semiarid climate is evident in the hydrology. Only the Palouse subunit receives enough rainfall (fig. 2) to support *perennial streams* that have high flows in the wetter winter months and low *base flows* in the dry, hot summer months (fig. 3). Before increased irrigation, the remainder of the Study Unit mostly supported intermittent streams that only had substantial streamflows following storms; this is still true for most of the North-Central subunit.

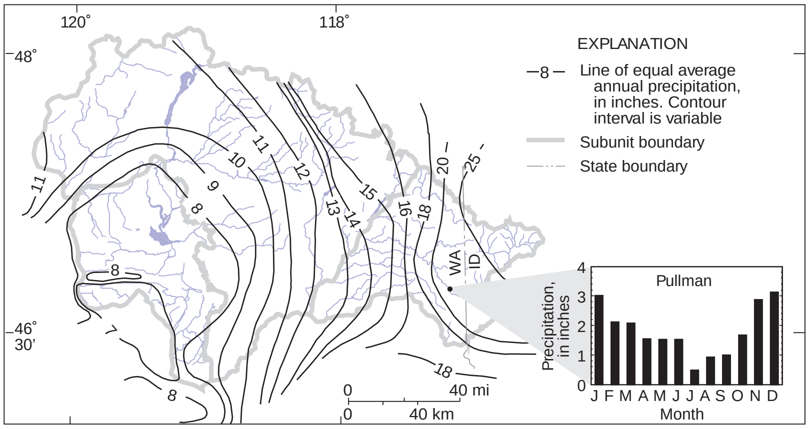


Figure 2. Average annual precipitation is highest in the Palouse subunit; average monthly figures for Pullman, Wash., show that precipitation mostly occurs in the winter (years of record 1956–77). Modified from [4].

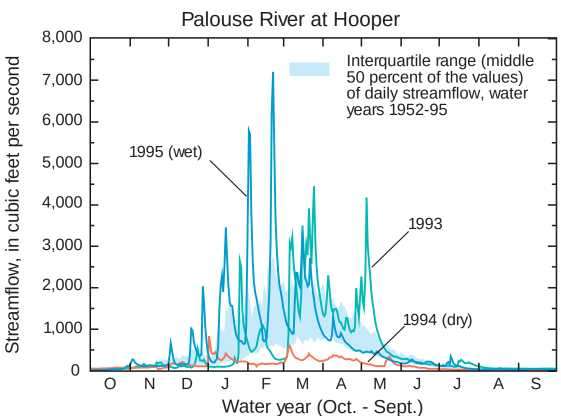


Figure 3. Conditions in the Palouse subunit were typical during 1993–95, the sampling period, with variable streamflows in dry, average, and wet years.

Irrigation has greatly altered the Quincy-Pasco subunit

Irrigation in the Quincy-Pasco subunit increased significantly during 1955–75 as the Columbia Basin Irrigation Project made more water available. Water diverted from the Columbia River, conveyed through irrigation canals, and applied to agricultural lands has raised the *water table* tens to hundreds of feet, creating or increasing base flow to many of the streams and *wasteways*. The result is an overall annual increase in streamflow, controlled mostly by irrigation, with base flow in the winter and high flows in the summer (fig. 4).

Most water withdrawals are for irrigation

About 94 percent of combined ground- and surface-water withdrawals are for irrigation [5]. Eighty-four percent of public and domestic supplies comes from ground water (fig. 5).

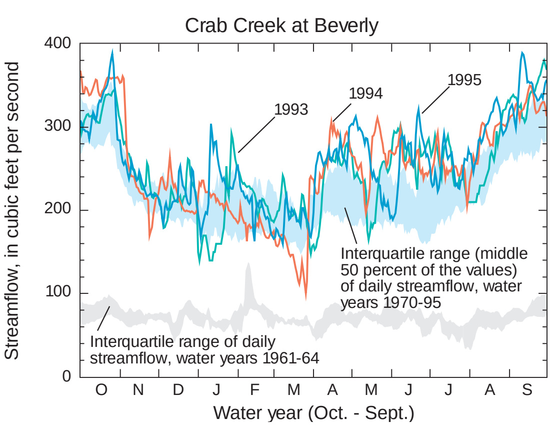


Figure 4. In the Quincy-Pasco subunit, irrigation has increased and stabilized streamflows throughout the year.

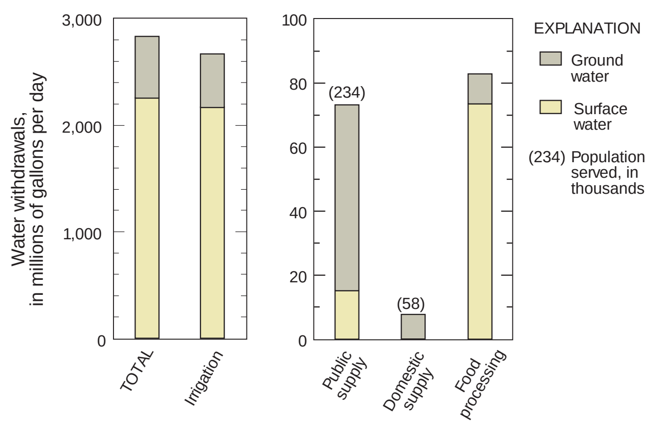


Figure 5. Most of the water in the Central Columbia Plateau is used for irrigation. Ground water is the main source of drinking water (1990 data shown; graphs have different vertical scales) [5].

Nitrate concentrations in many drinking water wells exceed the maximum contaminant level (MCL).

In the Central Columbia Plateau, 84 percent of drinking water comes from ground water. Both public supply and domestic water systems depend largely on ground water [5, 6] (fig. 5). Current nitrate data are generally available for public supply wells, which must be sampled regularly. Domestic wells, however, are generally sampled only for special studies. About 20 percent of wells in the Study Unit exceed the *MCL* for nitrate in drinking water [1, 7]; the MCL is set by the U.S. Environmental Protection Agency at 10 milligrams per liter (mg/L) [8]. Reducing nitrate in ground water has been the focus of cooperative efforts between Federal, State, and local agencies.

Nitrate concentration has been suggested as an indicator of overall ground-water quality [9, 10], and drinking water with high nitrate concentrations is a potential health risk, particularly for infants [7, 8, 11].

The Quincy-Pasco subunit has the highest percentage of wells exceeding the MCL

The Columbia Basin Irrigation Project brings more than 2,500,000 *acre-feet* (800 billion gallons) of water per year from the Columbia River to the Quincy-Pasco subunit, enabling intensive irrigated agriculture.

In much of the North-Central subunit, deep ground water is the only source of water. Most of this subunit's high nitrate concentrations are in the shallower wells bordering the Quincy-Pasco subunit.

The Palouse subunit, dominated by nonirrigated agriculture, has generally lower nitrate concentrations than the rest of the Study Unit.

Table 2. Percentage of drinking water wells sampled in 1985–96 with nitrate concentrations[a] exceeding the U.S. Environmental Protection Agency maximum contaminant level of 10 milligrams per liter [--, insufficient data; %, percent]

		Class A public supply wells [b]	Class B public supply wells [c]	Shallow domestic wells [d]
County [e]	Adams	3%	25%	- -
	Douglas	7%	- -	- -
	Franklin	28%	29%	33%
	Grant	1% [f]	3%	35%
	Whitman	7%	4%	6%
Subunit	Quincy-Pasco	9%	15%	35%
	North-Central	3%	5%	- -
	Palouse	7%	5%	5%
Study Unit		6%	12%	- -

[a] For wells sampled more than once, the most recent value was used. [b] 411 public water systems with at least 15 hook-ups; average depth 270 feet [9]. [c] 270 public water systems with less than 15 hook-ups; average depth 210 feet. [d] 67 domestic wells sampled for the NAWQA Land Use Study component (p. 24); average depth 140 feet [3]. [e] Percentages were not calculated for counties that fall partly outside the study area. [f] Most wells are deep, averaging 500 feet (see Moses Lake area, fig. 6).

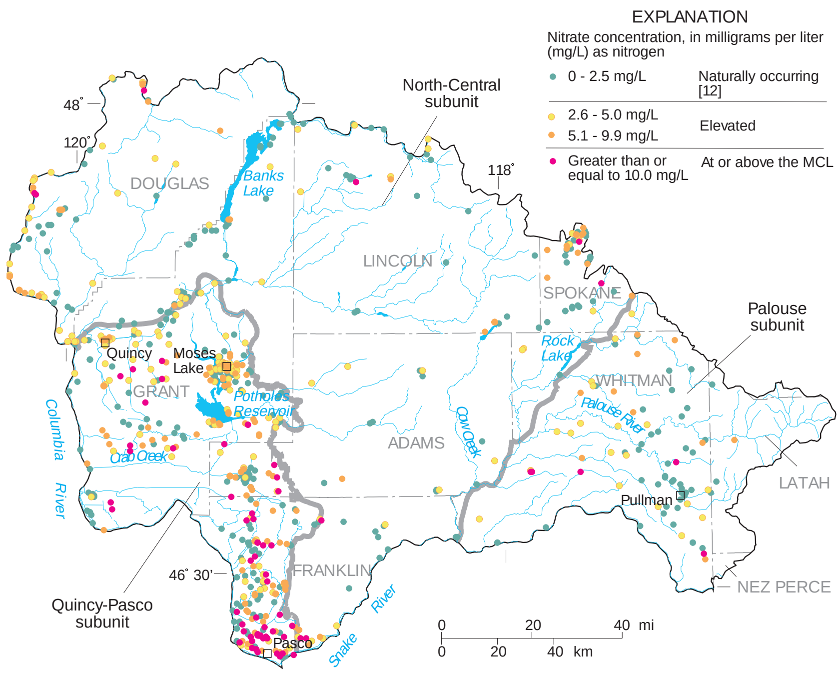


Figure 6. Most public supply wells [13] and domestic wells that exceed the maximum contaminant level (MCL) for nitrate are in the Quincy-Pasco subunit. (Wells were sampled from 1985 to 1996; for wells sampled more than once, the most recent value was used.)

Intensive application of fertilizers and irrigation water causes high nitrate concentrations in the Quincy-Pasco subunit

Synthetic fertilizers became widely available after World War II. Fertilizers are the source of 84 percent of nitrate inputs to the Central Columbia Plateau [16]. Other sources of nitrate include cattle feedlots, food processing plants, septic tanks, and treated wastewater; these are local and thus less important sources in most of the Study Unit.

Agricultural acreage continues to increase in the plateau, but nationally recommended application rates for fertilizer have been lowered in the last few years. As a result, fertilizer sales (fig. 7) and application have leveled off [12]. Irrigation, however, continues to increase in the plateau [fig. 8].

Two primary factors contribute to the Quincy-Pasco subunit's high nitrate concentrations: high rates of fertilizer application [fig. 9] and irrigation water. Ninety-four percent of all the water used in the plateau supports agricultural irrigation in the arid Quincy-Pasco subunit [5]. This extensive irrigation has greatly increased rates of recharge (fig. 10), which is water moving from the land surface to ground water. Recharge, especially at higher rates, moves nitrate into shallow ground water.

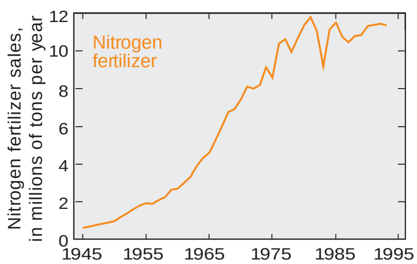


Figure 7. Sales of nitrogen fertilizer in the United States have leveled off [14, 15]. Graph modified from [12].

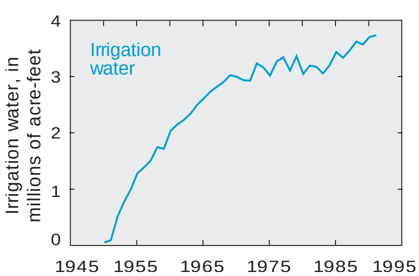


Figure 8. The amount of irrigation water diverted from the Columbia River has steadily increased [16].

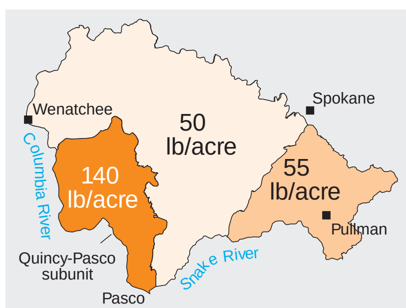


Figure 9. Annual application rates of nitrogen fertilizer are highest in the Quincy-Pasco subunit (rates are in pounds per acre (lb/acre)), (1991 data shown) [16].

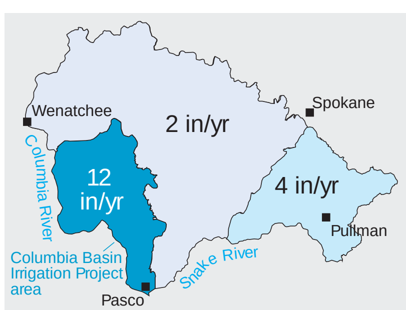


Figure 10. Average rates of recharge are highest in the Quincy-Pasco subunit (rates are in inches per year (in/yr)) [17].

Trends in nitrate concentrations vary across the Study Unit

Nitrate concentrations in the Central Columbia Plateau's ground water have generally increased since the 1950s. Although fertilizer application leveled off in about 1985, it is too early to be certain of any corresponding leveling off or decrease in nitrate concentrations in the regional ground-water system.

Individual wells may show trends that reflect only local conditions. For example, at Ringold Springs, one of the largest springs in the Study Unit, nitrate concentrations may have leveled off. However, the improvement is probably not as dramatic as is suggested by the decrease shown in figure 11.

Across the plateau, nitrate concentrations continue to increase in most areas. Examples of varying nitrate trends in ground- and surface-water systems are discussed on page 9.

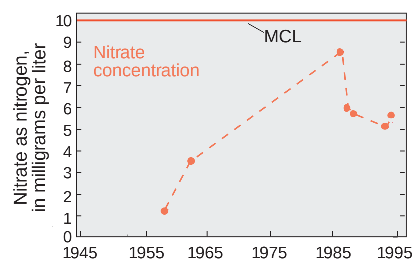


Figure 11. Nitrate concentrations may have leveled off at Ringold Springs, a large spring in the Study Unit (site A, fig. 14), from 1957 to 1994 [18]. However, data are limited and the peak concentration in 1986 may have been unusual.

Irrigation increases the variability of nitrate concentrations

Trends in individual wells may not reliably represent trends for a large area. In the Quincy-Pasco subunit, samples from springs and surface-water sites can give further insight into trends and variability of nitrate in ground water.

In the Quincy-Pasco subunit, nitrate concentrations in ground water can be much higher during the irrigation season (fig. 12). In some parts of the subunit, however, low-nitrate water leaking from irrigation canals may dilute nitrate in ground water, so that summer concentrations are close to naturally occurring levels (2–3 mg/L) [12].

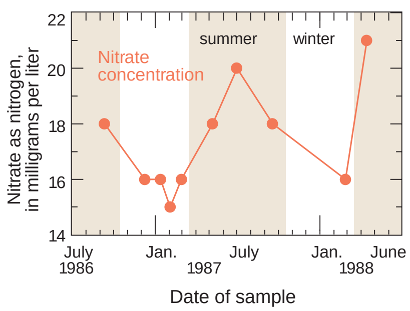


Figure 12. In a well in western Franklin County (site B, fig. 14), nitrate concentrations are higher during the peak irrigation season (Mar.–Oct.) [18].

The average nitrate concentration in regional shallow ground water is 6 mg/L or more. In fresh water diverted from the Columbia River for irrigation, nitrate concentrations are 1 mg/L or lower. As shown in figure 13, some wells close to canals have below-average nitrate concentrations due to dilution by water leaking from canals [18].

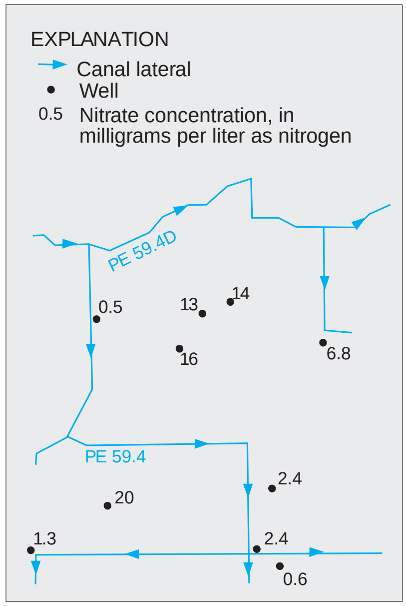


Figure 13. In an irrigated area in western Franklin County (area C, fig. 14), PE 59.4 Lateral has a nitrate concentration of 1.3 milligrams per liter. Most wells close to the canal have lower nitrate concentrations [18].

Deeper ground water, which is farther from sources of nitrate applied on the land surface, is less susceptible to contamination. Also, when irrigation raises the *water table* significantly, as has occurred in the Quincy-Pasco subunit, recently recharged ground water flows rapidly to surface waters instead of to deeper ground water. This prevents some of the nitrate present in recently recharged ground water from moving to deeper ground water. Figure 15 shows that nitrate concentrations are generally lower at greater depths. Many public supply wells are relatively deep, so have lower nitrate concentrations and exceed the MCL less frequently than do the shallower domestic wells (table 2).

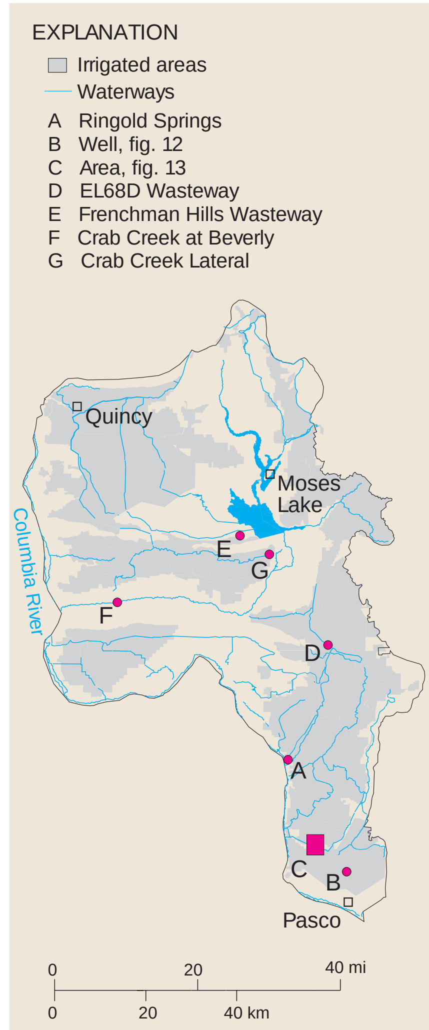


Figure 14. Sites in the Quincy-Pasco subunit (also the Columbia Basin Irrigation Project area) used to describe trends in nitrate concentrations.

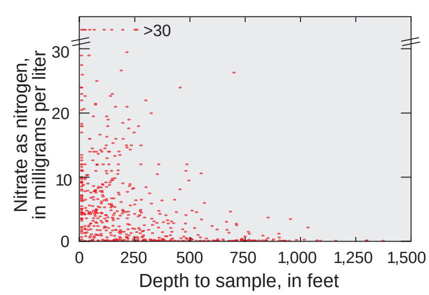


Figure 15. Nitrate concentrations are lower at greater depths; however, in irrigated areas (see fig. 14) some deep wells have elevated nitrate concentrations.

Sampling surface water at base flow is a cost-effective way to monitor trends in ground-water quality

Nitrate concentrations vary considerably in wells, requiring many samples to determine trends. However, in the Quincy-Pasco subunit many irrigation *wasteways* and other surface drains receive large contributions from ground-water discharge. For example, about 60 percent of total nitrogen discharged annually by EL68D Wasteway (site D, fig. 14) comes from ground-water discharges to the wasteway. From November to February, irrigation water is not delivered and storms large enough to produce runoff are rare. During this time, streamflow is low and ground water is the predominant source of nitrate in surface water conveyed by wasteways (fig. 16). Therefore, in the Quincy-Pasco subunit, samples of surface water during winter can be used to monitor nitrate trends in ground water for a large area. *Base-flow* surface-water sampling can also be used to track occurrence and trends in other dissolved constituents in ground water, including *pesticides* such as atrazine (p. 13).

Base-flow sampling in Palouse subunit streams is less indicative of ground water for several reasons. Base flow in the Palouse subunit occurs during the summer when plant growth is high; uptake of nitrogen by aquatic plants can greatly decrease nitrate concentrations in surface water. In addition, a substantial percentage of Palouse River flow in the summer is high-nitrate discharge from wastewater-treatment plants.

In the Quincy-Pasco subunit, nitrate concentrations are generally increasing . . .

In most parts of the Quincy-Pasco subunit, base-flow concentrations of nitrate in wasteways and other surface drains have increased since the 1960s — indicating an increase in nitrate concentrations in ground water. *Best management practices* (BMPs) in use in parts of the subunit may in time decrease these concentrations. However, changes in ground-water quality may not be apparent for decades or longer.

. . . but trends vary.

In Frenchman Hills Wasteway, base-flow nitrate concentrations doubled from about 3 to about 6 mg/L between 1966 and 1990 and appear still to be increasing (fig. 17). Ground water is the source of nearly 100 percent of base flow in the wasteway, so nitrate concentrations in nearby ground water have likely followed the same trend.

Base-flow nitrate concentrations are still increasing in Crab Creek at Beverly, but the increase has slowed since 1980. This trend is similar to trends that occurred in fertilizer sales (fig. 7) and irrigation (fig. 8) in much of the drainage basin. In addition, concentrations may be leveling off at this site because of contributions from the Crab Creek Lateral subbasin, where concentrations are decreasing.

In Crab Creek Lateral, base-flow concentrations of nitrate decreased from about 8 mg/L in 1966 to about 6 mg/L in 1991. This decrease may be partially explained by changing farming practices. For example, although the total amount of irrigated cropland draining to Crab Creek Lateral has not decreased, from 1974 to 1990 the proportion of this land used for orchards increased from 9 to 29 percent. Orchards require less applied nitrogen than do many of the row crops that they replaced [16].

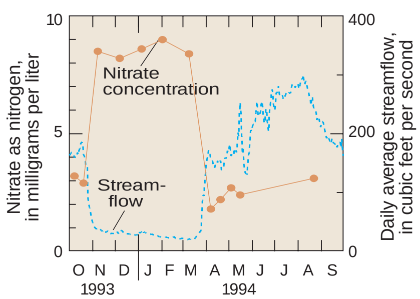


Figure 16. Nitrate concentrations at EL68D Wasteway (site D, fig. 14) are highest during the winter when the main source is ground-water discharge and there is little dilution by canals or return flows [2].

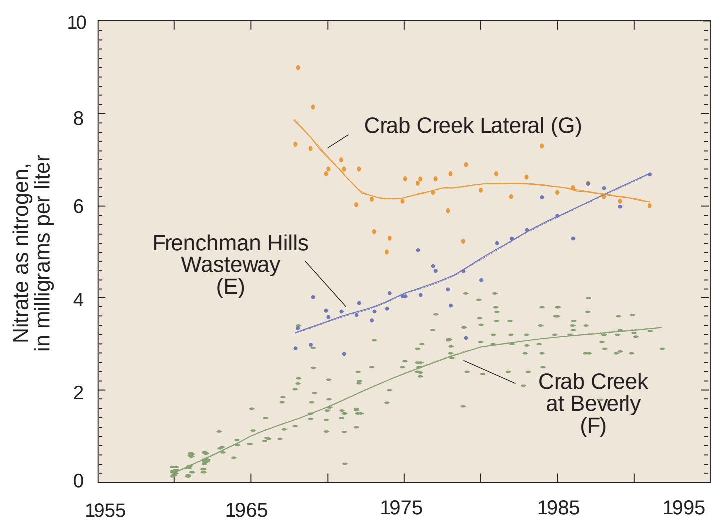


Figure 17. Three sites in the Quincy-Pasco subunit show varying trends in nitrate concentrations at base flow (Nov.-Feb.) from 1960–91. In Frenchman Hills Wasteway (site E, fig. 14), concentrations doubled. At Crab Creek at Beverly (site F), the increase has slowed since 1980. In Crab Creek Lateral (site G), there has been a decrease.

Samples from 255 wells in the Central Columbia Plateau were analyzed for 145 *pesticides* and *volatile organic compounds* (figs. 18, 20). Volatile organic compounds (VOCs) are used as solvents or metal degreasers and as pesticides (as inert ingredients or active ingredients to kill nematodes, insects, bacteria, or rodents). There were 24 pesticides and 15 VOCs detected; concentrations were mostly well below drinking water standards, ranging from the *method detection limit* (as low as 0.001 microgram per liter) to a maximum of 7.3 micrograms per liter for 1,2-dichloropropane (see p. 26). The significance of such low concentrations in drinking water is not clear; and in addition, no drinking water standards or guidelines have been established for 40 percent of the pesticides or VOCs analyzed. In the Quincy-Pasco subunit, four of the commonly used pesticides (*herbicides* or *insecticides*) were detected in ground water [19, 20]. In the Palouse subunit, none of the commonly used pesticides were detected in ground water [21].

Only discontinued compounds exceed drinking water standards

Only concentrations of 1,2-dichloropropane in one well and 1,2-dibromoethane (EDB) in two wells exceed the MCL. Both of these compounds are VOCs used as soil *fumigants* that were phased out in the late 1970s and 1980s, respectively. Herbicides, though applied in greater amounts and detected more frequently than other types of pesticides, were not detected at concentrations that exceed MCLs. Most of the newer pesticides break down more rapidly and thus are less persistent in the environment than the discontinued ones; they were not detected at concentrations above drinking water standards or guidelines [19, 20, 45].

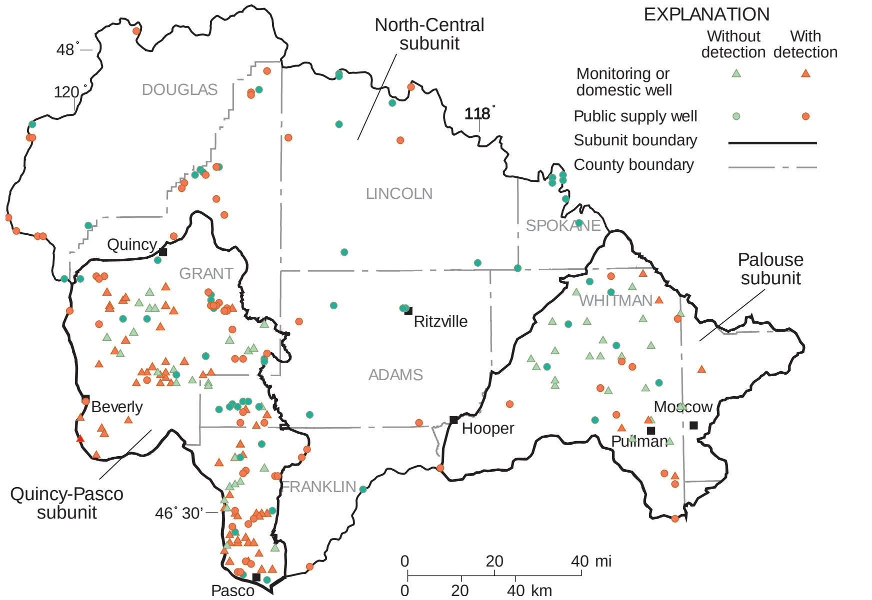


Figure 18. Locations of wells sampled for pesticides and volatile organic compounds in the Central Columbia Plateau.

Most drinking water is from deeper wells, which are somewhat less susceptible to contamination

Shallower wells have a greater number and percentage of pesticide detections [44]. Most people in the Central Columbia Plateau drink water from public supply wells (fig. 5), which are generally deeper than domestic wells (and deeper than this study's monitoring wells), and therefore contain water that is less susceptible to contamination. However, similar pesticides at similar concentrations have been detected in public supply wells, shallow domestic wells, and very shallow monitoring wells (fig. 20), indicating that some contamination does reach deeper wells. This could be due to faulty well construction, high pumpage rates, or local ground-water pathways (relatively common in fractured basalt aquifers) that allow water to move quickly to greater depths.

Samples from five public supply wells contained only *p,p′*-DDE, a *breakdown product* of DDT, which was discontinued for sale in the United States in the early 1970s. More modern pesticides were not detected, suggesting that these deeper wells are probably withdrawing older ground water that predates the use of newer pesticides.

Low concentrations of pesticides and VOCs were detected in 60 percent of samples from 117 shallow domestic and monitoring wells and in 46 percent of samples from 138 deeper public supply wells. Modern pesticides may get to shallow ground water before they have had time to break down; therefore, shallow wells tend to have a higher rate of detections. Thirty-one pesticides and VOCs were detected in samples from shallow domestic and monitoring wells, whereas 18 pesticides and VOCs were detected in samples from public supply wells.

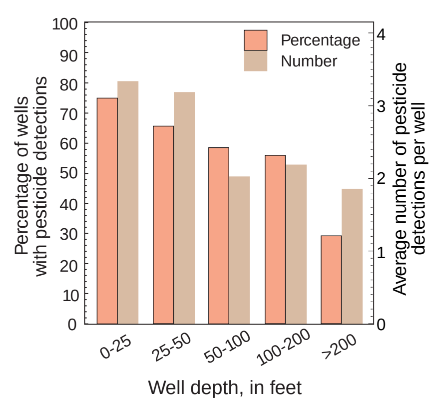


Figure 19. Shallow wells have a greater number and percentage of pesticide detections.

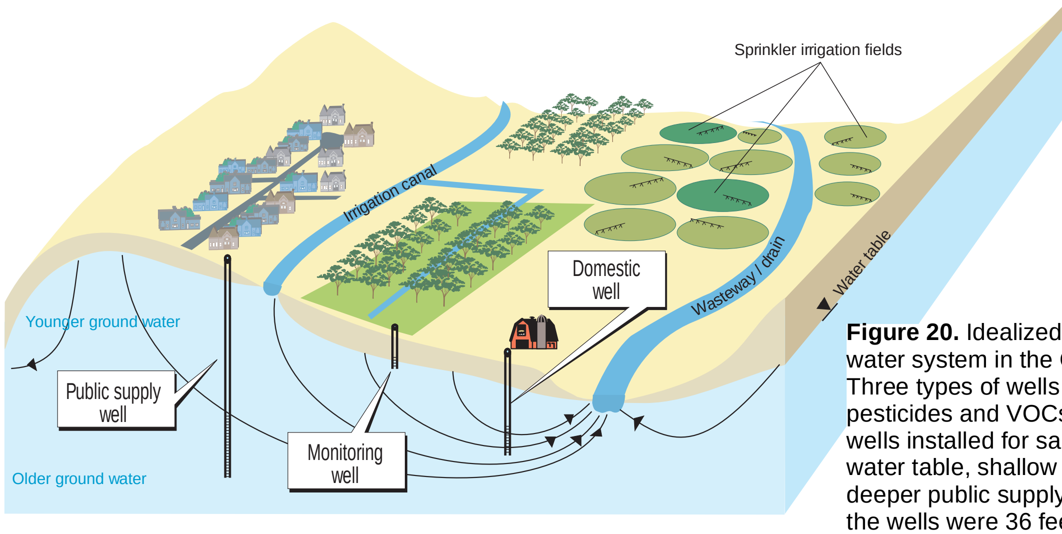


Figure 20. Idealized cross section of ground-water system in the Quincy-Pasco subunit. Three types of wells were sampled for pesticides and VOCs: very shallow monitoring wells installed for sampling purposes near the water table, shallow domestic wells, and deeper public supply wells. Median depths of the wells were 36 feet, 119 feet, and 197 feet, respectively.

Multiple pesticides were detected in some wells, especially shallow wells

Of samples with detections, 66 percent contained more than one pesticide. Generally, the highest frequency of multiple detections occurred in samples from very shallow monitoring wells (fig. 21). **Current drinking water standards or guidelines are only for individual compounds; no standards or guidelines have been established for multiple pesticides in drinking water.** Health effects of combinations of pesticides in drinking water are not clearly understood.

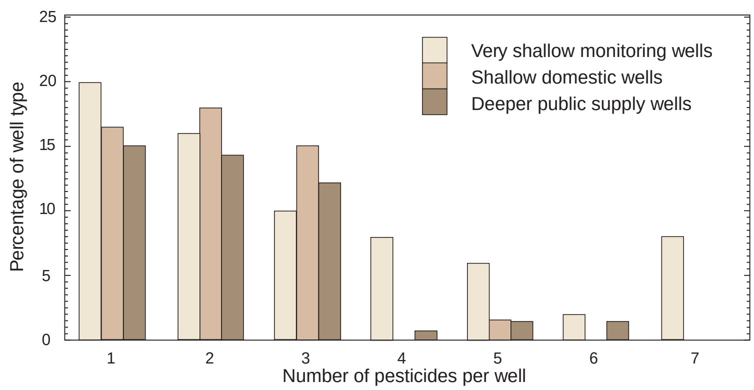


Figure 21. Most detections of more than one pesticide occurred in samples from very shallow monitoring wells.

Pesticides were frequently detected in wells with elevated nitrate

Many chemicals, including nitrate and pesticides, can leach through the soil to ground water. Pesticides are present in more than one-half of wells in the plateau that contain elevated nitrate concentrations (above the “natural” or background level of 2-3 mg/L [12]). Indeed, the higher the nitrate concentration, the greater the percentage of wells with pesticides (fig. 22). Because of this consistent correlation, sampling for nitrate may be cost effective for identifying wells that may be at risk of pesticide contamination. Nitrate testing is far less expensive than pesticide testing, and the latter could then be targeted more carefully.

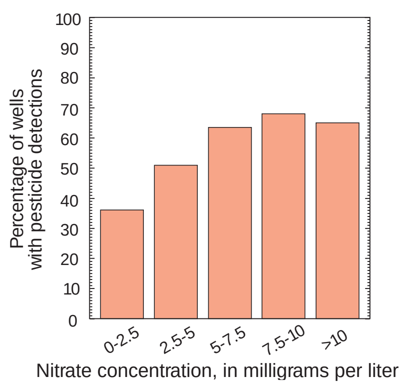


Figure 22. Pesticide detections correlate with nitrate concentrations.

Radon, a naturally occurring, radioactive decay product of radium, is a water-soluble gas from bedrock that emits high-energy alpha particles that can damage lung tissue. The primary health risk from radon and its decay products appears to be from inhalation of the gas, although there is an increased health risk from drinking water with high concentrations of radon. Dissolved radon is easily released into the air when water is used for showering and other purposes. In 151 ground-water samples, radon concentrations ranged from 110 to 4,100 picocuries per liter (pCi/L); the *median* concentration was 530 pCi/L, similar to the median in many parts of the United States (p. 23).

Pesticides were detected in streams all over the plateau

Thirty-one surface-water sites representing agricultural land use with different crops, irrigation methods, and other agricultural practices were sampled for *pesticides*. Pesticides were detected in samples from all sites except for Palouse River at Laird Park, a *headwaters* site in a forested area (see map, p. 24). Pesticide detections are usually related to pesticide applications (fig. 23) but are also influenced by agricultural practices, such as the rate of application, the rate at which the pesticide breaks down in the soil and water, and the ability of the pesticide to dissolve and be transported by water (fig. 24).

Concentrations of some pesticides may be harmful to aquatic life

Many pesticides were detected in surface water at very low concentrations. Concentrations of six pesticides in one or more surface-water samples exceed *freshwater-chronic criteria* for the protection of aquatic life in some samples (fig. 25). No pesticide concentrations exceed drinking water standards (however, surface water is not a drinking water source in the Central Columbia Plateau).

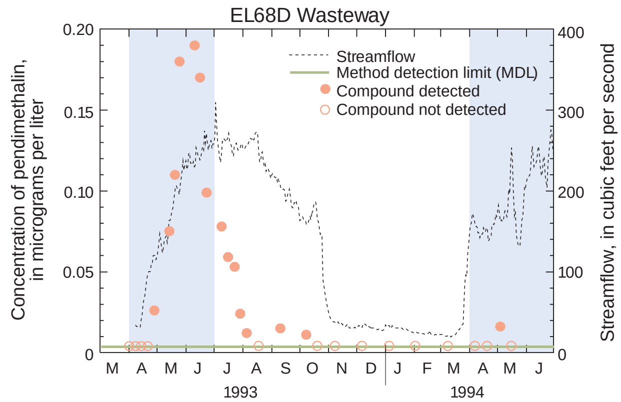


Figure 23. In the Quincy-Pasco subunit, concentrations of pendimethalin are highest during or shortly after reported periods of application, April to June (shaded areas).

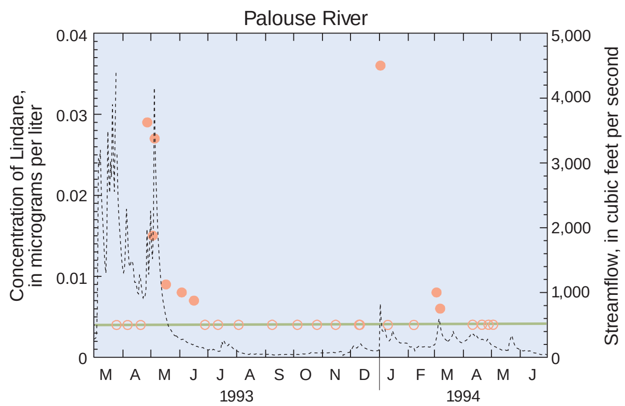


Figure 24. In the Palouse subunit, concentrations of *gamma*-HCH (Lindane) are highest during periods of storm runoff [2, 22]; *gamma*-HCH is not applied to crops but is registered for use as a livestock spray and as a seed treatment.

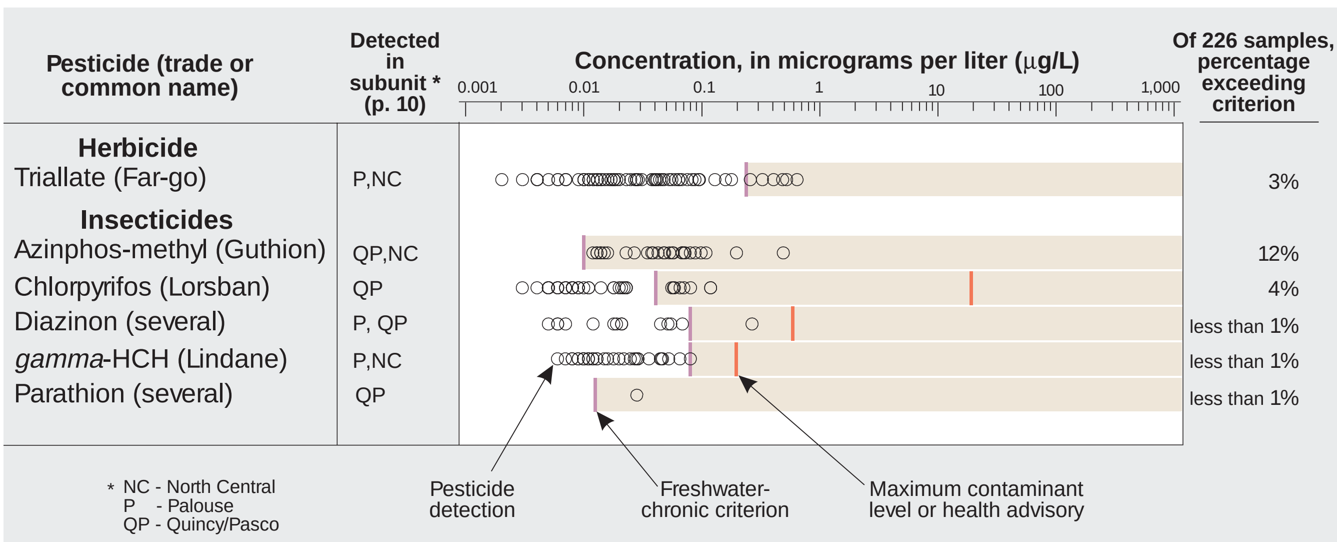


Figure 25. Concentrations of six pesticides (mostly insecticides) in surface water sometimes exceed guidelines for the protection of aquatic life. No concentrations exceed existing drinking water standards (see p. 26).

Some pesticides in surface water come from ground water

Like nitrate, soluble pesticides such as atrazine, metribuzin, and simazine can leach to ground water in the Quincy-Pasco subunit and later be transported to agricultural *wasteways* [2, 20]. Atrazine present in EL68D Wasteway during *base flow* comes from ground-water discharges to the wasteway (fig. 26).

Ground-water discharges make up a large percentage of the total *load* of some compounds transported by a wasteway. About 40 percent of the atrazine discharged annually by EL68D Wasteway enters via the ground water. For Crab Creek Lateral, the percentages for atrazine and other compounds are somewhat lower (table 3).

In summer, the wasteways also carry unused irrigation water and run-off of excess irrigation water that contains additional pesticides from the fields.

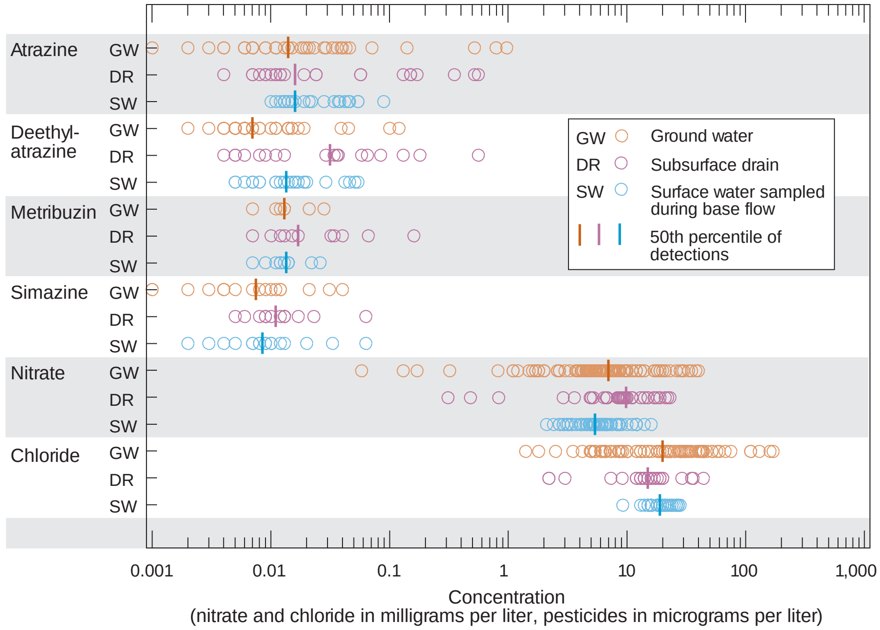


Figure 27. Median concentrations of pesticides, nitrate, and chloride are similar in ground water, subsurface drains, and surface water sampled during base flow.

Table 3. Estimated contributions of ground-water discharges to annual load [N, Nitrogen; %, percent]

Compound	EL68D Wastewa	Crab Creek
Atrazine	40%	10%
Metribuzin	20%	10%
Simazine	10%	5%
N-total	65%	30%

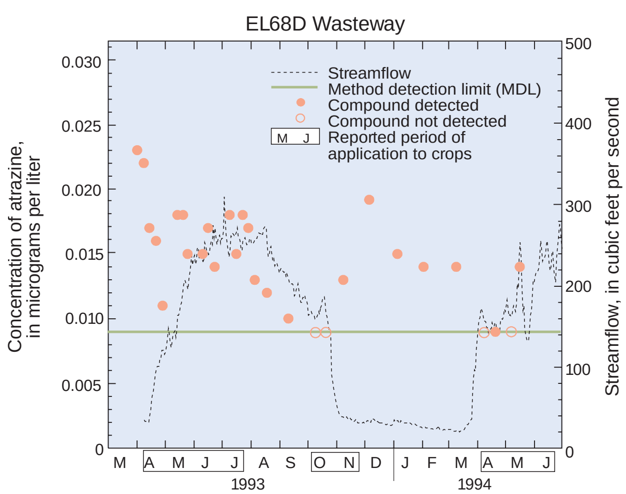


Figure 26. Concentrations of atrazine, a soluble pesticide, do not decrease during base flow.

Sampling surface water monitors ground-water quality cost-effectively

Ground-water quality is highly variable, requiring many samples to detect trends; therefore, it may be advantageous to sample surface drains during winter to monitor trends in ground-water quality. Sampling discharges from *subsurface field drains*, which collect and drain ground water to prevent waterlogging of fields, may also be useful. Figure 27 shows *median* concentrations of pesticides, nitrate, and chloride were similar (and usually not statistically different) among samples from monitoring wells, subsurface drains, and wasteways sampled during winter base flow. Concentrations in samples from wells usually varied the most because these samples represent only a small part of the aquifer. Because waters in wasteways and subsurface drains represent the largest ground-water volumes, concentrations in these samples usually varied the least; therefore, fewer samples are necessary for trend analysis.

For examples using nitrate concentrations in wasteways to infer trends in nitrate in ground water, see page 9.

Erosion depletes cropland of fertile soil and nutrients

Over the last 100 years, about 40 percent of the topsoil in the dryland-farming Palouse subunit has been lost because of erosion [23]. Most soil erosion in this region is caused by storm runoff. In the Quincy-Pasco subunit where irrigated farming predominates, most soil erosion is caused by runoff of excess irrigation water from cropland.

Erosion carries compounds like DDT into streams

Even though most *organochlorine pesticides* (DDT, for example) are no longer used, they break down slowly and are still present in the environment. Because they bind strongly to soils, they are carried with eroded soils into streams. The most persistent *breakdown product* of DDT, *p,p′*-DDE, was found in all parts of the Study Unit except in the *headwaters* of the Palouse River Basin and upper Crab Creek (fig. 28). Concentrations of *p,p′*-DDE exceed guidelines for the protection of aquatic life [24] at 22 percent of the sites sampled [25]. Other organochlorine pesticides found in streambed sediments at concentrations exceeding guidelines were heptachlor epoxide, dieldrin, and Lindane (fig. 29).

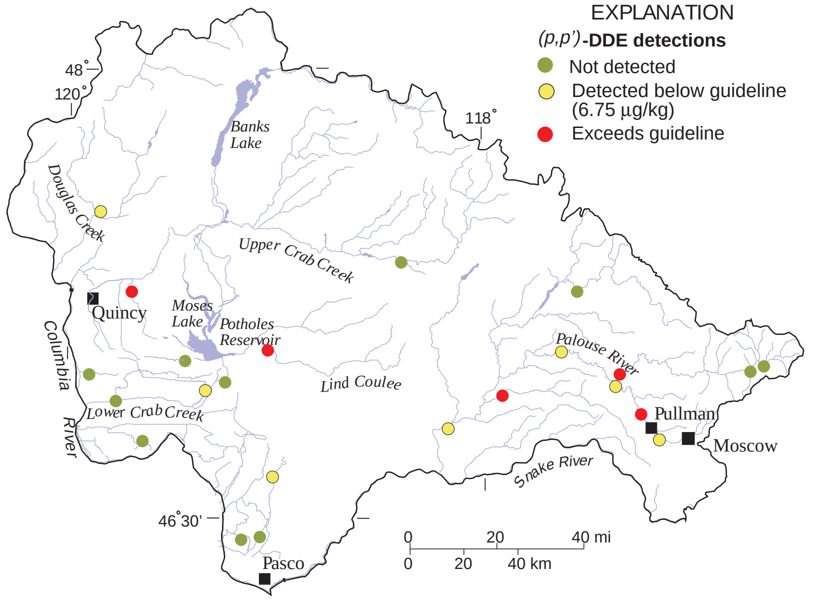


Figure 28. *p,p′*-DDE concentrations in streambed sediments commonly exceed the guideline for protection of aquatic life [24] in dryland farming areas.

Polychlorinated biphenyls (PCBs) are *organochlorine compounds* that were detected only at sites sampled downstream from the cities of Moscow and Pullman in the Palouse subunit [25]. PCBs, which were widely used in electrical transformers, have not been manufactured in the United States since the 1970s because they are toxic and persistent in the environment.

Irrigation can increase erosion

Furrow irrigation causes more erosion than sprinkler or drip irrigation [26]. DDT is carried with eroded soils [27], and highest concentrations of DDT in streambed sediment and fish tissue were detected in watersheds with more furrow irrigation (fig. 30).

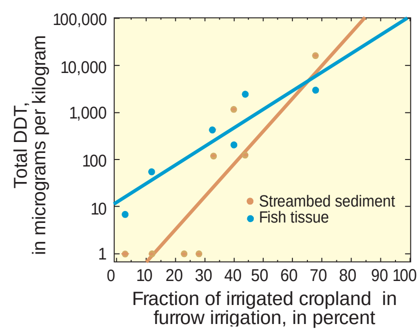


Figure 30. DDT concentrations in streambed sediment and fish increase as the percentage of furrow irrigation increases.

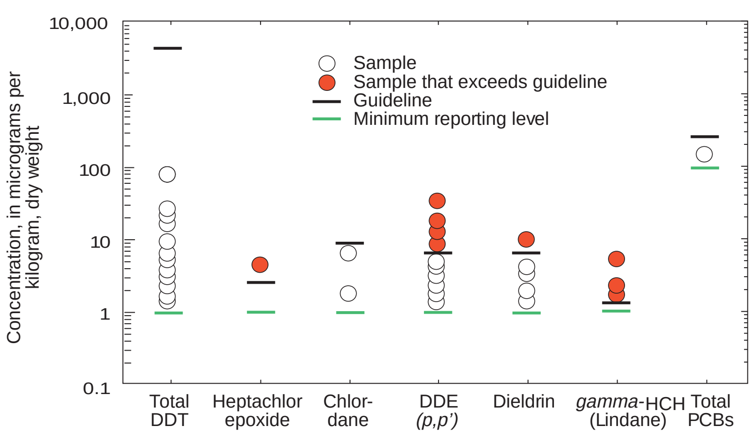


Figure 29. Concentrations of organochlorine compounds in streambed sediments sometimes exceed guidelines for the protection of aquatic life [24].

Beginning in the 1970s, the use of sprinkler irrigation in the Quincy-Pasco subunit increased; with this change in irrigation method came reports of reduced erosion. A good indicator of the severity of erosion in a drainage basin is the concentration of suspended solids in streams. Figure 31 shows the relation between irrigation method and average daily yields of suspended solids discharged by Lower Crab Creek to the Columbia River.

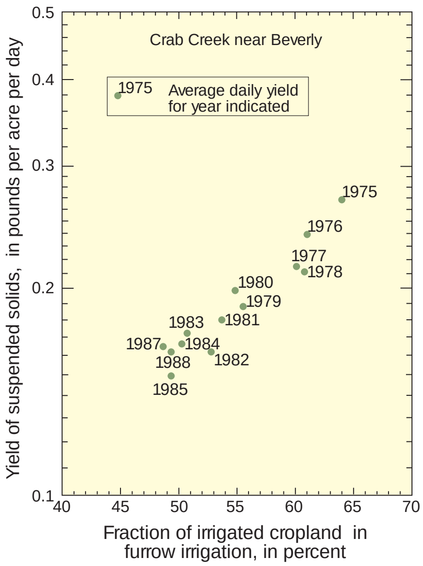


Figure 31. Average daily yields of suspended solids discharged by Lower Crab Creek to the Columbia River decreased from 1975 to 1988, coinciding with a decrease in the use of furrow irrigation [28, 29].

Data collected from 1993 to 1995 also show the relation between irrigation method and erosion. For nine drainage basins sampled in 1994, average daily yields of *suspended sediment* (which is collected and analyzed differently than suspended solids) ranged from 0.4 pound per acre from a basin with no furrow irrigation to about 20 pounds per acre from a basin where about 60 percent of cropland is irrigated by the furrow method [28, 29].

Erosion may be decreasing in dryland farming areas

Studies by the U.S. Department of Agriculture indicate that improved farming practices that began in the 1970s have reduced erosion of soil from cropland in the United States by up to 25 percent [30]. Field observations and studies indicate that a reduction in erosion of about the same magnitude has occurred in the Palouse subunit [31]. The decrease in suspended sediment discharged by the Palouse River may be indicative of less erosion (fig. 32). However, the average sediment concentration for the period from 1962 to 1971 is skewed by a very wet year (1963), which did not occur in 1993–96. Therefore, the difference between the two periods is probably exaggerated on the graph.

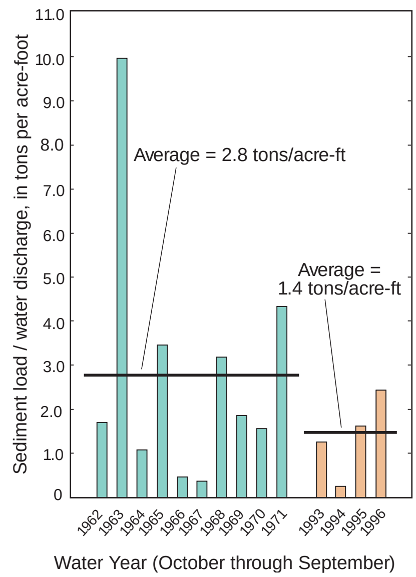


Figure 32. The average sediment load per unit volume of water discharged by the Palouse River has decreased (comparing 1993–96 with 1962–71 data).

Trace elements are not elevated in streambed sediments

Because *trace elements* bind to sediments, and sediments accumulate on the streambed during low flows, analysis of streambed sediments is a good way to relate concentrations to the effects of land use. In the Central Columbia Plateau, streambed sediments are derived mostly from eroded soils. If the concentration of a trace element in streambed sediments is greater than the concentration in undisturbed soils, a source related to land use is probable. However, most trace element concentrations in streambed sediments were not commonly above concentrations in undisturbed soils of the Study Unit (fig. 33) [32].

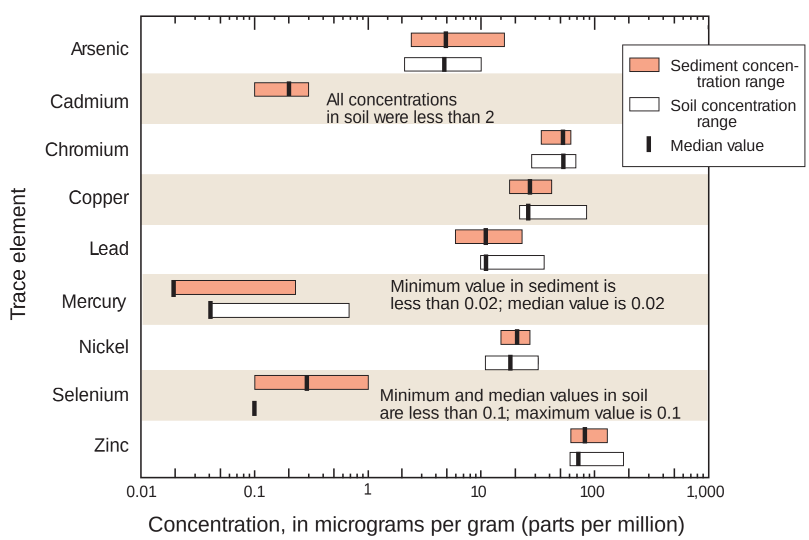


Figure 33. Except for selenium, concentrations of trace elements in streambed sediments and soils were not commonly above concentrations in undisturbed soils in the Central Columbia Plateau.

Concentrations of nutrients have increased in streams

Nutrients are an important indicator of surface water quality because inorganic nitrogen (nitrate and ammonia) and phosphorus control the growth of aquatic plants (p. 18). Excessive growth of aquatic plants can cause dissolved oxygen concentrations in streams to decrease during the night to levels that may not sustain certain species of fish.

In streams of the Central Columbia Plateau, naturally occurring levels of these essential nutrients have been increased as a result of land use practices. Inorganic nitrogen, which is water soluble, enters surface waters directly in runoff from agricultural fields treated with fertilizer, or indirectly via ground water. Phosphorus, also used as a fertilizer, is relatively insoluble and binds to soil particles, entering surface waters as a result of erosion. Nutrients also enter surface waters from feedlots and wastewater-treatment plants, either through runoff or via ground water in the case of land-applied waste.

Understanding the distribution of nutrients in surface waters permits managers to better identify *best management practices* (BMPs) that can improve water quality.

Nutrient concentrations vary over time and space

Seasonal variations in concentrations of nutrients are influenced by land use and by natural and human factors that cause variations in streamflow. For example, in the Quincy-Pasco subunit, high streamflows are from April through October, coinciding with the delivery of large quantities of irrigation water withdrawn from the Columbia River. Excess irrigation water, which contains low concentrations of nitrate, discharging to *wasteways* and drains dilutes nitrate present at high concentrations in ground water discharging to surface waters (see p. 8). Therefore, concentrations in surface waters are lowest in summer when delivery of irrigation water is at a peak (fig. 34).

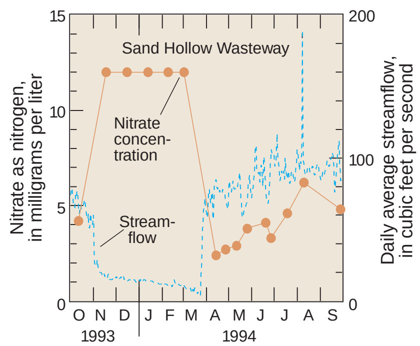


Figure 34. Nitrate concentrations in the Quincy-Pasco subunit are lowest in summer and highest in winter when irrigation water is not being delivered.

In the Palouse subunit, concentrations of nitrate in surface waters are highest during winter when storm runoff transports nitrogen from fields to streams (fig. 35). Lower concentrations of nitrate in surface waters during the summer are caused by lower nitrate concentrations in ground water discharging to streams and uptake by plants.

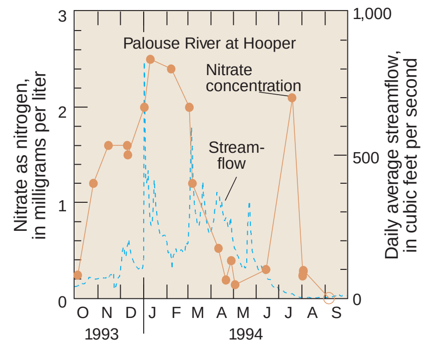


Figure 35. Nitrate concentrations in the Palouse subunit are highest in winter because of fall fertilizer applications and storm runoff.

As shown in figure 36, annual variation of inorganic nitrogen and phosphorus concentrations is related to land use. Phosphorus concentrations are generally less variable than nitrogen concentrations and are also generally lower in agricultural streams because phosphorus is applied to crops at a much lower rate and it binds with soil particles, thereby reducing its transport to surface waters.

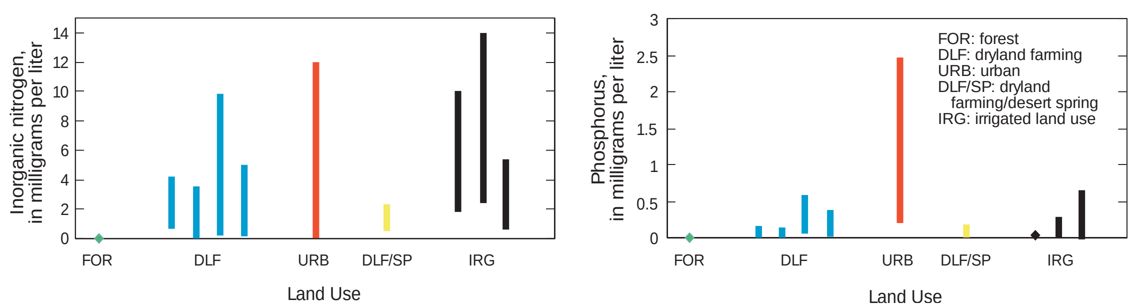


Figure 36. Inorganic nitrogen concentrations vary widely in streams in the dryland and irrigated agricultural and urban land use areas. In contrast, phosphorus concentrations are less variable throughout the year except at the urban land use sites, which are downstream from wastewater-treatment plant discharge to the South Fork of the Palouse River. (Each bar represents an annual range of concentrations at one site within that land use.)

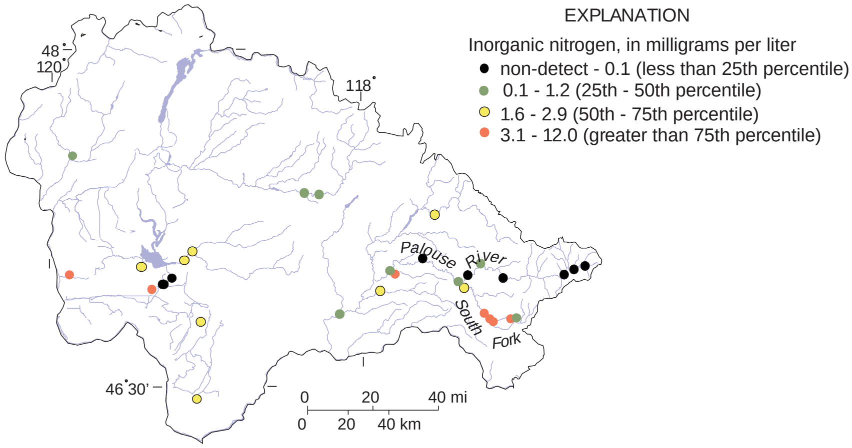


Figure 37. Sites with the highest summertime concentrations of inorganic nitrogen are in the South Fork of the Palouse River, which is dominated by wastewater discharge, and several streams in the Quincy-Pasco subunit [33].

Concentrations of nitrogen are most critical to aquatic life during the summer when aquatic plant growth is highest. Sites with the highest summertime concentrations include the wastewater-dominated South Fork of the Palouse River in the Palouse subunit and several irrigated streams in the Quincy-Pasco subunit (fig. 37) [33].

Wastewater is a significant point source of nutrients in the Palouse River

Discharge of treated wastewater during summer low flow elevates concentrations of nitrogen and phosphorus, resulting in *eutrophication* of the South Fork of the Palouse River (fig. 38). During the summer, plants in the South Fork increase to excessive amounts. Nitrogen is reduced in the lower river because of uptake by these aquatic plants whereas phosphorus concentrations are greater than what is required by plants, so concentrations in water remain high. The high phosphorus can be due to low oxygen conditions during the summer, which cause sediments to release phosphorus.

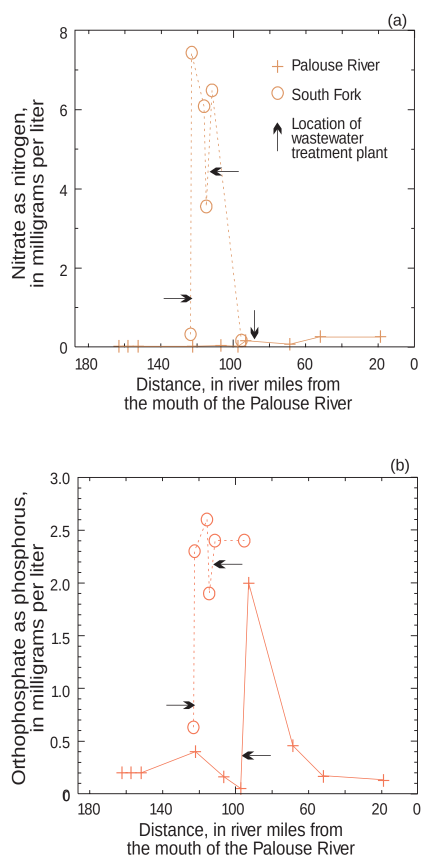


Figure 38. Summertime concentrations of (a) nitrogen and (b) phosphorus in the South Fork of the Palouse River (sampled August 1994) are elevated above levels at other sites on the river.

Nitrate trends are tied to land use

Concentrations of nitrate in the Palouse River have not changed significantly since 1965, which reflects the consistent land use (dryland agriculture) over time [33].

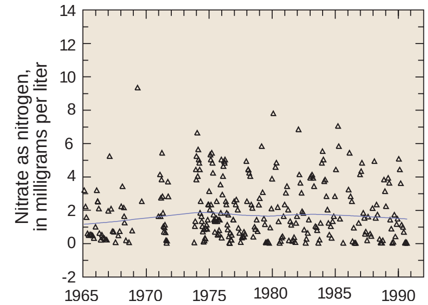


Figure 39. Nitrate trends in Palouse River at Hooper, Palouse subunit.

Nitrate has increased in Crab Creek because the acreage of irrigated land and therefore fertilizer application has increased.

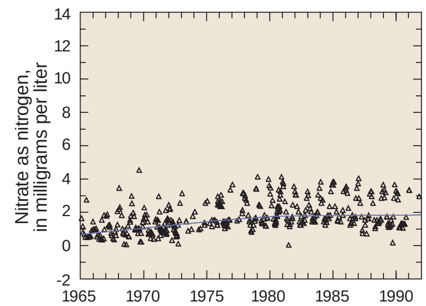


Figure 40. Nitrate trends in Crab Creek at Beverly, Quincy-Pasco subunit.

Nitrate in Crab Creek Lateral has decreased, probably because of an increase in acreage of orchards, which require less fertilizer than row crops.

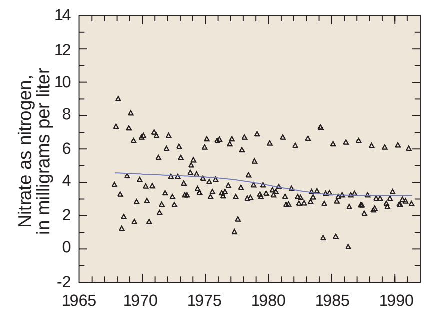


Figure 41. Nitrate trends in Crab Creek Lateral, Quincy-Pasco subunit.

Land use influences the chemical and physical characteristics of streams

Land use influences both the chemical and physical characteristics of streams, thereby affecting aquatic life. Assessing the relative importance of potential impacts to streams helps water resource managers allocate resources to better protect and manage streams. Most impacts on streams in the Central Columbia Plateau result from agricultural practices such as fertilizer and *pesticide* application and sediment from agricultural runoff. While grazing was more pervasive historically, it still occurs in localized areas and therefore influences *riparian* and instream habitat, especially in the North-Central subunit. The dominant impact from urban land use is *point source* discharge of nutrient-rich, treated wastewater from wastewater-treatment plants; however, urban impacts are overall less significant than agricultural impacts. Biological communities, including fish, that presently reside in streams of the Central Columbia Plateau are influenced by cumulative impacts from all these land use activities and are therefore influenced by three of the dominant water resource issues: *eutrophication* from excessive nutrient inputs, physical habitat alteration, and pesticides.

Eutrophication of many streams has increased

Eutrophication is a natural process which can be accelerated by human activities that increase inputs of nutrients, primarily nitrogen and phosphorus, to surface waters, thereby causing excessive growth of aquatic plants. This overgrowth causes a wide swing in oxygen concentrations over a 24-hour period; because of respiration and decay night-time oxygen can decrease to levels that will not sustain some aquatic life. Aquatic plant growth also alters physical habitat by slowing the flow of water and reducing sunlight penetration.

This eutrophication cycle has occurred in the wastewater-dominated South Fork of the Palouse River (fig. 38). This overgrowth resulted in dissolved oxygen concentrations decreasing below the level (5 mg/L) required for many fish species (fig. 42) [34].

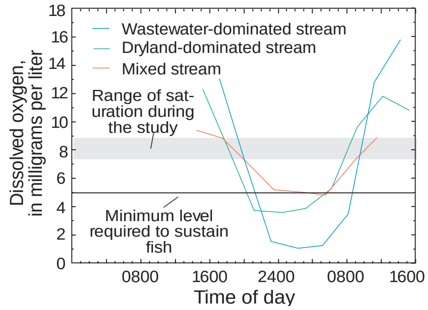


Figure 42. Dissolved oxygen concentrations decreased at night at three sites on the Palouse River; the decrease was greatest in the wastewater-dominated stream.

Oxygen also decreased in the dryland streams, but the decrease was less severe: the dryland reach has less plant growth than the wastewater-dominated reach. The Palouse River at Hooper, a site affected by a combination of both dryland farming and urban land uses, had dissolved oxygen concentrations that remained at or above the 5 mg/L level for sustaining fish.

Concentrations of nitrogen during the growing season were highest in the irrigated and urban land use and lowest in the forest and dryland farming/spring sites (fig. 36). The dryland sites were intermediate in nitrogen concentrations.

Algae are indicators of water quality

Understanding the relation between *algae* and nutrients is important for the development of integrated water- quality assessment and monitoring programs. Along with influencing dissolved oxygen in surface waters, individual species of algae respond to specific nutrient conditions and therefore serve as indicators of water quality. Indicator species can be either positively or negatively correlated with nutrient concentrations.

In streams where nutrient concentrations are low, such as in the forested land use, nutrient-poor species dominated (fig. 43); because these algae fix their own nitrogen, high nutrient levels need not be present in their environment. A dominance of nutrient-rich algae, as documented in the urban land use stream that has high inputs of nutrients during summer, indicates a high concentration of nutrients.

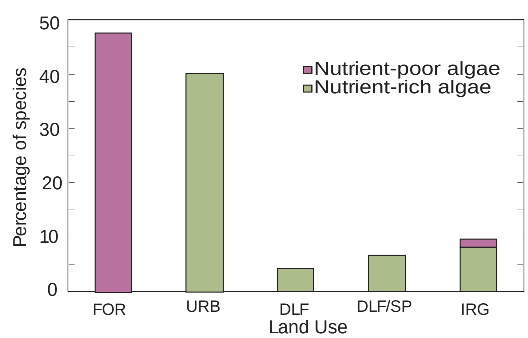


Figure 43. Algal communities in the forested land use streams (FOR) were dominated by nutrient-poor species, most of which were blue-green algae, while the urban stream (URB) was dominated by nutrient-rich species. Communities varied in streams in the dryland and irrigated land uses (DLF, DLF/SP, and IRG), but nutrient-rich species dominated. (Percentages do not add up to 100 because many

algal species are not correlated with nutrient concentrations.)

Physical habitat has been altered

In the Central Columbia Plateau, agriculture, grazing, and urban practices have singly, or in combination, impaired the riparian vegetation and bank stability, and have increased sediment erosion (p. 14), thereby affecting instream habitat.

Historically, much of the land in the Central Columbia Plateau was dominated by grasslands with an established riparian community, which maintained cooler water temperatures, provided food and cover for fish, and stabilized stream banks. Vegetated banks commonly have less bank erosion [35]. Current conditions, however, are greatly altered. Most streams lack a riparian community; average canopy cover is less than 20 percent, with most of this in isolated reaches. There is also substantial bank erosion (about 70 percent), which may be partially due to the reduction of riparian vegetation and agricultural practices [35].

Lack of a riparian community results in higher water temperatures (fig. 44); temperatures in urban and dryland streams in the Palouse subunit exceed levels that protect aquatic life (22 degrees Celsius) [34]. These higher temperatures may partially explain the lack of rainbow trout, which were historically present [36].

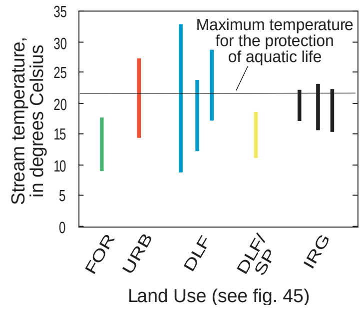


Figure 44. Stream temperature ranges in August 1994 and 1995 show that temperatures in urban (URB) and dryland (DLF) streams in the Palouse subunit exceed levels for protection of aquatic life (22 degrees Celsius).

Pesticides may be a concern for aquatic life

Organochlorine pesticides, most of which are banned in the U.S., are stored in streambed sediment and fatty tissue in fish. Some of these compounds were found at concentrations that may be detrimental to aquatic life. This is particularly true for *p,p′*-DDE in streambed sediments (p. 14) and fish tissue [25, 27].

Modern pesticides are more water-soluble and therefore less prone to be stored in sediment or accumulate in fish tissue. Concentrations in surface waters only occasionally exceed *freshwater-chronic criteria* (see p. 12, 26). However, regardless of criteria, these pesticides may influence aquatic life. For example, carp collected from Royal Lake within the Columbia Basin Irrigation Project had reduced concentrations of an important nervous system enzyme in their brains [37]. *Organophosphate pesticides*, which are used in the Central Columbia Plateau and were detected, are known to cause this effect. While the implications for sportfish are unclear, this finding indicates that modern pesticides may have a negative influence on some fish species.

Fish communities have been altered

Fish communities reflect cumulative effects of land use activities. Streams in the Palouse subunit, which once contained rainbow trout, are presently dominated by minnows (fig. 45). These streams have been impacted by elevated stream temperatures, extensive soil erosion from both agricultural runoff and bank destabilization, and reduced oxygen levels caused by eutrophication. The spring-fed Crab Creek in the North-Central subunit is able to sustain rainbow trout, likely due to cooler water temperatures and better water quality. Fish communities in the irrigated Quincy-Pasco subunit vary because of the diversity of stream conditions. Even with little riparian shading, stream temperatures remain low as a result of the input of cold irrigation water from the Columbia River. Furthermore, fish communities in the irrigation streams may be influenced by lakes downstream. Pesticides may also have an effect on fish species (p. 12, 14).

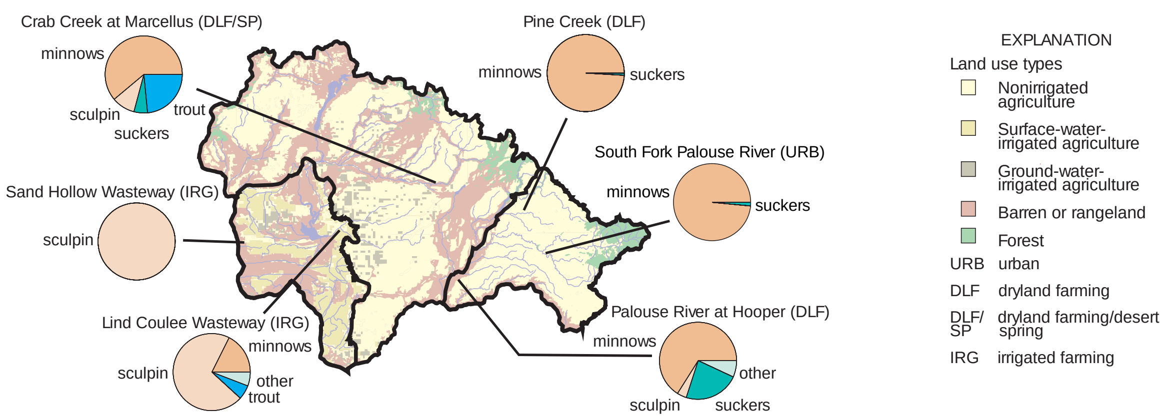
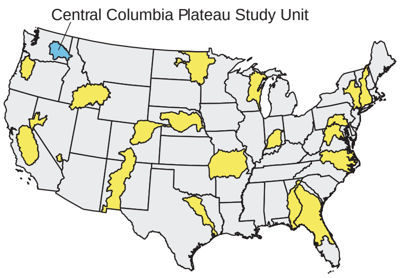


Figure 45. Composition of fish communities in various land uses. Minnows and sculpin are the dominant species.

Comparison of Stream Quality in the Central Columbia Plateau with Nationwide NAWQA Findings



Yellow areas indicate other NAWQA Study Units sampled during 1992–95.

Seven major water-quality characteristics were evaluated for stream sites in each NAWQA Study Unit. Summary scores for each characteristic were computed for all sites that had adequate data. Scores for each site in the Central Columbia Plateau were compared with scores for all sites sampled in the 20 NAWQA Study Units during 1992–95 (see map at left). Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA sites. Water-quality conditions at each site also are compared to established criteria for protection of aquatic life. Applicable criteria are limited to nutrients and pesticides in water, and semivolatile organic compounds, organochlorine pesticides, and PCBs in sediment. (Methods used to compute rankings and evaluate aquatic-life criteria are described in reference 38.)

EXPLANATION

Ranking of stream quality relative to all NAWQA stream sites — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more aquatic life criteria were exceeded.

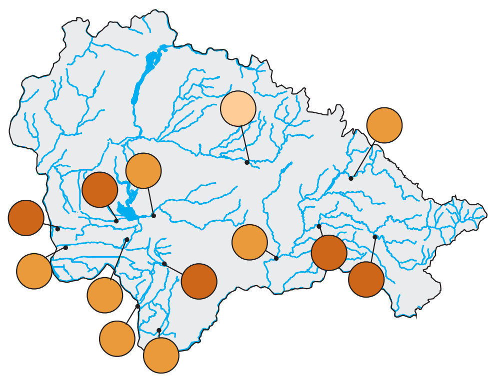
Greater than the 75th percentile (among the highest 25 percent of NAWQA stream sites)

Between the median and the 75th percentile

Between the 25th percentile and the median

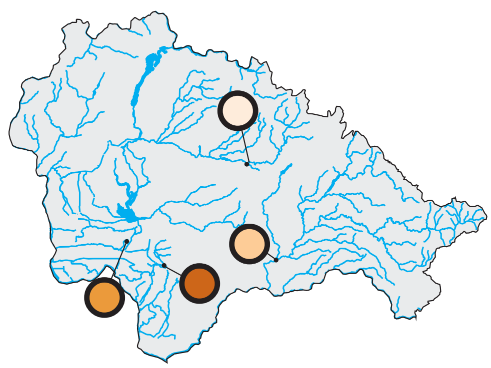
Less than the 25th percentile (among the lowest 25 percent of NAWQA stream sites)

NUTRIENTS in water



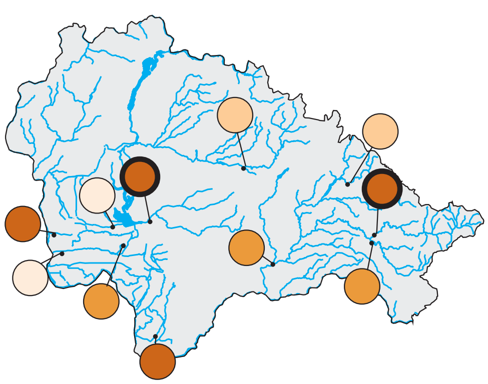
Nutrient levels are greater than the national median at all but one site, with 5 of 13 sites in the upper 25 percent of NAWQA sites. Elevated nutrient concentrations, primarily caused by fertilizer application on fields upstream of most sites and municipal wastewater at a few sites, are causing eutrophication. Effects of eutrophication include reduced dissolved oxygen, which can adversely affect fish, and nuisance growth of aquatic plants.

PESTICIDES in water



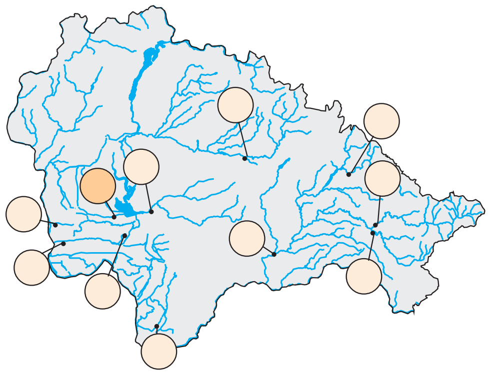
Many pesticides (12–45) were detected at four sites; the detection frequency at one of the sites is in the upper 25 percent of NAWQA sites. The two sites with the highest detection frequencies are in the Quincy-Pasco subunit, where irrigation and high chemical use combine to increase transport of pesticides to surface waters. Pesticide detection frequencies at sites in the dryland farming areas of the North-Central and Palouse subunits are below the national median for NAWQA sites. All of the sites had at least one pesticide concentration that exceeded a water-quality standard or guideline.

ORGANOCHLORINE PESTICIDES and PCBs in bed sediment and biological tissue



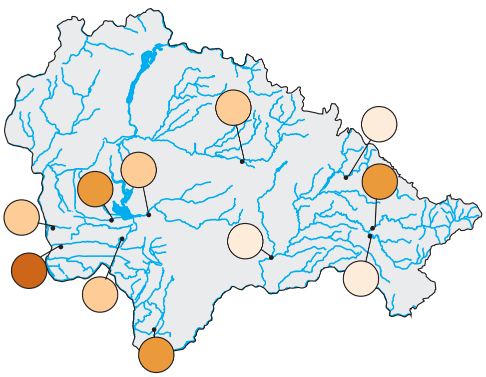
Concentrations of organochlorine pesticides and PCBs are higher than the national median (50th percentile) at 7 of 11 sites, with 4 sites in the upper 25 percent of all NAWQA sites. Elevated concentrations were observed in dryland farming areas as well as in irrigated areas. One or more environmental guidelines were exceeded at one of the sites in the Palouse River basin that is affected by urban wastewater as well as at Lind Coulee. Although most of these compounds have been banned, they still persist in the environment.

TRACE ELEMENTS in bed sediment



Trace elements, such as the metals lead and chromium, are low in the Central Columbia Plateau compared to other NAWQA Study Units because of the minimal influence of mining and urban sources and the low natural background concentrations in soils. All sites have trace element levels below the national median for NAWQA sites.

SEMIVOLATILE ORGANIC COMPOUNDS in bed sediment



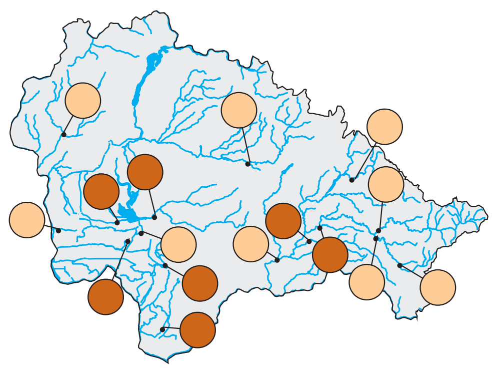
At 7 of 11 sites, concentrations of semivolatile organic compounds are lower than the national median. Three of four sites in the Palouse River drainage basin have levels in the lowest 25 percent of NAWQA sites. At Crab Creek near Beverly in the Quincy-Pasco subunit, levels are in the upper 25 percent of NAWQA sites.

CONCLUSIONS

In the Central Columbia Plateau, compared to other NAWQA Study Units:

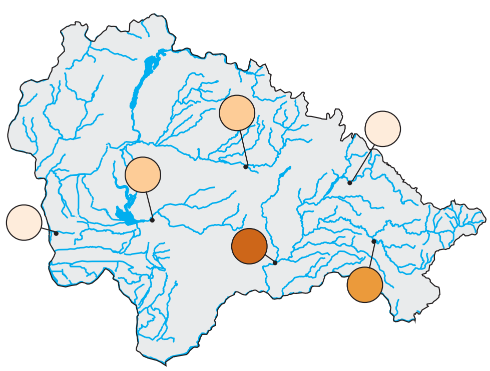
- High levels of nutrients, primarily from fertilizer, are causing eutrophication.
- Levels of pesticides in water and organochlorine compounds in bed sediment and fish tissue are relatively high: at all four sites where pesticides in water were measured over one year, a median concentration exceeded a freshwater-chronic criterion in at least one month; at 2 of 11 bed sediment sites, one or more organochlorine compounds exceeded an aquatic-life guideline.
- Habitat degradation is relatively high: seven of sixteen sites are in the upper 25th percentile, mainly because of reduced canopy cover and increased bank erosion.
- Fish community degradation is moderate.
- Levels of trace elements and semivolatile organic compounds in bed sediment are relatively low.

STREAM HABITAT DEGRADATION



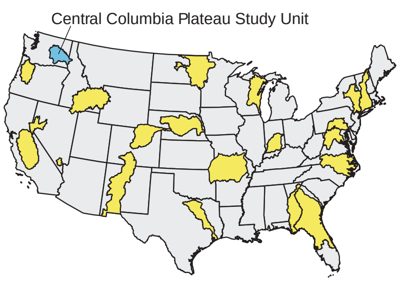
All 16 sites for which stream habitat degradation was evaluated in the Central Columbia Plateau showed some signs of habitat degradation; 44 percent are in the upper 25 percent. Streams in this Study Unit area have an average of only 20 percent canopy cover, with most having far less. The loss of riparian vegetation, combined with other land use practices, has resulted in streams having an average of 70 percent bank erosion. These factors, combined with high nutrient and sediment loading, have resulted in the majority of streams in this Study Unit having habitat conditions that are unsuitable for many native species.

FISH COMMUNITY DEGRADATION



Fish community degradation in the Central Columbia Plateau varies across the national range. Fish communities can be influenced by multiple factors, including pesticides, increased aquatic plant growth due to nutrients, reduced riparian habitat, and sediment runoff from agricultural practices. The two sites with the most impacted fish communities were a wastewater-dominated urban stream and a large dryland farming stream. Small dryland streams associated with spring systems contained the most trout.

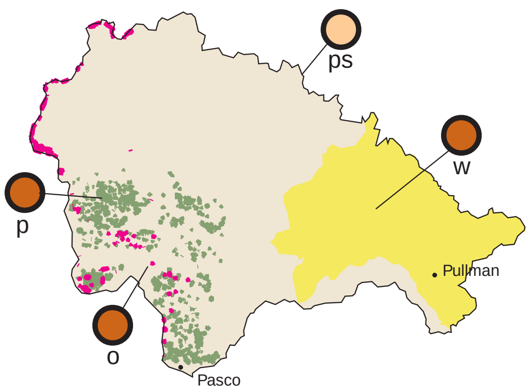
Comparison of Ground-Water Quality in the Central Columbia Plateau with Nationwide NAWQA Findings



Yellow areas indicate other NAWQA Study Units sampled during 1992–95.

Five major water-quality characteristics were evaluated for ground-water studies in each NAWQA Study Unit. Ground-water resources were divided into two categories: (1) drinking-water aquifers, and (2) shallow ground water underlying agricultural or urban areas. Summary scores were computed for each characteristic for all aquifers and shallow ground-water areas that had adequate data. Scores for each aquifer and shallow ground-water area in the Central Columbia Plateau were compared with scores for all aquifers and shallow ground-water areas sampled in the 20 NAWQA Study Units during 1992–95 (see map at left). Results are summarized by percentiles; higher percentile values generally indicate poorer quality compared with other NAWQA ground-water studies. Water-quality conditions for each drinking-water aquifer are also compared to established drinking-water standards and criteria for protection of human health. (Methods used to compute rankings and evaluate standards and criteria are described in reference 38.)

NITRATE



Median nitrate concentrations in deeper public supply wells are below the national median (50th percentile) for NAWQA drinking water sites. Shallow ground water associated with agricultural land use (wheat, orchards, and potatoes) have median nitrate concentrations that are in the upper 25 percent of NAWQA study median values. In the Central Columbia Plateau, high nitrate concentrations are due primarily to high rates of fertilizer application. Grazing and application of food processing-plant wastes are lesser influences.

EXPLANATION

Shallow wells were sampled in:

- Wheat and small grains (w) (domestic wells)
- Potatoes and corn (p) (domestic and very shallow monitoring wells)
- Orchards (o) (domestic and very shallow monitoring wells)

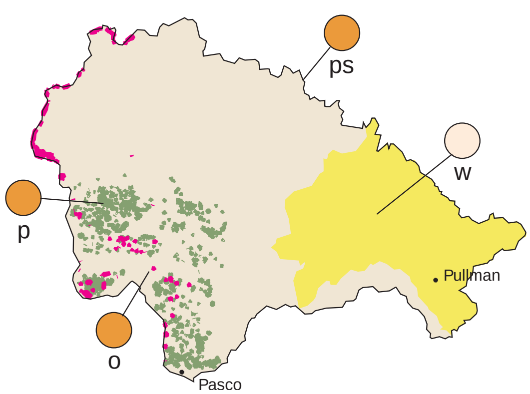
Public supply wells (ps) were sampled across the entire Study Unit - see p. 24

(For detailed land use map, see p. 4)

Ranking of ground-water quality relative to all NAWQA ground-water studies — Darker colored circles generally indicate poorer quality. Bold outline of circle indicates one or more drinking-water standards or criteria were exceeded in at least one well.

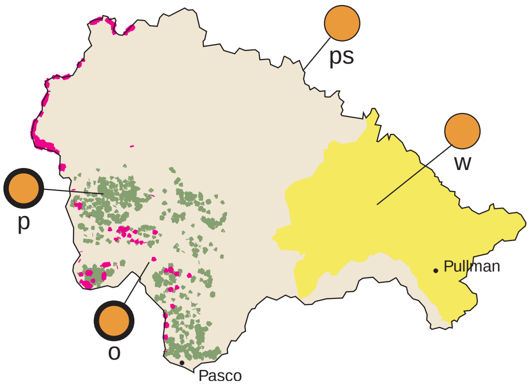
- **Greater than the 75th percentile** (among the highest 25 percent of NAWQA ground-water studies)
- **Between the median and the 75th percentile**
- **Between the 25th percentile and the median**
- **Less than the 25th percentile** (among the lowest 25 percent of NAWQA ground-water studies)

PESTICIDES



At three of four sites, pesticide detection frequencies in ground water were greater than the national median. Detection frequencies varied in shallow wells depending on the land use. Pesticide detections associated with potatoes are above the national median, but lower than those associated with orchards. The lowest pesticide detection frequency in shallow ground water was in the Palouse subunit, where wheat is the dominant crop.

VOLATILE ORGANIC COMPOUNDS



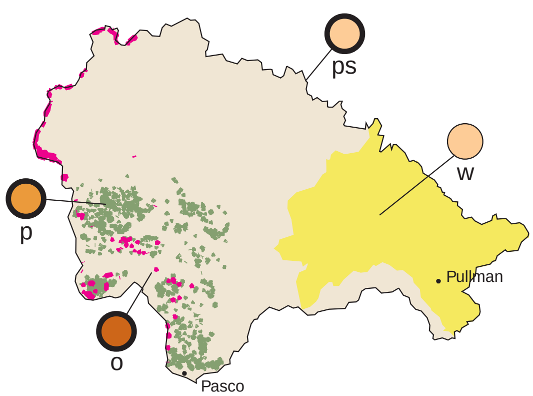
Concentrations of volatile organic compounds (VOCs) in both public supply wells and the more shallow land use wells are generally higher than the national median. The high application rate of fumigants on potatoes may explain the high concentrations of VOCs in the irrigated Quincy-Pasco subunit. Concentrations of several compounds (primarily older, discontinued fumigants) exceed water-quality standards or guidelines in land use wells in the Quincy-Pasco subunit.

CONCLUSIONS

In the Central Columbia Plateau, compared to other NAWQA Study Units:

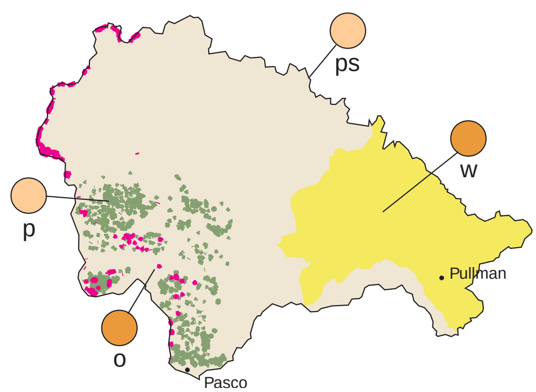
- Nitrate concentrations in ground water are high, with more than 20 percent of the wells exceeding the drinking water standard.
- Pesticides, though frequently detected, are generally at concentrations less than 10 percent of drinking water standards. However, pesticide-related health risks are difficult to assess because standards do not exist for about 40 percent of the pesticides analyzed, or for combinations of pesticides.

DISSOLVED SOLIDS



Dissolved solids in the public supply wells and in the more shallow, dryland farming Palouse subunit wells are below the national median for NAWQA sites. In contrast, dissolved-solids concentrations are greater than the national medians for both potatoes and orchards, with orchards in the upper 25 percent of NAWQA sites. The higher levels in the Quincy-Pasco subunit reflect the influence of irrigation water.

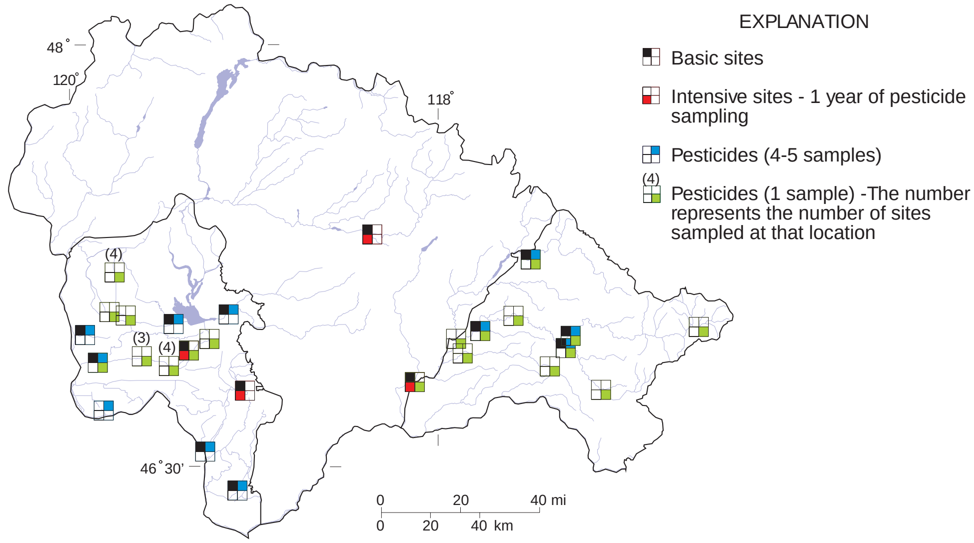
RADON



Radon, a decay product of radium, occurs naturally in soils (see p. 11). Radon concentrations in public supply wells and potato land use wells are below the national median for NAWQA sites. Wells associated with orchards in the Quincy-Pasco subunit and dryland wheat in the Palouse subunit exceed the national median.

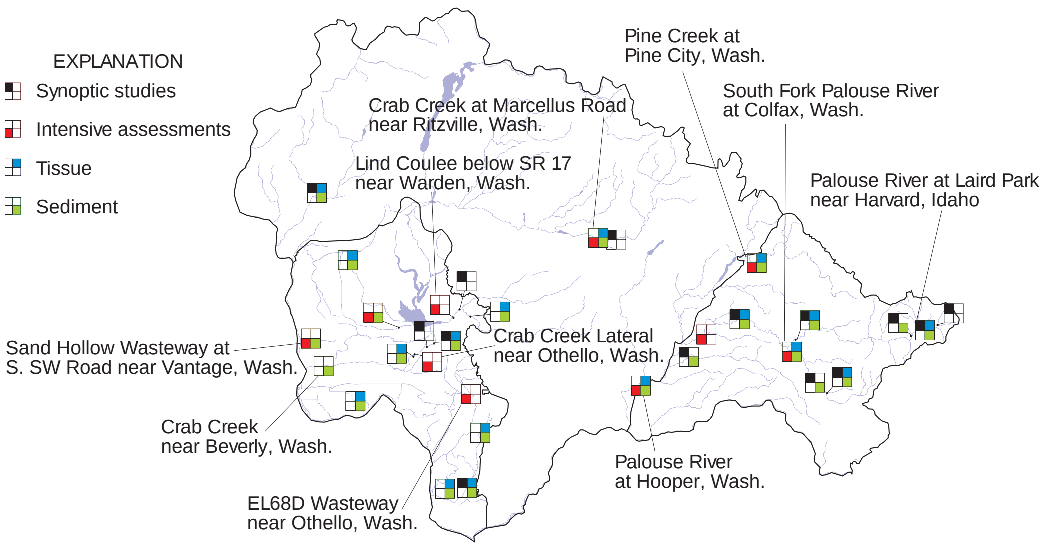
Stream Chemistry

The primary objective of the stream chemistry component was to assess the relationship between land use and chemical constituents of surface water. Surface-water sites were distributed among major land uses within each subunit; site types included basic, intensive, and synoptic sites.



Stream Ecology

The primary objective of the stream ecology component was to assess surface-water quality by integrating the physical, chemical, and biological factors. Ecology sites were distributed among the four dominant land uses: forest, urban, dryland, and irrigated farming. The number of sites per land use depended on the percentage of the land use within the Study Unit. Sites were classified as either intensive or synoptic on the basis of the level of the sampling effort or the number of years data were collected.



Ground-Water Chemistry

The primary objective of the ground-water chemistry component was to determine if the chemical constituents of ground water were related to specific land uses such as irrigated, orchard, and dryland agricultural farming. A survey of public supply wells across the Study Unit was also completed. Samples were also collected along a short ground-water flow path at a site near Pullman, Washington.

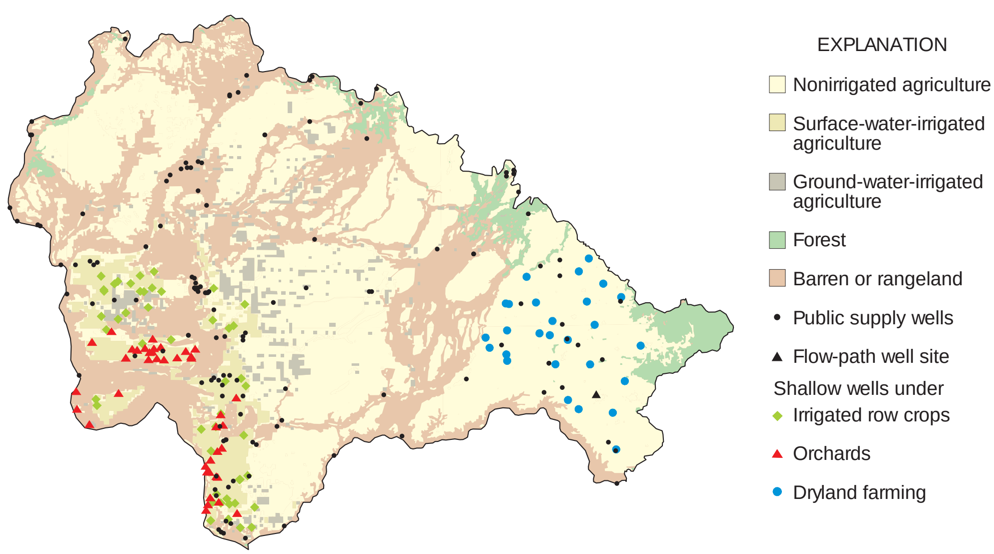


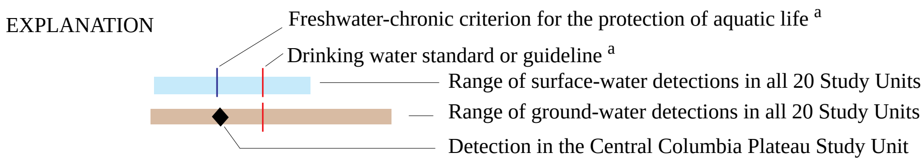
Table 4. Summary of data collection in the Central Columbia Plateau Study Unit, 1992–95, see [39] for NAWQA data design framework.

Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
Stream Chemistry				
Basic sites—general water chemistry	Concentrations, seasonal variation, and annual loads. Data included streamflow, nutrients, major ions, organic carbon, suspended sediment, water temperature, specific conductance, alkalinity, pH, and dissolved oxygen.	Basic Fixed Sites: representative of common land use mixes, as well as basin outflow sites	14	Monthly plus storms: Quincy-Pasco subunit for 1 year Palouse subunit, 2–3 years
Intensive sites—pesticides	Concentrations and seasonal variations in pesticides. Data included 85 dissolved pesticides plus above constituents.	Subset of basic sites: where land use was most homogeneous	4	Weekly to monthly: Feb. 1993–Mar. 1994
Synoptic sites—water chemistry	Spatial distribution of pesticides and nutrients. Data included 85 dissolved pesticides plus same constituents as basic sites.	Basic sites Other sites plus reference sites	11 27	4 times in spring and once in summer, 1994 Once in spring, 1994
Contaminants in bed sediments	Occurrence and distribution of contaminants in bed sediment. Data included total PCBs, 32 organochlorine pesticides, 63 semivolatile organic compounds, and 44 trace elements.	Depositional zones of most stream sites sampled in other components of study	23	Once, mostly in 1992–93
Contaminants in fish and benthic invertebrates	Occurrence and distribution of contaminants in biota. Data included total PCBs, 30 organochlorine pesticides in clams and whole fish; 24 trace elements in clam tissue, fish livers, and caddisflies.	Most stream sites sampled in other components of study where tissue could be collected	17	Once in either 1992 or 1994
Stream Ecology				
Intensive assessments	Relationship between biological communities and water chemistry, physical habitat, and land use. Includes spatial relationships, along with spatial and temporal variation. Data included algae, invertebrates, and fish communities; physical habitat all years; nutrients and other constituents in 1993.	Basic Fixed Sites	10 total 4 5 3	 1 reach - 1 year (1993) 1 reach - 3 years(1993–95) 3 reaches -1 year (1994 or 1995)
Synoptic studies	Sites permitted a better spatial and temporal assessment. Data collected were same as above except fish communities were not sampled.	Synoptic sites	14 total 11 3	 1 reach - 1 year (1993) 1 reach - 3 years (1993–95)
Ground-Water Chemistry				
Aquifer survey—public supply wells	Occurrence and distribution of chemicals in public supply wells. Data included major ions, nutrients, 85 pesticides, 60 volatile organic compounds, dissolved organic carbon, and radon. Estimate risks of pesticide detection. Data included 47 pesticides only.	Public supply wells across Study Unit Public supply wells across Study Unit	43 78	Once in 1994 Once in 1994
Land-use effects— irrigated row crops	Describe the effects of agricultural land use on shallow ground water in the Quincy-Pasco subunit. Data included major ions, nutrients, 85 pesticides, 60 volatile organic compounds, dissolved organic carbon, and radon.	Shallow domestic wells Very shallow monitoring wells Wells were generally within 100 feet of row cropped fields	30 19	Once in 1993–95
Land-use effects—orchards	Describe the effects of agricultural land use on shallow ground water in the Quincy-Pasco subunit. Data were same as above.	Shallow domestic wells Very shallow monitoring wells Wells were generally within 100 feet of orchards	18 22	Once in 1994–95
Land-use effects—dryland farming (grains)	Describe effects of agricultural land use on shallow ground water in the Palouse subunit. Data were same as row crops and orchards above.	Shallow domestic wells in basalt Very shallow monitoring wells in loess Wells were generally next to fields in the road right-of-way	19 8	Once in 1993–94
Variation along flow paths	Describe the processes controlling the fate of nitrogen and pesticides along a 1/4-mile flow path to an intermittent stream. Data included major ions, nutrients, 85 pesticides, 60 volatile organic compounds, dissolved organic carbon, radon, and age-dating constituents.	Cluster of eight wells at various depths along an approximate line of ground-water flow Palouse loess near Pullman, Wash.	1 site: 8 wells	Twice in 1994
Special Studies				
Palouse River nutrient processes	Processes affecting eutrophication in stream channels below wastewater-treatment plants. Data included algae biomass and nutrients, dissolved oxygen, and 24-hour temperature.	Palouse River	19 5	6-week colonization, 1994 3- to 6-hour intervals for one day in Aug. 1994
Pesticides from ground water at base flow	47 more-soluble pesticides and nutrients to compare nutrient concentrations and pesticide occurrence with what is found in shallow ground water.	Smaller irrigation drains and subsurface tile-drain outflows to surface drains	4 6	Once in winter 1995 Once in winter 1996

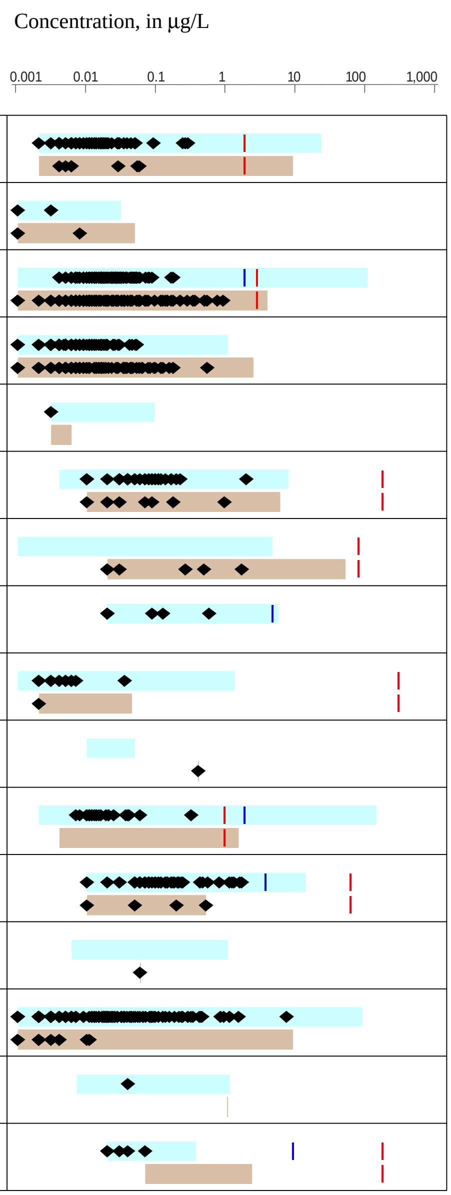
SUMMARY OF COMPOUND DETECTIONS AND CONCENTRATIONS

The following tables summarize data collected for NAWQA studies from 1992-1995 by showing results for the Central Columbia Plateau Study Unit compared to the NAWQA national range for each compound detected. The data were collected at a wide variety of places and times. In order to represent the wide concentration ranges observed among Study Units, logarithmic scales are used to emphasize the general magnitude of concentrations (such as 10, 100, or 1000), rather than the precise number. The complete dataset used to construct these tables is available upon request.

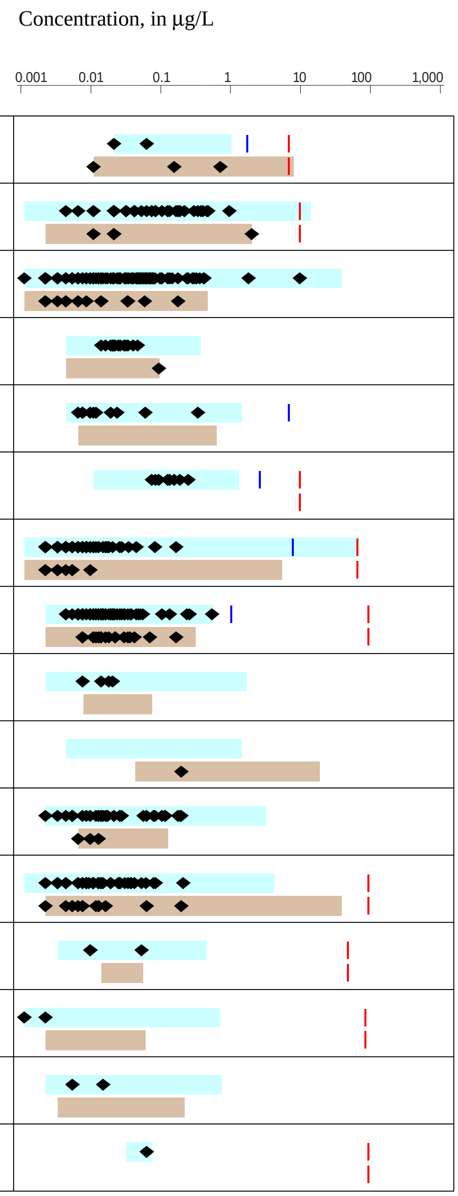
Concentrations of herbicides, insecticides, volatile organic compounds, and nutrients detected in ground and surface waters of the Central Columbia Plateau Study Unit. [mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; %, percent; <, less than; - -, not measured; trade names may vary]



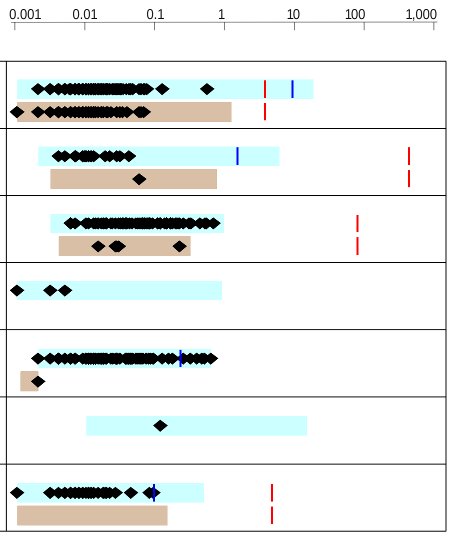
Herbicide (Trade or common name)	Rate of detection [b]
Alachlor (Lasso)	21% 1%
2,6-Diethylaniline (Alachlor metabolite)	<1% <1%
Atrazine (AAtrex, Gesaprim)	72% 26%
Deethylatrazine[c] (Atrazine metabolite)	13% 17%
Benfluralin (Balan, Benefin, Bonalan)	<1% 0%
Bentazon (Basagran, bentazone)	14% 4%
Bromacil (Hyvar X, Urox B, Bromax)	0% 3%
Bromoxynil (Buctril, Brominal, Torch)	2% 0%
Butylate (Sutan, Genate Plus, butilate)	<1% <1%
Clopyralid (Stinger, Lontrel, Dowco 290)	0% 1%
Cyanazine (Bladex, Fortrol)	9% 0%
2,4-D (2,4-PA)	27% 2%
2,4-DB (Butyrac, Embutox)	0% 1%
DCPA (Dacthal, chlorthal-dimethyl)	37% 1%
Dacthal, mono-acid (Dacthal metabolite)	<1% 0%
Dicamba (Banvel, Mediben, MDBA)	2% 0%



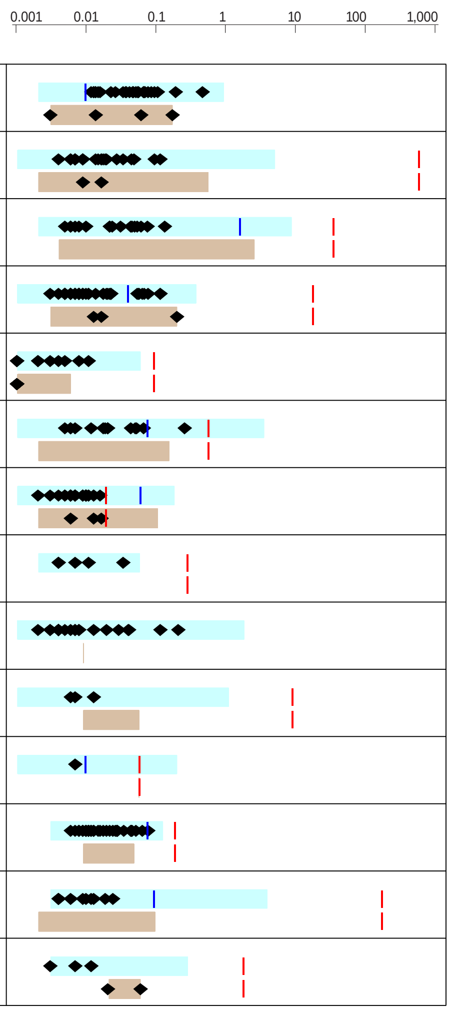
Herbicide (Trade or common name)	Rate of detection [b]
Dinoseb (DNBP, Dinitro, DN 289)	1% 2%
Diuron (Karmex, Direx, DCMU)	20% 3%
EPTC (Eptam)	36% 2%
Ethalfluralin (Sonalan, Curbit EC)	7% <1%
Linuron (Lorox, Linex, Linurex)	3% 0%
MCPA (Kilsem, metaxon)	4% 0%
Metolachlor (Dual, Pennant)	9% <1%
Metribuzin (Lexone, Sencor)	25% 6%
Napropamide (Devrinol)	1% 0%
Norflurazon (Evital, Solicam)	0% 1%
Pendimethalin (Prowl, Stomp)	10% <1%
Prometon (Gesagram, Pramitol)	14% 2%
Pronamide (Kerb, propyzamid)	<1% 0%
Propachlor (Ramrod, propachlore)	<1% 0%
Propanil (Stampede, Surcopur)	<1% 0%
Propham (Chem-Hoe, IPC, prophame)	<1% 0%



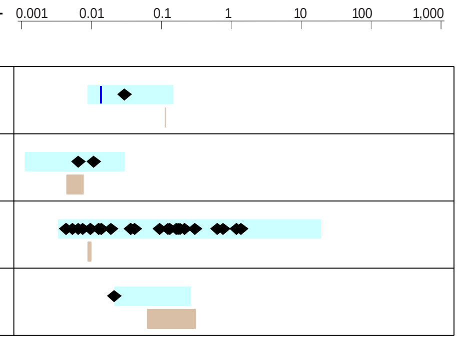
Herbicide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Simazine (Aquazine, Princep, Weedex)	47% 9%	
Tebuthiuron (Spike, Perflan)	7% <1%	
Terbacil[c] (Sinbar)	30% 2%	
Thiobencarb (Bolero, Saturn, benthiocarb)	<1% 0%	
Triallate (Far-Go)	29% <1%	
Triclopyr (Garlon, Grazon, Crossbow)	<1% 0%	
Trifluralin (Treflan, Trinin, Elancolan)	7% 0%	



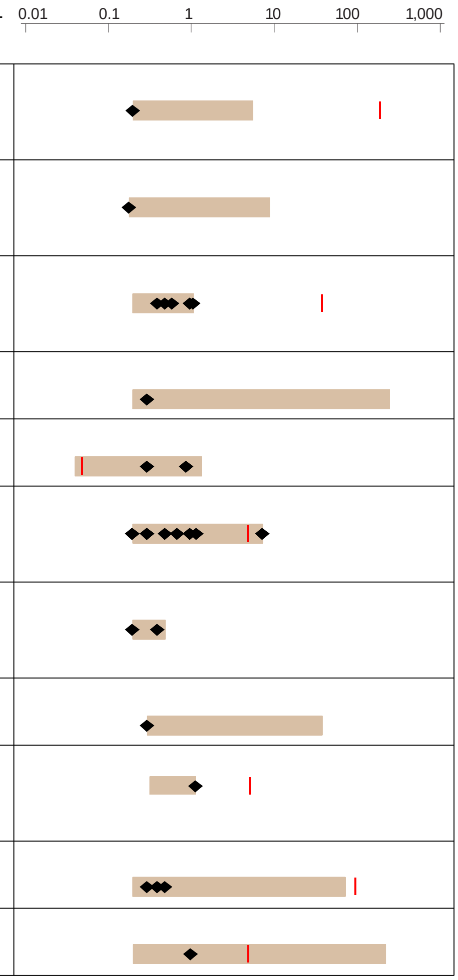
Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Azinphos-methyl[c] (Guthion, Gusathion)	12% 1%	
Carbaryl[c] (Sevin, Savit)	6% <1%	
Carbofuran[c] (Furadan, Yaltox)	5% 0%	
Chlorpyrifos (Lorsban, Dursban)	9% 1%	
p,p'-DDE (*p,p'*-DDT metabolite)	<1% <1%	
Diazinon	4% 0%	
Dieldrin (Panoram D-31, Octalox)	5% 1%	
Disulfoton[c] (Di-syston, Dithiosystox)	1% 0%	
Ethoprop (Mocap, Prophos)	3% 0%	
Fonofos (Dyfonate)	<1% 0%	
alpha-HCH (*alpha*-BHC, *alpha*-lindane)	<1% 0%	
gamma-HCH (Lindane, gamma-BHC)	12% 0%	
Malathion (maldison, malathon, Cythion)	2% 0%	
Methyl parathion (Penncap-M)	<1% 1%	



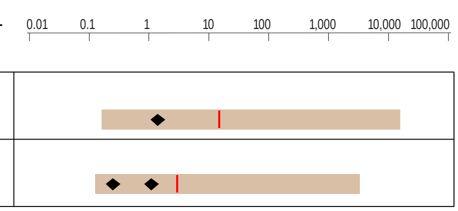
Insecticide (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Parathion (Thiophos, Bladan, Folidol)	<1% 0%	
cis-Permethrin[c] (Ambush, Pounce)	<1% 0%	
Propargite (Comite, Omite, BPPS)	9% 0%	
Propoxur (Baygon, Blattanex, Unden)	<1% 0%	

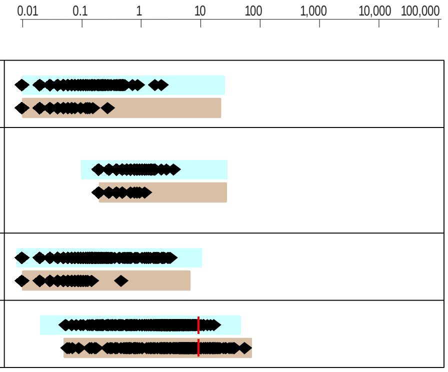


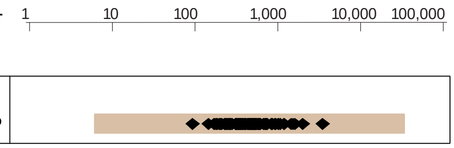
Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
1,1,1-Trichloroethane (Methylchloroform)	-- 1%	
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113)	-- 1%	
1,2,3-Trichloropropane (Allyl trichloride)	-- 3%	
1,2,4-Trimethylbenzene (Pseudocumene)	-- 1%	
1,2-Dibromoethane[d] (EDB)	-- 1%	
1,2-Dichloropropane (Propylene dichloride)	-- 6%	
1,3-Dichloropropane (Trimethylene dichloride)	-- 1%	
Chloroethane (Ethyl chloride)	-- 1%	
Tetrachloromethane (Carbon tetrachloride)	-- 1%	
total Trihalomethanes	-- 2%	
Trichloroethene (TCE)	-- 1%	



Volatile organic compound (Trade or common name)	Rate of detection [b]	Concentration, in µg/L
Methyl *tert*-butyl[e] ether (MTBE)	-- 1%	
Tetrachloroethene (Perchloroethene)	-- 1%	



Nutrient (Trade or common name)	Rate of detection [b]	Concentration, in mg/L 
Dissolved ammonia	91% 75%	
Dissolved ammonia plus organic nitrogen as nitrogen	81% 26%	
Dissolved phosphorus as phosphorus	89% 77%	
Dissolved nitrite plus nitrate	93% 95%	

Other	Rate of detection [b]	Concentration, in pCi/L 
Radon 222	-- 100%	

Herbicides, insecticides, volatile organic compounds, and nutrients not detected in ground and surface waters of the Central Columbia Plateau Study Unit.

Herbicides

2,4,5-T

2,4,5-TP (Silvex, Fenoprop)

Acetochlor (Harness Plus, Surpass)

Acifluorfen (Blazer, Tackle 2S)

Bromacil (Hyvar X, Urox B, Bromax)

Chloramben (Amiben, Amilon-WP, Vegiben)

Clopyralid (Stinger, Lontrel, Reclaim, Transline)

Dicamba (Banvel, Dianat, Scotts Proturf)

Dichlobenil (Barrier, Casoron, Dyclomec, Norosac)

Dichlorprop (2,4-DP, Seritox 50, Kildip, Lentemul)

Dinoseb (Dinosebe)

Fenuron (Fenulon, Fenidim)

Fluometuron (Flo-Met, Cotoran, Cottonex, Meturon)

MCPB (Can-Trol, Thistrol)

Molinate (Ordram)

Neburon (Neburea, Neburyl, Noruben)

Norflurazon (Evital, Predict, Solicam, Zorial)

Oryzalin (Surflan, Dirimal)

Pebulate (Tillam, PEBC)

Picloram (Grazon, Tordon)

Pronamide (Kerb, Propyzamid)

Triclopyr (Garlon, Grandstand, Redeem, Remedy)

Insecticides

3-Hydroxycarbofuran (Carbofuran metabolite)

Aldicarb sulfone (Standak, aldoxycarb, aldicarb metabolite)

Aldicarb sulfoxide (Aldicarb metabolite)

Aldicarb (Temik)

Chlorothalonil (Bravo, Daconil 2787, Exotherm)

Esfenvalerate (Asana XL, Sumi-alpha)

Methiocarb (Slug-Geta, Grandslam, Mesurol)

Methomyl (Lanox, Lannate, Nudrin)

Oxamyl (Vydate L, Pratt)

Phorate (Thimet, Granutox, Geomet, Rampart)

Propoxur (Baygon, Blattanex, Unden, Proprotox)

Terbufos (Contraven, Counter, Pilarfox)

Volatile organic compounds

1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA)

1,1,2,2-Tetrachloroethane

1,1,2-Trichloroethane (Vinyl trichloride)

1,1-Dichloroethane (Ethylidene dichloride)

1,1-Dichloroethene (Vinylidene chloride)

1,1-Dichloropropene

1,2,3-Trichlorobenzene (1,2,3-TCB)

1,2,4-Trichlorobenzene

1,2-Dibromo-3-chloropropane (DBCP, Nemagon)

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dichloroethane (Ethylene dichloride)

1,3,5-Trimethylbenzene (Mesitylene)

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Chloro-2-methylbenzene (*o*-Chlorotoluene)

1-Chloro-4-methylbenzene (*p*-Chlorotoluene)

2,2-Dichloropropane

Benzene

Bromobenzene (Phenyl bromide)

Bromochloromethane (Methylene chlorobromide)

Bromodichloromethane (Dichlorobromomethane)

Bromomethane (Methyl bromide)

Chlorobenzene (Monochlorobenzene)

Chloroethene (Vinyl Chloride)

Chloromethane (Methyl chloride)

Dibromochloromethane (Dibromochloromethane)

Dibromomethane (Methylene dibromide)

Dichlorodifluoromethane (CFC 12, Freon 12)

Dichloromethane (Methylene chloride)

Dimethylbenzenes (Xylenes (total))

Ethenylbenzene (Styrene)

Ethylbenzene (Phenylethane)

Hexachlorobutadiene

Isopropylbenzene (Cumene)

Methylbenzene (Toluene)

Naphthalene

Tribromomethane (Bromoform)

Trichlorofluoromethane (CFC 11, Freon 11)

cis-1,2-Dichloroethene ((Z)-1,2-Dichloroethene)

cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene)

n-Butylbenzene (1-Phenylbutane)

n-Propylbenzene (Isocumene)

p-Isopropyltoluene (*p*-Cymene)

sec-Butylbenzene

tert-Butylbenzene

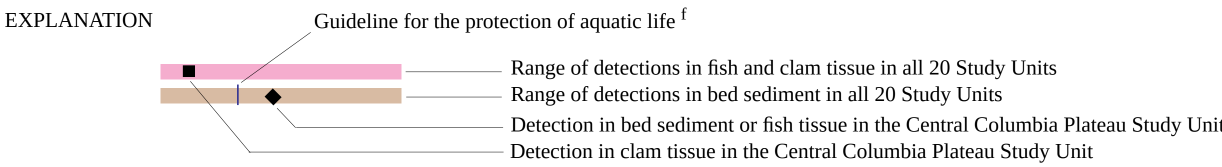
trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene)

trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene)

Nutrients

No non-detects

Concentrations of semivolatile organic compounds, organochlorine compounds, and trace elements detected in fish and clam tissue and bed sediment of the Central Columbia Plateau Study Unit. [µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; <, less than; - -, not measured; trade names may vary]

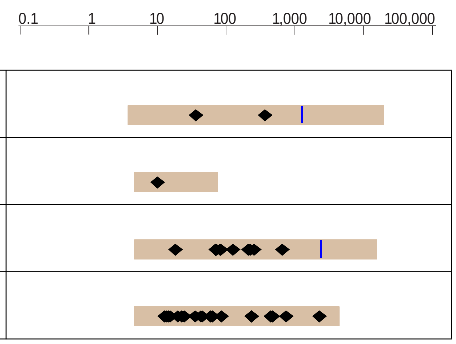


Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1, 1, 10, 100, 1,000, 10,000, 100,000)
1,6-Dimethylnaphthalene	-- 5%	
1-Methylpyrene	-- 9%	
2,3,6-Trimethylnaphthalene	-- 5%	
2,6-Dimethylnaphthalene	-- 45%	
2,6-Dinitrotoluene	-- 5%	
2-Methylanthracene	-- 5%	
3,5-Dimethylphenol	-- 5%	
4,5-Methylenephenanthrene	-- 5%	
9H-Carbazole	-- 5%	
Acenaphthene	-- 5%	
Acenaphthylene	-- 5%	
Acridine	-- 9%	
Anthracene	-- 9%	
Anthraquinone	-- 9%	
Benz[*a*]anthracene	-- 9%	
Benzo[*a*]pyrene	-- 32%	

Semivolatile organic compound	Rate of detection [b]	Concentration, in µg/kg (0.1, 1, 10, 100, 1,000, 10,000, 100,000)
Benzo[*b*]fluoranthene	-- 36%	
Benzo[*ghi*]perylene	-- 9%	
Benzo[*k*]fluoranthene	-- 36%	
Butylbenzylphthalate	-- 59%	
Chrysene	-- 9%	
Di- *n* -butylphthalate	-- 95%	
Di- *n* -octylphthalate	-- 9%	
Dibenz[*a,h*]anthracene	-- 5%	
Diethylphthalate	-- 32%	
Dimethylphthalate	-- 27%	
Fluoranthene	-- 9%	
Indeno[1,2,3- *cd*]pyrene	-- 9%	
Isoquinoline	-- 5%	
N-Nitrosodiphenylamine	-- 5%	
Phenanthrene	-- 9%	
Phenol	-- 86%	

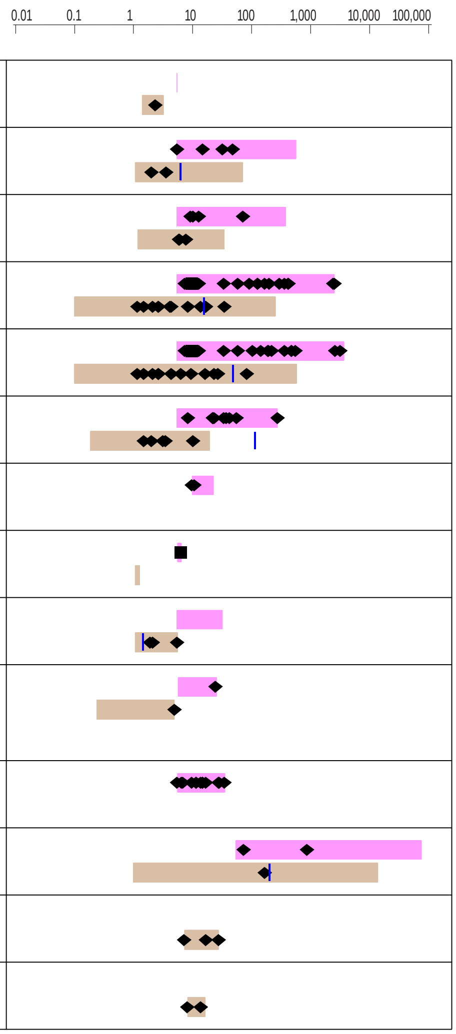
Semivolatile organic compound	Rate of detection [b]
Pyrene	-- 9%
Quinoline	-- 5%
bis(2-Ethylhexyl)phthalate	-- 55%
p-Cresol	-- 91%

Concentration, in µg/kg



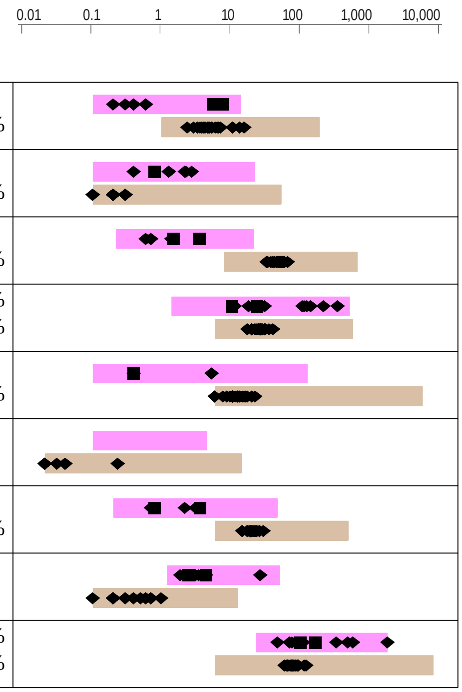
Organochlorine compound (Trade name)	Rate of detection [b]
Aldrin (HHDN, Octalene)	0% 4%
total-Chlordane	20% 9%
DCPA (dacthal, chlorthal-dimethyl)	20% 13%
p,p'-DDE (*p,p'*-DDT metabolite)	90% 52%
total-DDT	90% 52%
Dieldrin (Panoram D-31, Octalox)	45% 22%
Endrin (endrine)	10% 0%
beta-HCH (*beta*-BHC)	5% 0%
gamma-HCH (lindane, *gamma*-BHC)	0% 13%
Heptachlor epoxide (heptachlor metabolite)	5% 4%
Hexachlorobenzene	65% --
PCB, total	10% 4%
cis-Permethrin (Ambush, Pounce)	-- 14%
trans-Permethrin (Ambush, Pounce)	-- 9%

Concentration, in µg/kg



Trace element	Rate of detection [b]
Arsenic	73% 100%
Cadmium	64% 100%
Chromium	82% 100%
Copper	100% 100%
Lead	27% 100%
Mercury	0% 57%
Nickel	45% 100%
Selenium	90% 96%
Zinc	100% 100%

Concentration, in µg/g



Semivolatile organic compounds, organochlorine compounds, and trace elements not detected in fish and clam tissue and bed sediment of the Central Columbia Plateau Study Unit.

Semivolatile organic compounds

1,2,4-Trichlorobenzene

1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB)

1,2-Dimethylnaphthalene

1,3-Dichlorobenzene (*m*-Dichlorobenzene)

1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)

1-Methyl-9H-fluorene

1-Methylphenanthrene

2,2-Biquinoline

2,4-Dinitrotoluene

2-Chloronaphthalene

2-Chlorophenol

2-Ethylnaphthalene

4-Bromophenyl-phenylether

4-Chloro-3-methylphenol

4-Chlorophenyl-phenylether

9H-Fluorene

Azobenzene

Benzo [*c*] cinnoline

C8-Alkylphenol

Dibenzothiophene

Isophorone

N-Nitrosodi-n-propylamine

Naphthalene

Nitrobenzene

Pentachloronitrobenzene

Phenanthridine

bis (2-Chloroethoxy)methane

Organochlorine compounds

Chloroneb (chloronebe, Demosan, Soil Fungicide 1823)

Endosulfan I (*alpha*-Endosulfan, Thiodan, Cyclodan, Beosit, Malix, Thimul, Thifor)

Endrin (Endrine)

Heptachlor (Heptachlore, Velsicol 104)

Isodrin (Isodrine, Compound 711)

Mirex (Dechlorane)

Pentachloroanisole (PCA, pentachlorophenol metabolite)

Toxaphene (Camphechlor, Hercules 3956)

alpha-HCH (*alpha*-BHC, *alpha*-lindane, *alpha*-hexachlorocyclohexane, *alpha*-benzene hexachloride)

delta-HCH (*delta*-BHC, *delta*-hexachlorocyclohexane, *delta*-benzene hexachloride)

o,p'-Methoxychlor

p,p'-Methoxychlor (Marlate, methoxychlore)

Trace elements

No non-detects

[a] Selected water-quality standards and guidelines [38].

[b] Rates of detection are based on the number of analyses and detections in the Study Unit, not on national data. Rates of detection for herbicides and insecticides were computed by only counting detections equal to or greater than 0.01 µg/L in order to facilitate equal comparisons among compounds, which had widely varying detection limits. For herbicides and insecticides, a detection rate of "<1%" means that all detections are less than 0.01 µg/L, or the detection rate rounds to less than one percent. For other compound groups, all detections were counted and minimum detection limits for most compounds were similar to the lower end of the national ranges shown. Method detection limits for all compounds in these tables are summarized in [38].

[c] Detections of these compounds are reliable, but concentrations are determined with greater uncertainty than for the other compounds and are reported as estimated values [43].

[d] In the Central Columbia Plateau Study Unit, several ground-water samples were analyzed for 1,2-dibromoethane (EDB) at a lower detection limit (0.04 µg/L). The detections shown on page 27 were confirmed, and EDB was detected in one additional well.

[e] The guideline for methyl *tert*-butyl ether is between 20 and 40 µg/L; if the tentative cancer classification C is accepted, the lifetime health advisory will be 20 µg/L [38].

[f] Selected sediment-quality guidelines [38].

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The terms in this glossary were compiled from numerous sources. Some definitions have been modified and may not be the only valid ones for these terms.

Acre-foot - A volume of water equal to one foot in depth and covering one acre; equivalent to 43,560 cubic feet or 325,851 gallons.

Algae - Chlorophyll-bearing nonvascular, primarily aquatic species that have no true roots, stems, or leaves; most algae are microscopic, but some species can be as large as vascular plants.

Base flow - Sustained, low flow in a stream; ground-water discharge is the source of base flow in most places.

Best management practice (BMP) - An agricultural practice that has been determined to be an effective, practical means of preventing or reducing nonpoint source pollution.

Breakdown product - A compound derived by chemical, biological, or physical action upon a pesticide; also called "metabolite." The breakdown is a natural process which may result in a compound that is more or less toxic and more or less persistent.

Dissolved solids - Amount of minerals, such as salt, that are dissolved in water; amount of dissolved solids is an indicator of salinity or hardness.

Eutrophication - The process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen, thereby causing excessive growth of aquatic plants.

Flow path - An underground route for ground-water movement, extending from a recharge (intake) zone such as a hill to a discharge (output) zone such as a shallow stream.

Freshwater-chronic criteria - The highest concentrations of contaminants that freshwater aquatic organisms can be exposed to for an extended period of time (4 days) without adverse effects. *See also* **Water-quality criteria.**

Fumigant - A substance or mixture of substances that produces gas, vapor, fume, or smoke intended to destroy insects, bacteria, or rodents.

Furrow irrigation - A type of surface irrigation where water is applied at the upper end of a field and flows in furrows to the lower end.

Headwaters - The source and upper part of a stream.

Health advisory - A nonregulatory level of a contaminant in drinking water or edible fish that may be used as guidance in the absence of a regulatory limit. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Herbicide - A pesticide that is applied primarily for the purpose of killing undesirable plants.

Insecticide - A pesticide intended to prevent, destroy, or repel insects.

Load - General term that refers to the amount of a material or constituent in solution, in suspension, or in transport; usually expressed in terms of mass or volume.

Loess - A homogeneous, fine-grained sediment made up primarily of silt and clay, and deposited over a wide area (probably by wind).

Maximum contaminant level (MCL) - The maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCL's are enforceable standards established by the U.S. Environmental Protection Agency (USEPA).

Median - The middle or central value in a distribution of data ranked in order of magnitude. The median is equal to the 50th percentile.

Metabolite - *See* **breakdown product.**

Method detection limit (MDL) - The minimum concentration of a substance that can be accurately identified and measured with present laboratory technologies.

Minimum reporting level (MRL) - The smallest measured concentration of a constituent that may be reliably reported using a given analytical method. In many cases, the MRL is used when documentation for the method detection limit is not available.

Nonpoint source - A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution. *See* **point source.**

Organochlorine compound - Synthetic organic compounds containing chlorine. As generally used, term refers to compounds containing mostly or exclusively carbon, hydrogen, and chlorine. Examples include organochlorine insecticides, polychlorinated biphenyls, and some solvents containing chlorine.

Organochlorine pesticide - A class of organic pesticides containing a high percentage of chlorine. Includes dichlorodiphenylethanes (such as DDT), chlorinated cyclodienes (such as chlordane), and chlorinated benzenes (such as lindane). Most organochlorine insecticides were banned or severely restricted in usage because of their carcinogenicity, tendency to bioaccumulate, and toxicity to wildlife.

Organophosphate pesticide - A class of pesticides derived from phosphoric acid. They tend to have high acute toxicity to vertebrates. Although readily metabolized by vertebrates, some metabolic products are more toxic than the parent compound.

Perennial stream - A stream that normally has water in its channel at all times.

Pesticide - A chemical applied to crops, rights of way, lawns or residences to control weeds, insects, fungi, nematodes, rodents, or other "pests." *See also* **herbicide, insecticide, fumigant**.

Point source - A source at a discrete location such as a discharge pipe, drainage ditch, tunnel, well, concentrated livestock operation, or floating craft. *See* **nonpoint source**.

Riparian - The area adjacent to rivers or streams with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

Sediment guideline - Threshold concentration above which there is a high probability of adverse effects on aquatic life from sediment contamination, determined using modified USEPA (1996) procedures.

Semivolatile organic compound (SVOC) - Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Subsurface drain - A slotted or porous drainage pipe installed in an irrigated field to intercept the rising ground-water level and maintain the water table at an acceptable depth below the land surface.

Suspended sediment - Particles of rock, sand, soil, and organic detritus carried in suspension in the water column, in contrast to sediment that moves on or near the streambed.

Synoptic site - A site sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Trace element - An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Triazine herbicide - A class of herbicides containing a symmetrical triazine ring. Examples include atrazine, propazine, metribuzin, and simazine.

Volatile organic compound (VOC) - An organic chemical that has a high vapor pressure relative to its water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Wasteway - A waterway used to drain excess irrigation water dumped from the irrigation delivery system.

Water-quality criteria - Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refer to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water-quality guideline - A specific level of water quality which, if reached, may adversely affect human health or aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Water-quality standard - A legally-enforceable state-adopted and U.S. Environmental Protection Agency-approved ambient standard for water bodies. Standards include the use of the water body and the water-quality criteria that must be met to protect the designated use or uses.

Water table - The point below the land surface where ground water is first encountered and below which the earth is saturated. Depth to the water table varies widely across the Study Unit.

Water year - The continuous 12-month period, October 1 through September 30, in U.S. Geological Survey reports dealing with the surface-water supply. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1980, is referred to as the "1980" water year.

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