CHAPTER 4. THE SWRR INDICATORS

The SWRR framework of indicators encompasses the following set of categories/subcategories for key indicators. For each of the 17 candidate indicators, we provide the following information:

- What is the indicator;
- Why is the indicator important; and
- What does the indicator show?

A. **System capacities, quality and allocation:** Capacities are the amounts (e.g., flow rates) and quality of water available in nature and the related ability to allocate water among various human uses through social and economic processes.

1. **Gross water availability**. An estimate of the total amount of renewable water supply in the natural system

2. **Total withdrawals for human uses.** A measure of the total water withdrawn for use by people

3. **Water in the environment**. A measure of the water remaining in the environment after withdrawals and consumption

4. **Water quality**. A representation of the quality of water in the environment

5. **Total capacity to store, deliver, and treat the water supply over unit of time** (i.e., infrastructure capacity). By basin, watershed or aquifer, estimations of:
   - Public supply, private supply
   - Irrigation
   - Industrial/commercial
   - Thermo-electric
   - Capacity for treatment of return flows in municipal waste streams

6. **Social and organizational capacity**. Measures of the capacity of society and its organizations to manage water sustainably, including:
   - Number of organizations dedicated to water and water-related education
   - Number of states active in statewide comprehensive water planning
   - Numbers of states with regulations providing equal protection and access by all sectors to water resources
   - Numbers of states with emergency rules in place that address human preparedness, resistance and resilience to/from/with water problems and disasters

B. **Consequences of the way we allocate water capacity:** Allocations result in the flow of water to various human uses and water remaining in the environment.

7. **Environmental conditions.** Indices of the biological, chemical and physical conditions of the environment, including:

- Index of biological integrity
- Extent of eutrophication (chlorophyll a, organic carbon)
- Contaminant body burdens in biota (or contaminant burdens in excess of health advisory triggers)
- Water quality impacts (need composite index or method) (plankton biodiversity index by water body type, since plankton=base of food chain)
- Extent of altered wetlands (acres or % wetlands converted)
- Extent of altered river flow (e.g. due to impoundment or levee constraints)

8. **Resources and conditions**. Characterization of the amounts and quality of resources supported by water, including:

- Total availability of waters of suitable quality to maintain recreational uses
- Toxics body burdens and population changes in fish and birds

9. **The quality and quantity of water for human uses.** Measuring the quality and quantity of water used in different sectors, including:

- Quantity of water used for public supply: per capita use of water (would need total population)
- Quantity of water used for irrigation: per acre use of water for irrigation (by major crop type)
- Quantity of water used for industrial & commercial purposes: usage per day per employee (or per ton of finished product; or per unit produced)
- Quantity of water used for thermo-electric power generation: per unit of power generated, or consumptive use per unit of power generated
- Populations served by community water systems (drinking water measure) that meet all health-based standards
- Hydro-electric output per unit flow

10. **Resources withdrawals and use.** Uses of resources that depend upon water in the ecosystem, including:

- Uses of harvested resources (e.g. consumption of fish, oysters, crabs, cranberries or other resources); numbers of sport fishing, water fowl hunting licenses sold annually
- Uses of non-harvested water dependent resources (e.g. water-based recreation days); boat, water craft sales/licenses sold; marine fuel sales, non-sport birding surveys)

C. **Effects on people of the conditions and uses of water resources:** Flows of water in the environment affect water dependent resources and the environmental conditions for humans.

11. **Human conditions**. Measures of the value people receive from the uses of water and the costs they incur, including:

- Value of goods and services related to uses of water withdrawn (e.g. public supply, etc.)
- Value of use of non-harvested water dependent resources (e.g. recreation days)
- Value of uses of harvested resources (e.g. fish value or cranberry value)
- Human health conditions related to water resource use/exposure

D. **Important factors affecting water resources:** People use land, water and water dependent resources in ways that affect the conditions of ecosystems and human life.

12. **Land use.** Measures of the important elements of land use that affect water quality and quantity, including:
    - A GIS-based presentation of land cover elements, including information on impervious surfaces, stream crossings, point and non-point sources, etc.

13. **Residual flows.** An accounting of the flow of water and wastes back into the water system, including:
    - Loading from point sources (chemical and biological pollutants)
    - Loading from non-point sources (chemical and biological pollutants)

14. **Social and economic processes.** Measures of the systems people and organizations develop to influence water resources and sustainability, including:
    - Water pricing (e.g., full-cost basis for pricing)

15. **Ecosystem (environmental) processes.** Measures of ecosystem system processes that govern water resources and sustainability, including:
    - Net Ecosystem Productivity – carbon flux over time per unit area

E. **Composite sustainability assessment:** These indicators combine or otherwise integrate some of the above indicators. Although more thought needs to be given here, we suggest two indicators. Each should be GIS based and designed for presentation at watershed, regional, state or national levels.

16. **Water use sustainability.** In each watershed, show the ratio of water withdrawn to renewable supply.

17. **Water quality sustainability**. In each watershed, indicators of the suitability of water quality for the uses desired, including ecosystem uses.

Indicator #1: Gross Water Availability

What is This Indicator?

This indicator reports the total amount of renewable water supply in the natural system. Different approaches have been used to quantify gross water availability, but all approaches require measurements (or estimates) of one or more of the water-budget components illustrated in Appendix A.

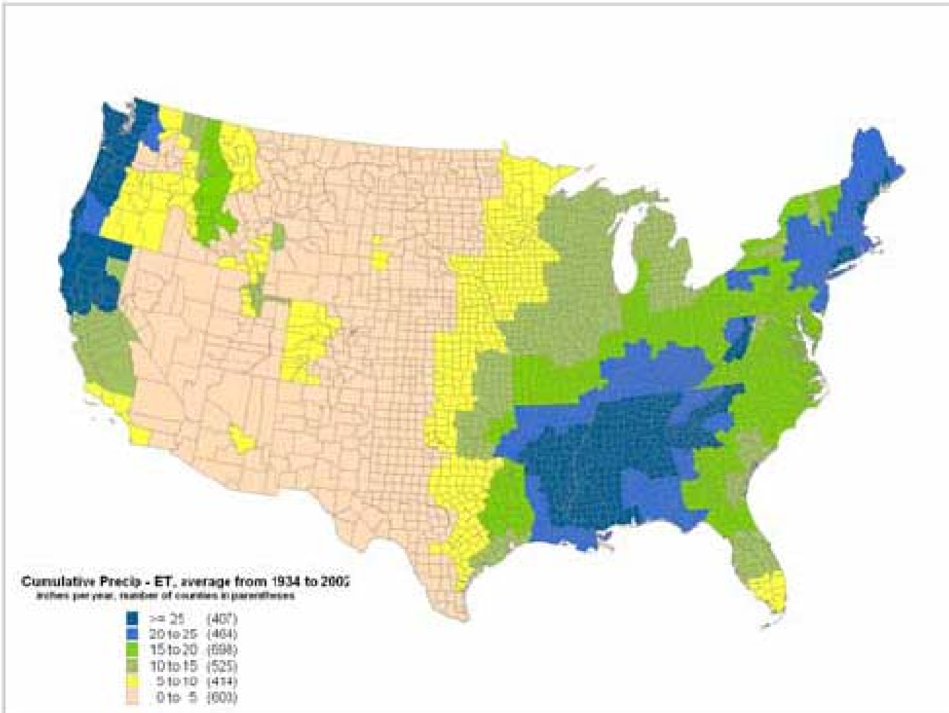
One of the simplest approaches is to quantify the mean annual surface and sub-surface (shallow aquifer) runoff, accumulated as river discharge.[1] Another approach defined the *renewable supply* in a region as the amount of available precipitation, which is shown in Figure 4.1.1.[2] Available precipitation is defined as the difference between precipitation and potential evapotranspiration totaled for all months in a year when precipitation exceeds potential evapotranspiration.

The U.S. Geological Survey defined the renewable supply of water within a watershed as the sum of precipitation and imports, minus natural evapotranspiration and exports.[3] They also showed that renewable supply could, alternatively, be determined as the sum of surface-water outflow and consumptive use minus the long-term depletion of ground-water storage in a watershed. The USGS noted that although renewable supply represents the flow that is theoretically available for use in a watershed on a permanent basis, it is actually a “simplified” upper limit to the amount of water consumption that could occur in a region on a sustained basis. It is simplified in the sense that the variables involved—precipitation, imports, natural evapotranspiration, and exports—are subject to change due to natural causes and human intervention. Moreover, where there are legal and institutional requirements to maintain minimum flows in streams to enable uses such as navigation, hydroelectric power generation, fish propagation and habitat, the actual amount of available water is reduced to an amount that might be defined as *net water availability*.

An important yet unresolved issue concerns how to measure and report the variability of gross water availability over both short and long periods of time. Although the amounts of water that are available for average hydrologic and climate conditions are important, many additional issues in water sustainability are concerned with the availability of water over a wide range of hydrologic conditions extending from very low-flow conditions to very high-flow conditions. As a result, an indicator (or indicators) of gross water availability should reflect how the variability of water availability changes with time. Work remains to determine statistical measures of the variability of gross water availability that provide meaningful information to decision-makers and the public.

Water, water, everywhere, Nor any drop to drink.
The Ancient Mariner. Part ii. Samuel Taylor Coleridge (1772–1834)

Figure 4.1.1
Available Precipitation (difference between monthly precipitation and potential evapotranspiration) across the United States based on 1934-2002 average data at the climate division level.



(Source: Figure from S. Roy, K. Summers and R. Goldstein, using USGS data, paper presented at SWRR meeting at EPRI, Palo Alto, March 2004)

Why is it Important?

Gross water availability is important because it is the foundation for understanding the quantities of water that are available for human and ecosystem uses and how those quantities vary over time.

What Do the Data Show?

Nationwide, the renewable supply of water (precipitation less evapotranspiration) is much larger than the rate of consumptive use.[4] From a national perspective, therefore, water resources appear ample. Locally, however, the situation varies widely. Much of the western U.S., except some coastal areas, has far lower water availability than the eastern U.S. In the eastern states, water availability is lower in regions with higher potential evapotranspiration, such as south Florida.[5] Overall, these results are consistent with those of the USGS using 1980 data and updated by Alley using 1995 data. Alley notes, however, that these maps can suggest a relative abundance of water in regions that actually face challenging water-availability issues. He cites as an example the South Atlantic-Gulf region, an area with so-called “water wars” among competing in the courts for allocations of water from sources that cross boundaries.

End Notes

1. Vorosmarty, C.J., Green, Pamela, Salisbury, Joseph, and Lammers, R.B., 2000, Global water resources—Vulnerability from climate change and population growth: *Science*, v. 289, p. 284 - 288.

2. Roy, S.B., Ricci, P.F., Summers, K.V., Chung, C.F., and Goldstein, R.A., 2005, Evaluation of the sustainability of water withdrawals in the United States, 1995-2025: submitted for publication.

3. U.S. Geological Survey, 1984, National water summary 1983—Hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250.

4. Alley, W.M., 2002, Some reflections on the sustainability of water resources: *in* Gerhard, L.C., Leahy, P.P., and Yannocone, V.J., Jr., Sustainability of energy and water through the 21st century—*Proceedings of the Arbor Day Farm Conference*, October 8-11, 2000: Kansas Geological Survey Special Publication, p. 81-87.

5. Roy et al, *op. cit*.

The life in us is like the water in the river. It may rise this year higher than man has ever known it, and flood the parched uplands; even this may be the eventful year, which will drown out all our muskrats. It was not always dry land where we dwell. I see far inland the banks which the stream anciently washed, before science began to record it freshets.

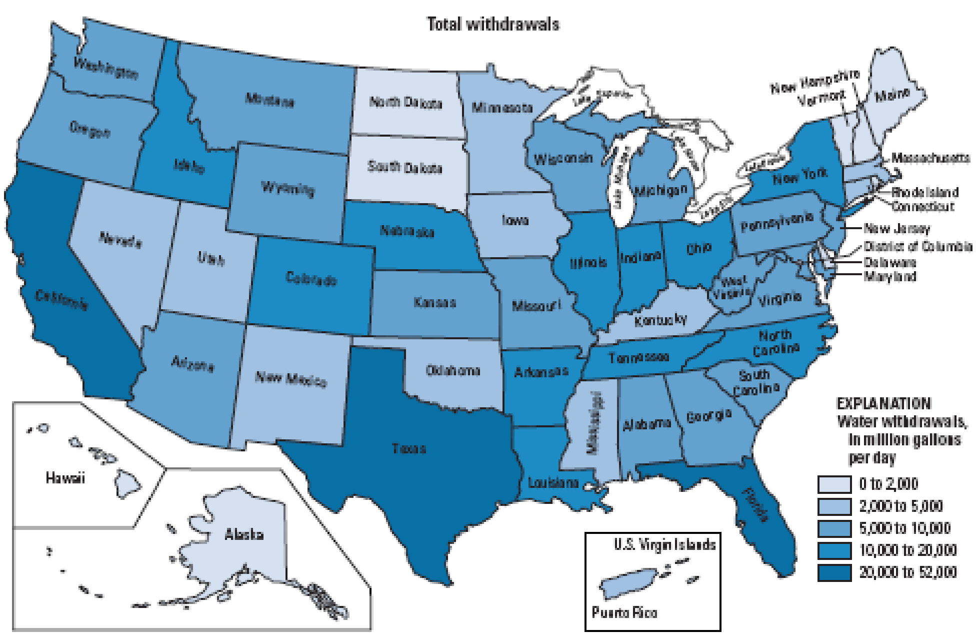
— *Henry David Thoreau, 1854, from "Walden*

Indicator #2: Total Water Withdrawals for Human Uses

What Is This Indicator?

This indicator reports the total amounts of surface water and ground water that are withdrawn from the natural system for human uses. The indicator includes both fresh water and saline-water withdrawals. The U.S. Geological Survey (USGS) has collected withdrawal data at five-year intervals since 1950 (Figure 4.2.1). The USGS data show how total amounts as well as the relative amounts withdrawn from surface water and ground water change over time for a given location. The USGS collects data at the county level, but reports the totals for each state. The data could also be aggregated to estimate withdrawals by river basin or sub-basin.[1]

Figure 4.2.1
Total water withdrawals for the United States, 2000[2]



Why Is This Indicator Important?

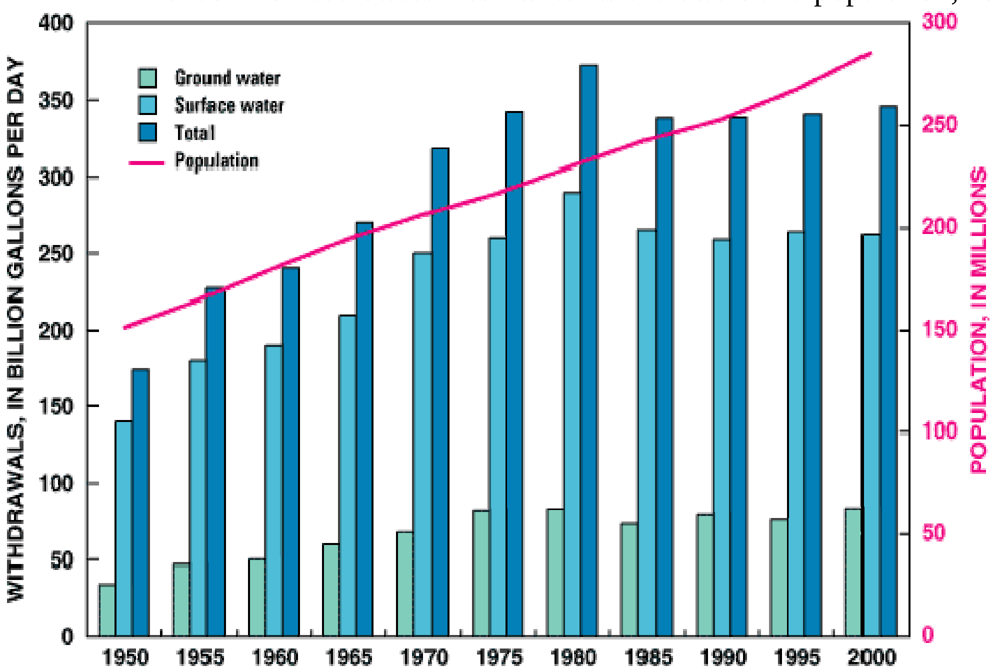
This indicator shows how human needs and uses impact total water availability as well as other measures of water resource sustainability (see also Indicator 16 on water use sustainability).

What Do the Data Show?

Total surface water and ground water withdrawals in the United States were about 408 billion gallons per day (Bgal/d) in 2000. Approximately 85 percent came from fresh water sources; fresh surface water withdrawals were 262 Bgal/d and fresh ground water withdrawals were 83 Bgal/d. California had the largest total withdrawals (51.2 Bgal/d).

Total withdrawals of water in the United States increased steadily from 1950 to 1980, and then declined more than 9 percent from 1980 to 1985. Withdrawal totals have varied by less than 3 percent between the 5-year intervals since 1985 (Figure 4.2.2). Although the population of the United States has steadily increased over the past 50 years, withdrawals have remained relatively stable since 1985 because withdrawals for the two largest uses of water—thermoelectric power and irrigation—have stabilized (see also Indicator 9 on the quality and quantity of water for human uses).

Figure 4.2.2
Trends in United States fresh water withdrawals and population, 1950-2000[3]



End Notes

1. U.S. Geological Survey, 2004, Estimated Use of Water in the United States County-level data for 2000: data available at: http://water.usgs.gov/watuse/data/2000/index.html.

2. Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated Use of Water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.

3. Ibid.

Indicator #3: Water in the Environment

What is This Indicator?

This indicator reports the flows and storage volumes of water in the environment. The data needed to support these indicators are partially available at this time. Streamflow data are collected as part of the National Streamflow Information Program of the USGS.[1] The USGS currently operates about 7,000 streamflow gauges, which would provide a substantial database. Data networks to support ground-water level indicators are not as well established. Although there are approximately 42,000 long-term observation wells in the United States that have five or more years of water-level records, there is no nationwide, systematic ground-water level monitoring program to support a water-resources indicator program.[2] The USGS does maintain a smaller network of about 140 wells to monitor the effects of droughts and other climate variability on ground-water levels.[3] Additional sources of hydrologic data that would be useful for monitoring water in the environment include data on the storage content of many of the nation's largest reservoirs reported by the U.S. Bureau of Reclamation,[4] and the data for approximately 76,000 dams maintained by the U.S. Army Corps of Engineers.[5]

As with several of the other indicators related to water flow, an important yet currently unresolved issue concerns how to measure and report the variability of hydrologic conditions over both short-term and long-term periods. Many SWRR participants have recommended that streamflow conditions should be reported for a range of flows that extend from very low-flow to very high-flow conditions, and not simply reported for the annual mean flow. Work remains to determine the most appropriate range of flow and storage conditions to monitor and report.

Why is This Indicator Important?

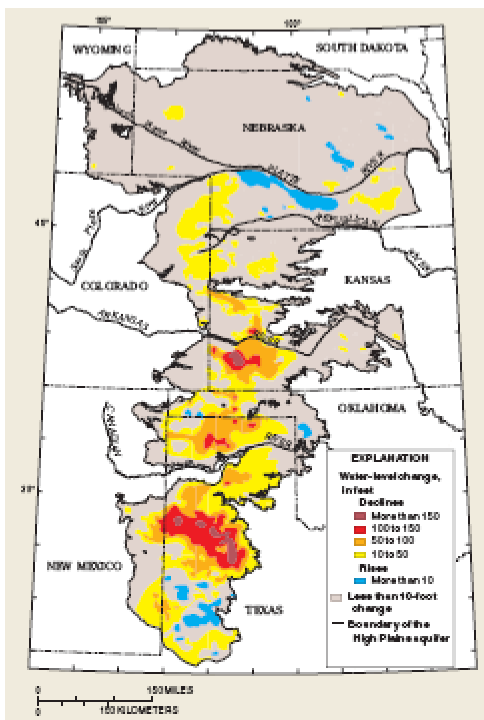
This indicator is important for determining how much water is currently available in our rivers, lakes, reservoirs, and aquifers, and how these flow rates and storage volumes are changing in response to natural variation and human intervention. This water supports the needs of all forms of life living in the ecosystem and is a resource for future human uses.

What Do the Data Show?

Changes in the hydrologic regime of a watershed result from natural causes and human actions. One of the primary benefits of information networks that collect hydrologic data over long periods of time is that they provide the data to document these changes and inform management decisions. Recently, several studies have used the Hydro-Climatic Data Network streamflow dataset to evaluate changes in streamflow across the nation. This dataset, developed by the USGS, consists of streamflow data collected at more than 1,500 gauging stations at sites that are relatively free of human influences. These studies indicate an upward trend in the lower and moderate streamflows in parts of the U.S. since the late 1930s, yet do not show statistically significant increases in higher streamflows.[6,7,8]

Withdrawing groundwater from wells creates a cone of depression and a reduction in water pressure and water levels. If recharge is enhanced by pumping, there may be no long-term reduction in the amount of water stored in an aquifer, and water-levels can rebound when pumpage is reduced or terminated. On the other hand, if groundwater is removed from an aquifer at a rate greater than it can be recharged, resulting in ever-lowering groundwater levels, then groundwater is mined and the amount of water stored in the aquifer is reduced permanently. In addition to reducing the amount of water that is stored in an aquifer, ground-water depletion can reduce surface-water flows, cause land subsidence, or lead to a deterioration of ground-water quality, particularly in coastal aquifers that are susceptible to saltwater intrusion.[9] Ground-water depletion occurs at scales ranging from a single well to regional aquifer systems underlying several states. One of the best documented examples of regional ground-water depletion occurs in the High Plains aquifer, where ground-water withdrawals, primarily for irrigation, have caused large-scale declines of the water table and accompanying reductions in ground-water storage (see Figure 4.3.1). In response to these declines, in 1988, Federal, state, and local water-resource agencies collaborated to implement a monitoring program to assess annual changes in ground-water levels.

Figure 4.3.1
Changes in ground-water levels in the High Plains aquifer from before ground-water development to 1997[10]



End Notes

1. U.S. Geological Survey, 2005a, National Streamflow Information Program: program information and data available online at http://water.usgs.gov/nsip/.

2. Taylor, C.J., and Alley, W.M., 2002, Ground-water-level monitoring and the importance of long-term water-level data: U.S. Geological Survey Circular 1217, 68p.

3. U.S. Geological Survey, 2005b, Ground-water climate response network: information and data available online at http://groundwaterwatch.usgs.gov/

4. U. S. Bureau of Reclamation, 2005, Dams and reservoirs dataweb: information and data available online at http://www.usbr.gov/dataweb/dams/index.html

5. U.S. Army Corps of Engineers, 2005, National inventory of dams: information and data available online at http://crunch.tec.army.mil/nid/webpages/nid.cfm

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7. Douglas, E.M., Vogel, R.M., and Kroll, C.N., 2000, Trends in floods and low flows in the United States—impact of spatial correlation: *Journal of Hydrology*, v. 240, p. 90-105.

8. McCabe, G.J., and Wolock, D.M., 2002, A step increase in streamflow in the conterminous United States: Geophysical Research Letters, v. 29, no. 24, 2185.

9. Bartolino, J.R., and Cunningham, W.L., 2003, Ground-water depletion across the Nation: U.S. Geological Survey Fact Sheet 103-03, 4 p.

10. U.S. Geological Survey, 2002, Concepts for national assessment of water availability and use: U.S. Geological Survey Circular 1223, 34 p.

Indicator #4. Water Quality in the Environment

What is This Indicator?

This indicator provides a representation of the quality of water in the environment. Because of the myriad chemical constituents that can potentially impair water quality, it is clear that this indicator would need to address a large number of constituent types. Therefore, the indicator likely would be a composite indicator that could take one of a number of forms. For example, the indicator might consist of a single value, or index, that synthesizes all of the data into an overall measure of the quality of the water environment, such as "the percentage of streams within a basin that meet all water-quality standards." Alternatively, the indicator might consist of several water-quality measures shown together in a single summary graphic (such as a star diagram, or two- or three-dimensional bar charts; see Lane and others, 1999, for examples)[1] or shown separately in a series of maps, graphs, or tables.

Several suggestions were made during the SWRR discussions concerning the specific types of data that should contribute to a composite water-quality indicator. To a large extent, these suggestions were consistent with the data types identified in other environmental indicator initiatives, such as the Heinz Center's *State of the Nation's Ecosystems*[2] and U.S. EPA's *State of the Environment*.[3] These data types include nutrients (such as nitrogen and phosphorus concentrations); dissolved oxygen levels; bacterial measures; and pesticides, volatile organic compounds, and other chemical contaminants.

Why is This Indicator Important?

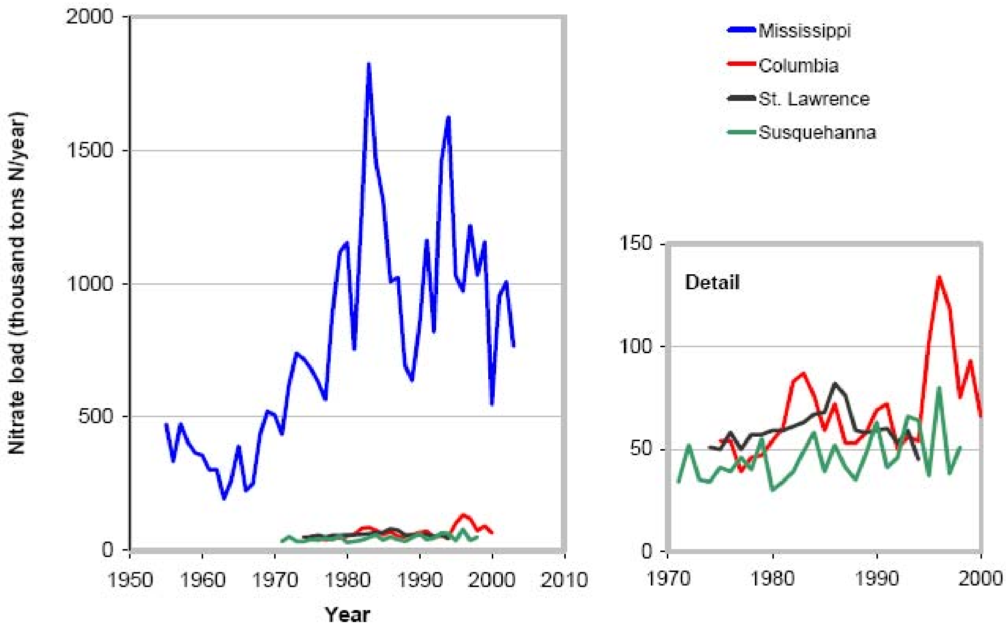
Water quality is critical to the health of human beings and ecosystems.

What Do the Data Show?

One of the most important measures of the water quality conditions of a stream or lake is the concentration of nitrogen. Nitrogen is a critical nutrient for plants and animals and a key indicator of ecosystem function. Excess nitrogen concentrations may indicate a decline in the ability of watersheds to assimilate point and non-point and atmospheric sources of nitrogen pollutants. The resulting nitrogen may have harmful effects as it moves downstream to coastal ecosystems. An indicator of nitrogen in the water environment has been prepared for the Heinz Center and EPA indicator initiatives using stream flow and water quality data collected by the USGS. The indicator tracks trends in the discharges of nitrate from the four largest rivers in the United States: the Mississippi, Columbia, St. Lawrence, and Susquehanna. While not inclusive of the entire nation, these four rivers account for approximately 55 percent of all fresh water flow entering the ocean from the lower 48 States.

The amount of nitrate carried by two of the four rivers covered in this indicator increased for several decades peaking in the early 1980s or 1990s. (see Figure 4.4.1). The Mississippi River had the most striking increase in nitrate discharge but has declined in recent years. The Mississippi, which drains more than 40 percent of the area of the lower 48 states, carries roughly 15 times more nitrate than any other U.S. river. The nitrate load in the Columbia River increased to almost twice its historical loads during the later half of the 1990s, but returned to levels similar to those seen in the 1980s during 2000, the last year of record. Nitrate loads in the Susquehanna and St. Lawrence Rivers do not appear to have shown upward or downward trends during their periods of record.

Figure 4.4.1
Nitrate Load Carried by Major Rivers.[4]



(Source: Figure prepared for the U.S. Environmental Protection Agency State of the Environment 2006 report using data from U.S. Geological Survey.)

End Notes

1. Lane, M.E., Kirshen, P.H., and Vogel, R.M., 1999, Indicators of impacts of global climate change on U.S. water resources: Journal of Water Resources Planning and Management, v. 125, no. 4, p. 194-204.
2. Heinz Report
3. U.S. EPA Report, State of the Environment, 2006.
4. *Ibid.*

Indicator #5: Total Capacity to Store, Deliver, and Treat Water

What is This Indicator?

This indicator reports the ability of the nation's infrastructure to store, deliver, and treat water for human use. The United States has invested enormous resources to build capacity to ensure adequate water supplies despite geographic and seasonal variations in the natural hydrologic cycle. Human water use requires infrastructure that can meet specific needs. These needs include drinking water, irrigation, industry and commerce, navigation, and thermo-electric generation, among others.

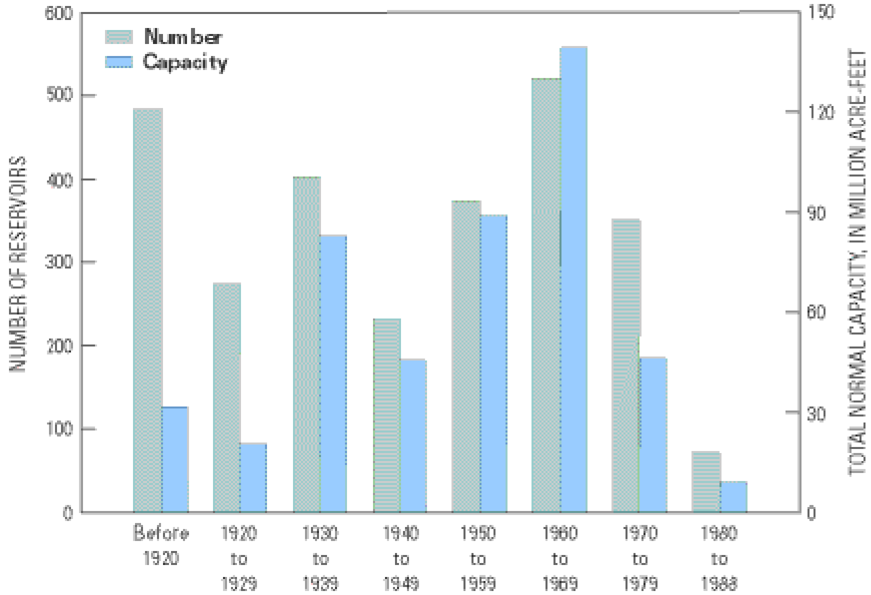
It is important to quantify the available infrastructure in a watershed to withdraw, store, deliver, and treat water for various human needs. These quantities could be reported in units that are consistent with other water budget components of the hydrologic cycle (such as million gallons per day or cubic feet per second). As an example, it's critical that communities know that they have the capacity to withdraw so many Mgal/day from surface-water and ground-water sources, and that they withdraw 50 percent of that capacity on an average day, but 90 percent of that capacity on a peak-demand day. State and local water-resource agencies would likely need to compile this type of data.

Storage

The number and size of reservoirs are important sub-indicators of water infrastructure capacity, particularly surface-water storage. Figure 4.5.1. shows the number and total normal capacity of large reservoirs in the United States and Puerto Rico completed before 1920, during each decade from 1920 to 1979, and from 1980 to 1988. Normal capacity is the total volume in a reservoir below the normal retention level.[1]

Total reservoir storage conditions change in response to variability in the hydrologic cycle, water use, reservoir sedimentation, and reservoir construction and removal. In a 2002 Report to Congress, the USGS recommended that an appropriate assessment of surface-water storage would regularly update reservoir storage conditions and account for construction of new reservoirs, decreases in reservoir storage capacity due to sedimentation, and any removal of dams.[2]

Figure 4.5.1
Number and Capacity of Reservoirs Built Since Before 1920 to 1988



(Source: U.S. Geological Survey, Report to Congress, *Concepts for National Assessment of Water Availability and Use*, U.S. Geological Survey Circular 1223, August 2002)

Treatment

Local water utilities must make significant investments to install, upgrade, or replace equipment in order to deliver safe drinking water and protect public health. Every four years, EPA conducts a survey of the states for anticipated costs of these investments and reports the results to Congress. The results are also used to help determine the amount of funding each state receives for its Drinking Water State Revolving Fund program, which funds the types of projects identified in the survey. Table 4.5.1 shows the total national need by system size and project type as well as by current and future need over the next 20 years.[3] The need includes installation of new infrastructure as well as rehabilitation or replacement of deteriorated or undersized infrastructure. It also includes the need to address aging infrastructure that is adequate now, but will require replacement or significant rehabilitation over the next 20 years.

Table 4.5.1
Total Need by Project Type
(in millions of January 2003 dollars)

System Size and Type	Distribution and Transmission	Treatment	Storage	Source	Other	Total Need	Number of Systems[6]
Large Community Water Systems (serving over 50,000 people)	$89,779.9	$20,091.3	$6,994.5	$4,715.8	$1,270.2	$122,851.7	1,041
Medium Community Water Systems (serving 3,301 to 50,000 people)[1]	$73,454.4	$14,906.2	$9,473.3	$4,392.8	$790.9	$103,017.4	7,638
Small Community Water Systems (serving 3,300 and fewer people)[1,2]	$18,624.3	$6,164.1	$6,263.8	$2,871.0	$248.3	$34,171.5	43,039
Costs Associated with the Recently Promulgated Arsenic Rule[3]		$947.4				$947.4	
Not-for-profit Noncommunity Water Systems[4]	$425.3	$670.2	$1,620.3	$681.0	$0.8	$3,397.5	21,400
American Indian and Alaska Native Village Water Systems [4,5]	$1,347.3	$462.2	$490.3	$135.1	$13.6	$2,448.5	974
Subtotal National Need	$183,631.1	$43,241.4	$24,842.2	$12,795.6	$2,323.7	$266,834.1	
Costs Associated with Proposed and Recently Promulgated Regulations (Taken from EPA Economic Analyses)		$9,927.4				$9,927.4	
Total National Need	$183,631.1	$53,168.8	$24,842.2	$12,795.6	$2,323.7	$276,761.5	

System Size and Type	Distribu-tion and Trans-mission	Treat-ment	Storage	Source	Other	Total Need	Number of Systems[6]

Note: Numbers may not total due to rounding.

[1]Does not include the costs associated with the recently promulgated Arsenic Rule and proposed or recently promulgated SDWA regulation; these costs are included on a separate line in this table.
[2]1999 Needs Assessment findings adjusted to January 2003 dollars and reallocated based on 2003 inventory of small systems.
[3]Does not include costs for American Indian and Alaska native village water systems to comply with the recently promulgated Arsenic Rule; these costs are incorporated in the estimate for American Indian and Alaska native village water systems.
[4]1999 Needs Assessment findings adjusted to January 2003 dollars.
[5]Includes cost for compliance with the recently promulgated Arsenic Rule
[6]Number of large, medium, and small systems is determined from the 2003 Needs Assessment sample frame. Number of not-for-profit, American Indian, and Alaska native village systems is determined from the 1999 Needs Assessment sample frame. The numbers in the 2003 Needs Assessment may differ from the Safe Drinking Water Information System (SDWIS) due to changes in system inventories and the way the 2003 Needs Assessment classifies some systems (i.e., systems that serve Alaska native villages are classified in SDWIS as small systems, but are classified in the 2003 Needs Assessment as Alaska native village water systems).

Other Indicators

The American Society of Civil Engineers (ASCE) periodically issues a progress report on the condition of the nation's infrastructure, including drinking water, wastewater, dams, and navigable water ways (see Table 4.5.2).[4] In 2003, with the guidance of a 20-member advisory council, ASCE evaluated existing data reports for each category. ASCE determined progress and trends since 2001 by evaluating the infrastructure's condition, performance, capacity, and funding relative to actions taken by policy makers to address issues and problems.

Table 4.5.2
ASCE Progress Report on the Nation's Infrastucture, 2003

Area	2001 Grade	2003 Trend	Comment
Drinking Water	D	Down	"While drinking water quality remains good, the infrastructure of the nation's 54,000 drinking water systems is aging rapidly. Federal funding remains flat, while the infrastructure needs continue to increase. There is an annual shortfall of $11 billion needed to replace or rehabilitate facilities that are nearing the end of their useful life and to comply with federal water regulations."
Wastewater	D	Down	"The nation's 16,000 wastewater systems face enormous needs. Some sewer systems are 100 years old and many treatment facilities are past their recommended life expectancy. Currently, there is a $12 billion annual shortfall in funding for

Area	2001 Grade	2003 Trend	Comment
			infrastructure needs; however, federal funding has remained flat for a decade. Because of this continuing shortfall, more than one-third of U.S. surface waters do not meet water quality standards.”
Dams	D	Down	“The number of unsafe dams has risen by 23 percent to nearly 2,600. Because of downstream development, the number of "high-hazard potential dams" - those whose failure would cause loss of life - has increased from 9,921 in 2001 to 10,049 in 2003.” ”Some progress is being made through the repair of small watershed dams constructed with assistance from the USDA since 1948. This is only a small portion of the total number of non-federal dams. On the federal side, the federally-owned dams are in good condition; however, continuing budget restrictions are placing pressure on and limiting many agency dam safety programs.”
Navigable Waterways	D+	Down	“Despite the significance of the waterway link to the global economy, national investment in water resources projects has not kept pace with U.S. economic and social expansion.” ”Half of the navigation locks on inland waterways exceed their 50-year design life. System capacity has been impacted by deferred maintenance, which has led to a doubling of out-of-service times at navigation locks over the last 10 years. Funding shortfalls have delayed completion of many ongoing capital improvement projects by 5 to 10 years, resulting in construction cost increases of $300 million and lost benefits of over $2 billion. The unexpended balance in the Inland Waterway Trust Fund has grown to $360 million.”

(Source: American Society of Civil Engineers)

Why is This Indicator Important?

An abundance of water in the aggregate belies increasingly limited water supplies in many regions, reflecting uneven distribution of the nation's water resources. Dam construction, groundwater pumping, and interbasin conveyance provides the water to meet growing human needs. However, future opportunities for large-scale expansion of seasonally reliable water supplies are limited due to lack of project sites, reduced funding, and other social and economic factors. Future water needs will increasingly be met by reallocation of existing supplies.[5]

What Do the Data Show?

Storage

According to the U.S. Army Corps of Engineers, in 2001, there were 77,000 dams higher than 6 feet in the United States and Puerto Rico. Because some reservoirs have multiple dams, this corresponds to about 68,000 reservoirs nationwide. Omitting dams that are control structures on large natural lakes, such as Lake Superior, the total volume of water stored in these reservoirs under typical conditions is about 422 million acre-feet (520 cubic kilometers).

In 1995, the U.S. Global Change Research Information Office found that the developed capacity of reservoirs represented only about 70 percent of the potential capacity.[6] They also reported that sedimentation was reducing existing reservoir capacity by about 1.5 million acre-feet (maf) per year. They also concluded that sizable investments were needed to rehabilitate, maintain, and, in some cases, remove dams.

Treatment

There are approximately 160,000 public drinking water systems in the United States. The U.S. Environmental Protection Agency classifies public supply systems into various categories. In 2004, most people in the U.S. (268 million) received their water from a community water system. There are approximately 54,000 community water systems, but just 7percent of those systems serve 81 percent of the people.[7]

The EPA's 2003 Needs Assessment indicates that community water systems and non-for-profit non-community water systems need $276.8 billion over the next 20 years to install, upgrade, and replace infrastructure. The nation's 1,041 largest community water systems (serving more than 50,000 people) accounted for 44 percent of the total need. Most of the infrastructure needs represent projects that would fund preventive measures to ensure the continued provision of safe drinking water rather than as corrective actions to address an existing violation of a drinking water standard. In addition, transmission and distribution projects represented about two-thirds of the total needs.

End Notes

1. Ruddy, B.C., and Hitt, K.J., 1990, *Summary of Selected Characteristics of Large Reservoirs in the United States and Puerto Rico*, U.S. Geological Survey Open-File Report 90–163, p. 295.

2. U.S. Geological Survey, Report to Congress, *Concepts for National Assessment of Water Availability and Use*, U.S. Geological Survey Circular 1223, August 2002, http://water.usgs.gov/pubs/circ/circ1223/html/cover.html.

3. U.S. EPA, *Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress*, June 2005, p. 24 and 27.

4. American Society of Civil Engineers, "2003 Progress Report," http://www.asce.org/reportcard/index.cfm?reaction=full&page=6.

5. U.S. Department of Agriculture, *Agricultural Resources and Environmental Indicators*, Agricultural Handbook No. (AH722), February 2003, Chapter 2.1, page 1, http://www.ers.usda.gov/publications/arei/ah722/.

6. Kenneth D. Frederick, "America's Water Supply: Status and Prospects for the Future," *Consequences*, Vol. 1., No. 1, Spring 1995.

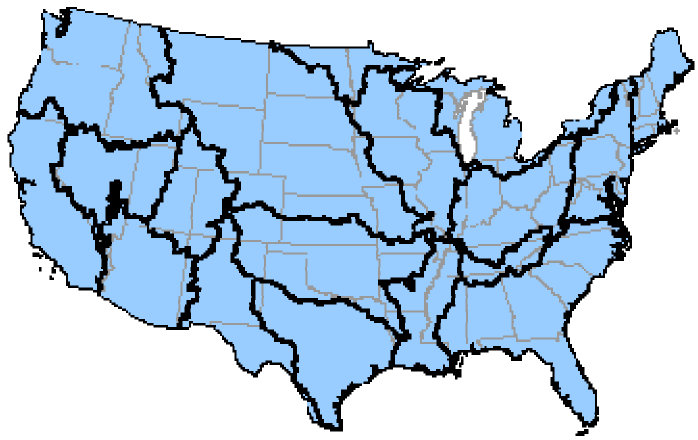
7. U.S. EPA, FACTOIDS: Drinking Water and Ground Water Statistics for 2004.

As water spilt on the ground, which cannot be gathered up again.

The Bible: 2 Samuel xiv. 14.

Indicator 6: Social and Organizational Capacity

Figure 4.6.1
Organizations by Watershed



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Source: EPA/CTIC Know Your Watershed: http://www.ctic.purdue.edu/KYW/NWN/US_Watersheds_8digit.html, accessed October 18, 2005.

What is this Indicator?
This indicator measures the capacity of society and its organizations to manage water sustainably. Social capacity is demonstrated by the existence of organizations dedicated to engaging civil society and government in water quality protection—whether at the regional, state, watershed, sub-watershed, or community level. This indicator will provide a count of these organizations per capita as a way of assessing the social and organizational capacity. Since numbers in and of themselves tell only part of the story, the indicator will build on work by Moote and Koontz (2003) in classifying watershed organizations as citizen-based, agency-based, and mixed. This will indicate the not only the number of watershed organizations, but also the type of organizations. Social scientists who study watershed management have increasingly argued that the membership composition is extremely important in the kinds of activities these organizations are willing to undertake, their level of community support, and their ability to sustain activity over time (Moote and Koontz 2003; Bloomquist and Schlager 2005).

Why is this Indicator Important?
Water resources sustainability is ultimately dependent on social action. Watershed organizations are widely viewed as the expressions of civic interest in water quality protection (NAS 1999). Their durability over time should indicate social and organizational capacity for management of water resources. Watershed organizations and water stewardship organizations potentially provide an oversight organization that can support or encourage regulation and management decisions by federal or local government, on the one hand, and create resistance for decisions that may harm water quality over time. Even if water quality, measured biophysically, does not improve in the short term, the existence of watershed organizations or other water activist organizations indicates civic engagement in water issues, and thus capacity to manage water resources on the basis of goals of water resources sustainability.

What do the current data show?
While databases have been identified, analysis of the number and type of watershed organizations has not yet been completed. The web sites listed below are compilations of watershed organizations by region and nationally. They need to be analyzed and tabulated to complete this indicator.

End Notes

1. National Academy of Sciences. 1999. *New Strategies for America's Watersheds*. Washington, DC: National Academy Press.

2. Moote, Elizabeth and Thomas Koontz. 2003. A Typology of Collaborative Watershed Groups: Citizen-Based, Agency-Based, and Mixed Partnerships. *Society and Natural Resources*. 16:451–460, 2003.

3. Bloomquist, W and R. Schlager. 2005. Political pitfalls of integrated watershed management. Society and Natural Resources 18 (2): 101-117 2005.

3. http://www.chesapeakebay.net/wshed_directory.htm

4. http://www.ctic.purdue.edu/kyw

5. http://www.dep.state.pa.us/dep/deputate/watermgt/WC/Subjects/WSNoteBks/shedtable.htm

6. http://www.rivernetwork.org/library/index.cfm?doc_id=116

Indicator #7: Environmental Conditions

What is This Indicator?

This indicator addresses consequences of water allocations on the physical, biological, and chemical conditions of the environment. There are no good summaries of water quality currently accepted in the US partly because of widely different standards and methods among the many agencies that take measurements. A rating system developed for the second National Coastal Condition Report (NCCR II) can serve as a good example.

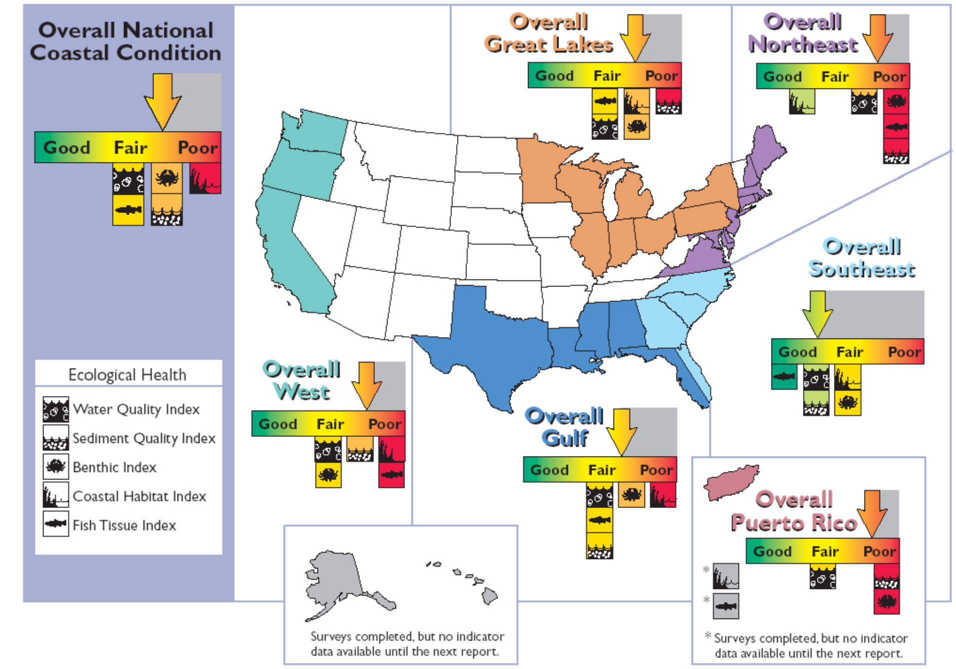
Other reports attempt to address environmental conditions. The U.S. EPA's Draft Report on the Environment (ROE) (2003) has two indicators for the condition of surface waters and watersheds in the U.S. Altered fresh water ecosystems, reports the percentage of each of the major fresh water ecosystems that are altered. The definition of "altered" varies for each water type. The data are incomplete, vary in consistency from state to state, and are not aggregated. The conceptual approach has merit, despite problems in development and implementation of the index The second index in the ROE is the lake trophic state index, which classified lakes into eutrophic, mesotrophic, or oligotrophic states. No national data were available, and the one report was based on phosphorus concentrations in northeast lakes. The limitations to this index include: the lack of national data; no accounting for non-lentic water bodies; and the fact that biota respond to variables besides phosphorus.

The second National Coastal Condition Report (NCCR II) is the result of collaboration among the U.S. EPA, NOAA, U.S. Fish and Wildlife Service, and USGS. The NCRR II is concerned with the condition of coastal regions of the United States. The NCRR II characterizes coastal water bodies based on measures related to aquatic and human uses. The ecological condition of individual sites is scored and assigned to one of three categories: 'good,' 'fair,' or 'poor.' Each region is then assigned a rating based on the overall condition of individual sites (Figure 4.7.1). For the NCRR II, coastal condition was characterized using data from EPA's National Coastal Assessment (NCA), NOAA's Status and Trends Program (NS&T), and FWS's National Wetlands Inventory (NWI). Table 4.7.2 shows the indices used to measure aquatic and human uses.

Table 4.7.1
Indices Used for the National Coastal Condition Report II map

Aquatic Use Indices	**Index components**
1. Water Quality Index	dissolved oxygen, chlorophyll a, nitrogen, phosphorus, water clarity
2. Sediment Quality Index	sediment toxicity, sediment contaminants, sediment TOC
3. Benthic Index	benthic community diversity, pollution-tolerant species, pollution-sensitive species
4. Coastal Habitat Index	long-term decadal wetland loss rate (1780-1990); present decadal wetland loss rate (1990-2000)
Human Use Indices	
5. Fish Tissue Contaminants Index	composite concentrations in relation to EPA Guidance range
All indices calculated based on 1997-2000 data.	

Figure 4.7.1
Overall national and regional coastal condition between 1997 and 2000



(Source: U.S. EPA, December 2004. National Coastal Condition Report II. Office of Research and Development/Office of Water. EPA-620/R-03/002.
(http://www.epa.gov/owow/oceans/nccr2/)

Why is This Indicator Important?

The information provided by the NCCR II can help focus the attention of water quality managers and decision-makers on three critical challenges: 1) areas with problems in need of restoration; 2) areas with good water quality in need of protection; and 3) areas where additional data are needed.

What Do the Data Show?

The NCRR II rated the overall quality of national coastal waters as 'fair.' Specifically, 21 percent of the estuarine area of the country is unimpaired and 44 percent is threatened for human and/or aquatic life uses. The remaining 35 percent are considered impaired: 15 percent of the coastal waters are impaired for both human and aquatic life use; 13 percent for aquatic life use only; and 7 percent for human use only.

To reflect the natural geographic differences in aquatic ecosystem characteristics, the NCRR II identified indices specific to six major regions in the U.S. The scale of each indicator was unique to the site within each region. The whole region was then ranked based on the percentage of sites that were categorized good, fair, or poor. A system of this type is important for characterization at regional and national scales; however, an obvious drawback of NCRR II is the limited geographic focus on coastal waters

The NCRR II is a product of the data that comprises it. Debate is inevitable regarding the relative importance of certain data as well as the presence or absence of certain data. Although the data elements included in these indices are broad, there are no elements that explicitly deal with impacts of ground water withdrawal or threatened/endangered species. There is no perfect index and different data elements may be needed at finer geographic scales. The NCRR II report relies heavily on data collected through EPA's National Coastal Assessment (NCA) from 1999 - 2000 and the coastal portion of the 1997-1998 Mid-Atlantic integrated Assessment (U.S. EPA/EMAP and NCA). In summary, it is difficult to find a single set of water indicators useful at all scales and for all regions. A challenge of future work in developing indicators to assess environmental condition will be to find commonalities that can work at the national level, but have sufficient detail to be helpful to regions and specific sites.

End Notes

1. Gerritsen, J. 1995. Additive biological indices for resource management. J. No. Am. Benthol. Soc.14L 451-457.

2. U.S. EPA. 2001. National Coastal Condition Report. United States Environmental Protection Agency. Office of Research and Development and Office of Water. EPA 620/R-01/005. Washington, D.C.

3. Draft Report on the Environment. Technical Document. US EPA Office of Research and Development and the Office of Environmental Regulation. EPA 600-R-03-050, U.S. EPA. 2003, Washington, D.C. and Science Advisory Board comments on ROE: http://www.epa.gov/sab/pdf/sab_05_004.pdf)

4. U.S. EPA. 2004. National Coastal Condition Report II. United States Environmental Protection Agency. Office of Research and Development and Office of Water. EPA 620/R-03/002. Washington, D.C.

Greater familiarity with marshes on the part of more people could give man a truer and more wholesome view of himself in relation to Nature. In marshes, Life's undercurrents and unknowns and evolutionary changes are exemplified with a high degree of independence from human dominance as long as the marshes remain in marshy condition. They have their own life-rich genuineness and reflect forces that are much older, much more permanent, and much mightier than man.

— *Paul L. Errington "Of Men and Marshes*

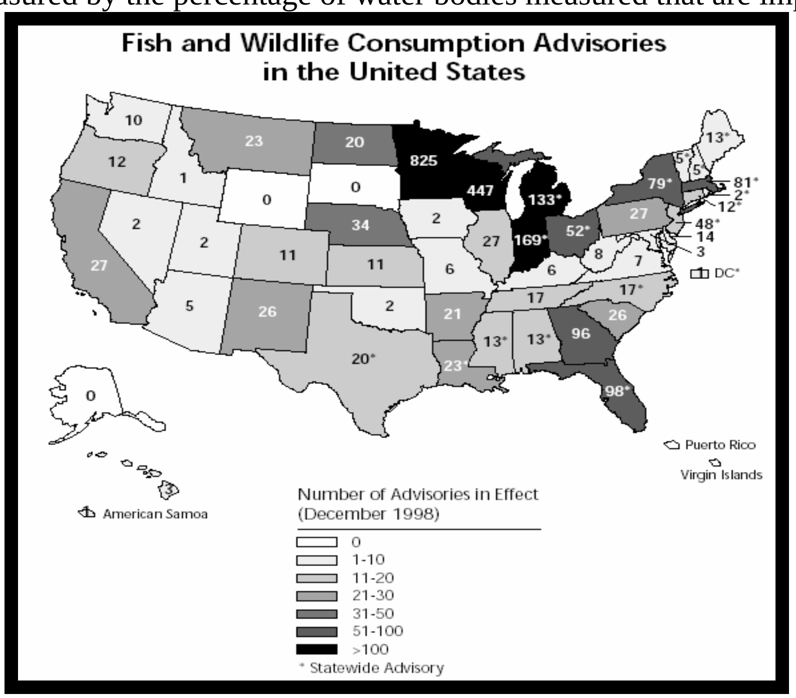
Indicator #8: Resources and Conditions

What is This Indicator?

This indicator characterizes the amount and quality of resources that are directly or indirectly dependent on water quality and/or quantity. It includes measures that can indicate whether resources in the environment associated with water are impacted by changes in the biogeochemical integrity of aquatic ecosystems. Such measures include fish contamination and the percentage of impaired water bodies.

Indicator 8 is designed to be a measure of the condition of the resource in the natural environment rather than when consumed by people. Fish consumption advisories, while based on safety of the fish for human consumption are also a measure of the condition of a watershed itself because they are issued when the concentration of toxic substances in fish and shellfish in a water body exceed safe levels. Contamination of edible organisms like oysters, indicate pollution problems in a water body such as persistent toxic chemicals contaminating the sediments or pathogens contaminating the water.

Figure 4.8.1
Contamination of Fish and Wildlife
(as measured by the percentage of water bodies measured that are impaired)



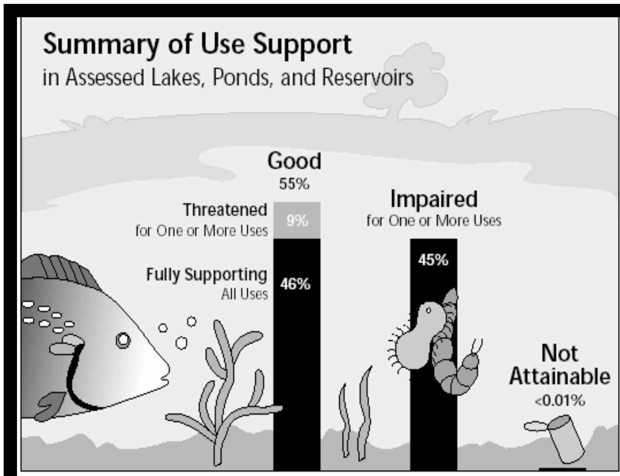
(Source: U.S. Environmental Protection Agency, National Water Quality Inventory 1998 Report (http://www.epa.gov/305b/98report/index.html)

Measures of the toxicity levels in the bodies of fish and other aquatic species represent a pinnacle indicator in aquatic ecosystems because of the bio-accumulation of chemicals that can occur in aquatic food chains where fish harvested for human use are the top predators in the system

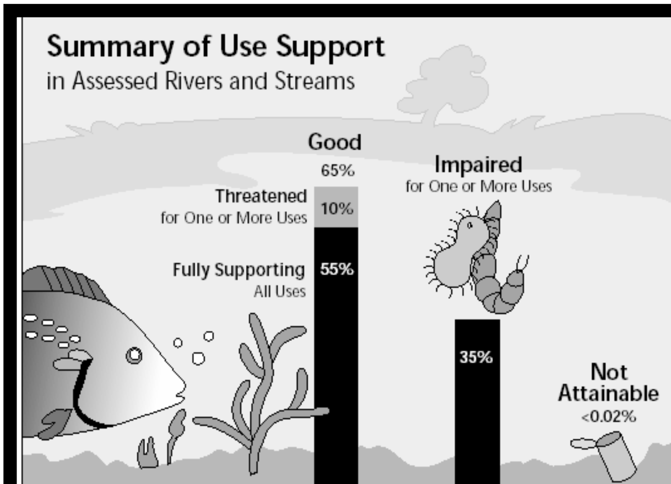
Synthetic chemicals, trace elements, and other contaminants can, in sufficient quantities, harm people as well as fish and other wildlife. As a result, it is important for the public and decision-makers to understand both the frequency of chemical contamination and the degree to which these contaminants exceed regulatory standards and guidelines. The number of contaminants found in fresh water fish offer information about how widespread these compounds are in the environment. Although the presence of chemical contamination does not necessarily mean that the levels are high enough to cause problems, comparison to standards and guidelines offer a useful reference to help judge the significance of contamination.

The two figures (Figures 4.8.2 and 4.8.3) below illustrate the percent of impaired waters based on the 1998 U.S. Environmental Protection Agency State and Tribal Section 305(b) Reports for rivers and streams and lakes, ponds, and reservoirs, respectively. While based on standards for use of the resources by people, the data say something about the condition of the water and the life within it. The data supporting these measures are based upon the assessment of 23 percent of all known rivers and streams in the U.S. and 42 percent of all known lakes, ponds, and reservoirs in the U.S.

Figure 4.8.2 and Figure 4.8.3
Summary of Use Support



This figure presents the status of the assessed acres of lakes, reservoirs, and ponds. Of the more than 17 million acres of lakes, reservoirs, and ponds assessed, 55% fully support their designated uses and 45% are impaired for one or more uses. Nine percent of the assessed waters are fully supporting uses but threatened.

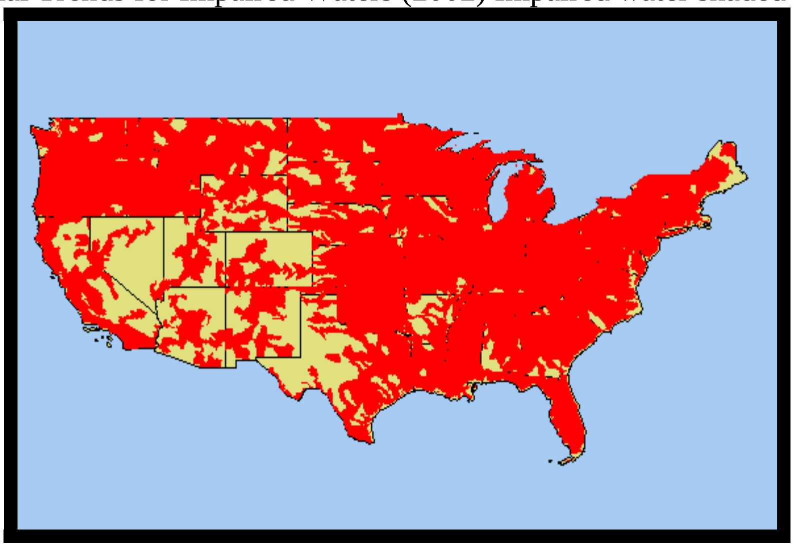


This figure presents the status of the assessed miles of rivers and streams. Of the more than 800,000 miles of rivers and streams assessed, 65% fully support their designated uses and 35% are impaired for one or more uses. Ten percent of the assessed waters are fully supporting uses but threatened.

(Source: 1998 U.S. EPA State and Tribal Section 305b Report)

Another sub-indicator compares the number of water bodies (streams, rivers, lakes, reservoirs, etc.) that are safe from any kind of harm in recreational use by the public with the total number of measured water bodies available for public use. Harm includes public health reasons or other physical public risk issues. The U.S. Clean Water Act Section 303(d) requires states to report a prioritized list of waters not meeting water quality standards and to establish Total Maximum Daily Loads (TMDLs) to correct the impairments. The "Impaired Waters" map for the U.S. shown below is from the 2002 National Water Quality Assessment Database, which summarizes water quality information provided by the states in the 2002 305(b)/303(d) Integrated Reporting cycle. In the SWRR criteria for indicators Indicator 8 is an indicator of the condition of resources in the environment and Indicator 10 is a measure of resources withdrawn by people for their use. The impaired waters map is not purely a map of resource condition since the criteria for whether waters are impaired is based on suitability for various human uses but it does give a general idea of the condition of water resources.

Figure 4.8.4
U.S. EPA, Watershed Tracking and Environmental Results, EnvrioMapper for Water to show National Trends for Impaired Waters (2002) Impaired water shaded in red.



Source: U.S. EPA, http://www.epa.gov/waters/enviromapper/index.html)

What Do the Data Show?

The consumption advisory map for 1998 illustrated in Figure 4.8.1 shows that only 2 of the 48 contiguous states did not report the need for issuing consumption advisories. For the other 46 states, the Great Lake's states had the highest number of fish consumption advisories, followed by the states in the extreme southeast of the U.S. The Sustainable Water Resources Roundtable only found data for 1998 so no trends can be reported for consumption advisories across the U.S. Although no continuous records on an annual basis were discovered for the reporting of consumption advisories, the importance of this measure as a potential health risk indicator to humans from the use of water related resources suggests the need to keep continuous and consistent annual reporting records on this measure.

In 2002, the U.S. EPA estimated that 300,000 miles (482,790 km) of impaired rivers and shorelines existed in the U.S. (Cech, 2003; pg. 334). Contamination was caused primarily by sediments, excess nutrients, and micro-organisms. The EPA also estimated that most of the U.S. population lives within ten miles of these impaired waters.

#9: The Quantity and Quality of Water for Human Uses

What is This Indicator?

The first part of this indicator reports how the water that is withdrawn within (or imported to) a watershed is actually used by the different water use sectors within the watershed. The USGS has collected national data at five-year intervals on amounts of water used in homes, businesses, industries, and agriculture.[1,2] The data are collected at the county level, but are totaled and reported for each state. SWRR recommends that water uses be reported periodically for at least the following four water use categories: public supply, irrigation, industrial and commercial purposes, and thermo-electric power generation. These data might also be used to derive related indicators, such as per capita use of water, per acre use of water (by major crop type), water usage per day per employee (or per ton of finished product or per unit produced), and per unit of power generated (or consumptive use of water per unit of power generated).

Several people involved in SWRR have recommended that the amount of water withdrawn for human uses that is reused be reported. This could include the total quantity of water that is used in multiple cycles in industrial or thermo-electric power generation processes. The quantity of water reused in a watershed is important to sustainability because it demonstrates the extent to which communities and industries within a watershed are conserving (or efficiently using) their water supplies. The quantity that is actually reported would need to be considered carefully. For example, one could report the quantity of water that is delivered to a facility without regard to how many cycles the water is used once it arrives at the facility (for example, one million gallons per day delivered). Alternatively, one could report the total amount of water that is delivered to a facility and multiply it by the number of cycles in which it is used before being consumed or discarded (for example, one million gallons per day delivered multiplied by five cycles of use while at the facility, for a total of five million gallons per day). Work remains to be done on this aspect of this indicator.

The second part of this indicator reports on the quality of water delivered for human uses. One possible measure of this could be the percentage of the population served by community water systems that meet all health-based standards.

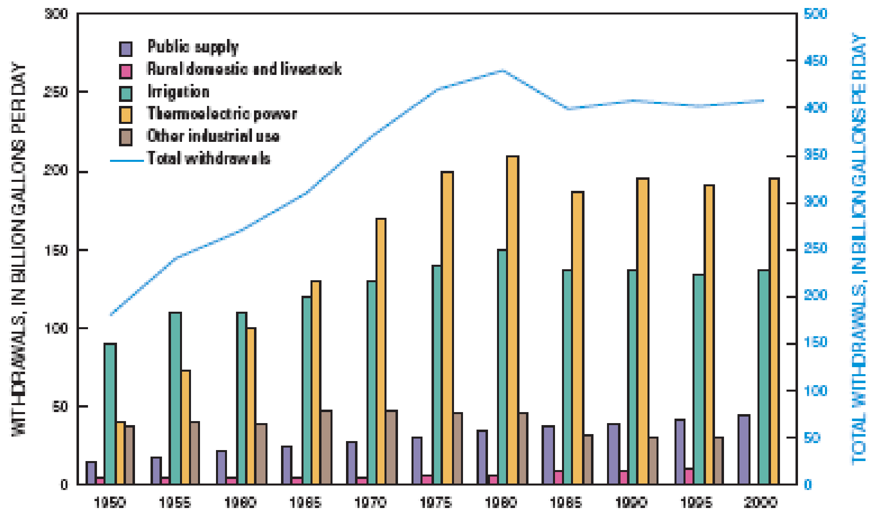
Why is This Indicator Important?

This information is important for understanding the types of uses to which the water is being supplied and how those uses change with time in response to demographic changes, economic trends, and other factors.

What Do the Data Show?

Trends in the allocation of water withdrawals to the major water use categories for the 50-year period 1950-2000 are shown in Figure 4.9.1. The largest uses of water have consistently been for irrigation and thermo-electric power generation, although the amounts of water used for these purposes have stabilized since 1985. With respect to water use for thermo-electric power generation, since the 1970s, power plants increasingly were built with (or converted to) closed-loop cooling systems or air-cooled systems, instead of using once-through cooling systems. The use of re-circulated water for cooling in a closed-loop system reduces the water requirement of a power plant, resulting in reduced water withdrawals.[3] Estimated withdrawals for public supply have increased continually since 1950, as has the population served by public suppliers. The percentage of population served by public suppliers increased from 62 percent for 1950 to 85 percent for 2000.[4]

Figure 4.9.1
Trends in total water withdrawals by water-use category, 1950-2000.[5]



End Notes

1. Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.
2. U.S. Geological Survey, 2004, Estimated use of water in the United States county-level data for 2000: data available at: http://water.usgs.gov/watuse/data/2000/index.html.
3. Hutson et al, op. cit.
4. Ibid.
5. Ibid.

Indicator 10: Resources withdrawals and use

What is This Indicator?

Indicator 8 is a measure that assesses the condition of water related resources in their natural state. This indicator, by contrast, measures resources directly or indirectly dependent on water that are withdrawn from the environment and used by people. Such measures include public participation in fresh water recreation.

Americans enjoy recreation in and around water, from bird watching and fishing to sailing and swimming. The sub-indicator measures the number of fresh water anglers and total fishing licenses sold annually to illustrate trends in the public activity of fresh water fishing in the U.S. These measures of public participation in fresh water recreation imply the value and importance that people place on this form of recreation. Information on trends in participation in fishing document the demand for recreation opportunities and can be useful in assessing people's perceptions regarding the value and safe use of these resources. If the demands change over time, this can be a factor indicating changing public perception of the risks associated with using water resources.

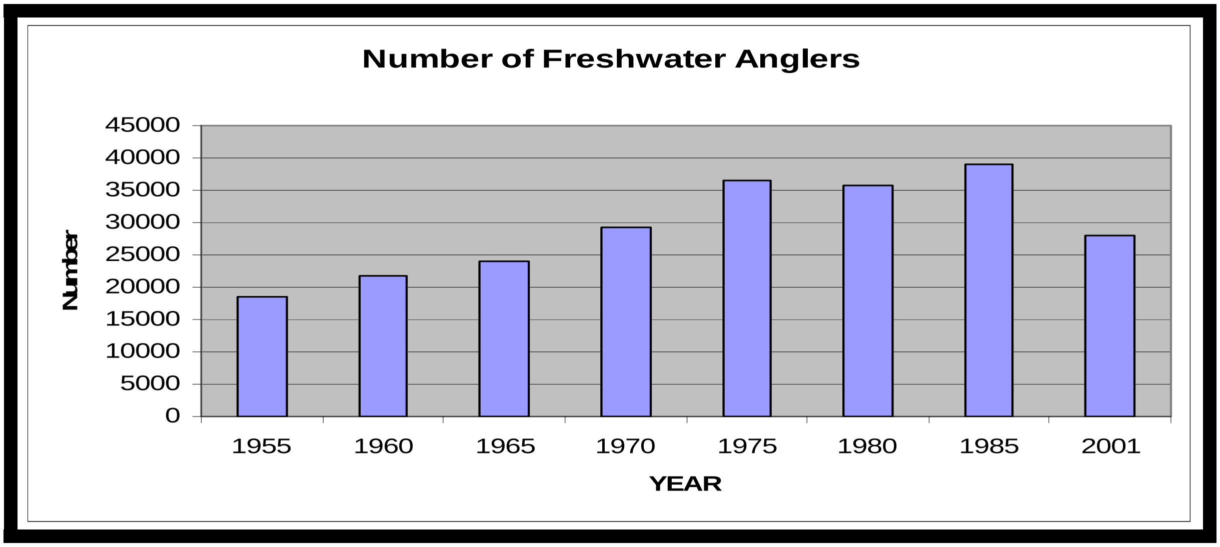
What do the Data Show?

The U.S. Fish and Wildlife Service sponsors a National Survey of Fishing, Hunting, and Wildlife-Associated Recreation every five years. The questions are developed in concert with technical committee members from every state and with representatives of non-governmental organizations such as the Wildlife Management Institute and the American Sportfishing Association. The most-recent survey was conducted in 2001. The 2001 survey indicated that:

- over 34 million people went fishing;
- they fished an average of 16 days per participant and spent an average $1,046 each;
- 28.4 million anglers went fresh water fishing, while 9.1 million went saltwater fishing; and
- overall, anglers spent $14.7 billion in 2001 for fishing trips, $17 billion on equipment, and $4 billion for licenses, stamps, tags, land leasing and ownership, membership dues and contributions, and magazines.

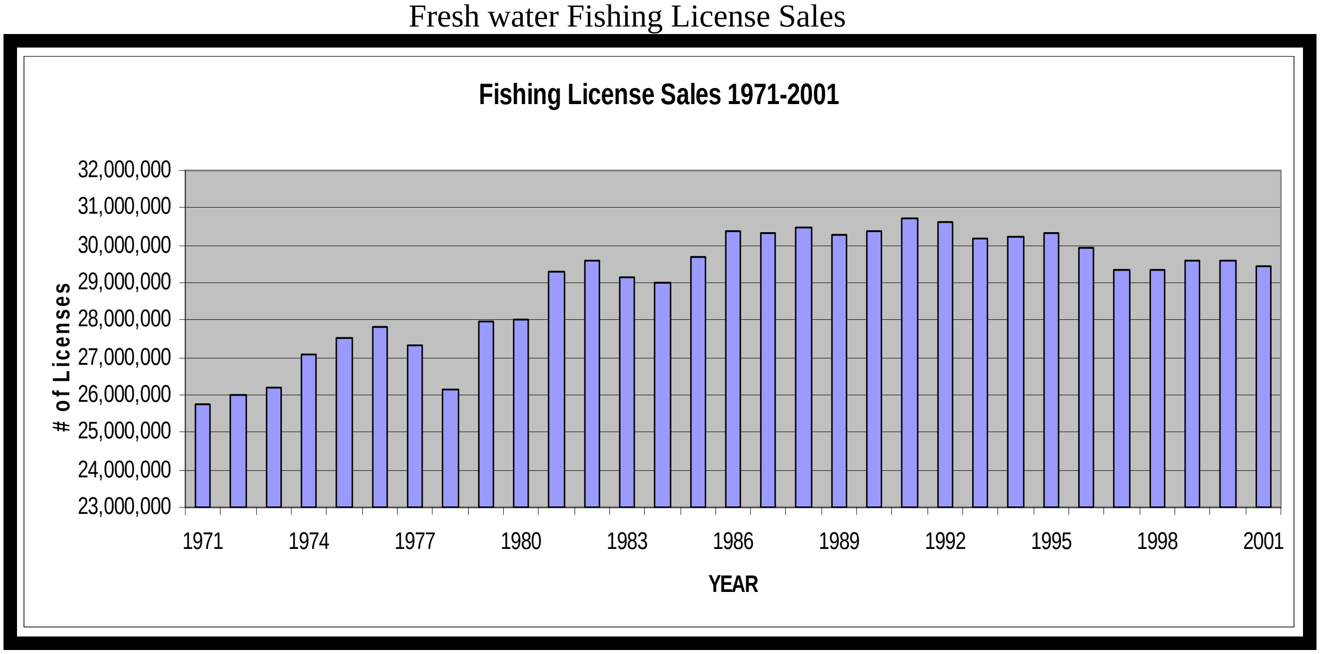
If the two graphs below, Figures 4.10.1 and 4.10.2 for number of fresh water anglers and fishing license sales over a 45 and 30 year period respectively are examined for trends, it appears that both measures suggest a decline in fresh water fishing in recent years. Peaks in human fishing participation occurred in the late 1980s and early 1990s. Present measures for fresh water anglers have dropped to levels observed in the early 1970s, even though the U.S. population has significantly increased over this period of time. This drop in fresh water participation could potentially be linked to either a decline in amount of fish being caught in more recent years, and thus less desire on the part of the angler, or to the perception that fresh water fishing resources are not as safe and free of human health risk as they use to be.

Figure 4.10.1
Public Participation in Fresh water Recreation
(as measured by the number of fishing licenses, number of anglers - change per year)



(Source: U.S. Fish and Wildlife Service – National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (http://www.fws.gov/fishing)

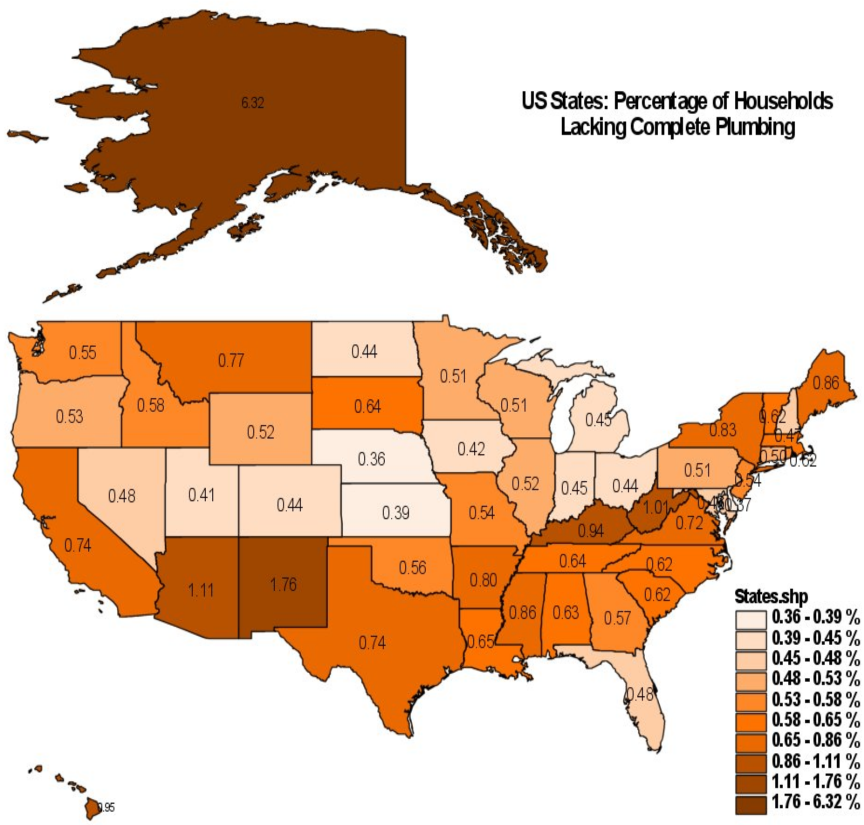
Figure 4.10.2
Fresh water Fishing License Sales



(Source: American Sport Fishing Association - http://www.asafishing.org/asa/statistics/participation/fishlicense_30yr.html)

Indicator 11: Human Conditions.

Figure 4.11.1
Percent of the Population Lacking Complete Plumbing by State



Source: Rural Community Assistance Partnership. 2004. *Still Living without the Basics in the 21st Century*. http://www.rcap.org/resources/basics.html, accessed 10/03/05.

What is this Indicator?

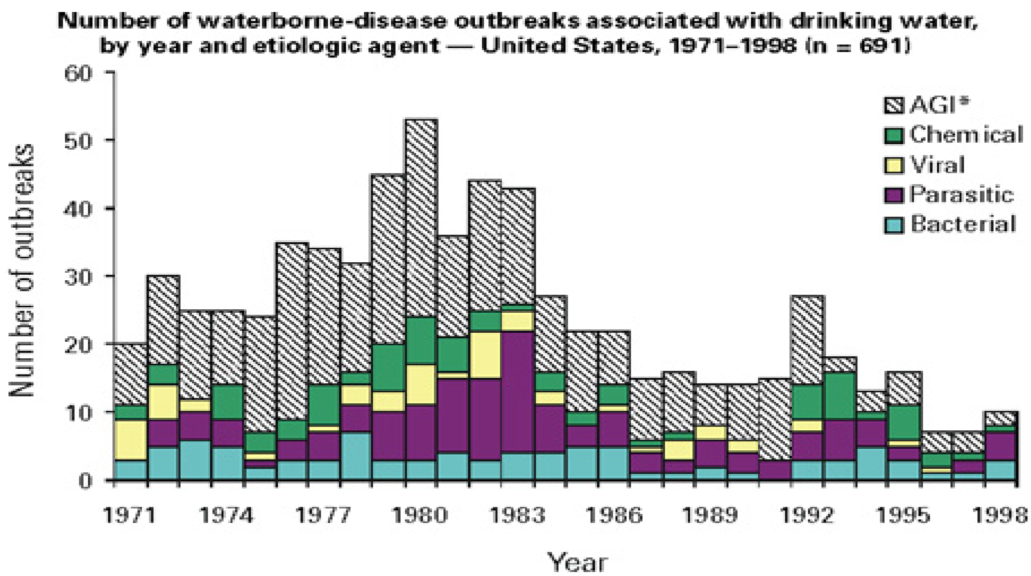
This indicator measures the value people receive from the uses of water and the cost they incur from not having these resources. One of the critical measures of value is the access of people to potable water and sanitation. A measure of that is the availability of plumbing and sanitation for the population. This tells us the population living with access to the basic resources of potable water and sanitation. There is a well established link between potable water and public health.

A second measure of the quality of the water coming through the infrastructure system is the number of reported cases of waterborne disease from 1972 through 1998. Waterborne disease outbreaks provide a good measure of the quality of the water that is delivered to people in the U.S. While this may be seen as an indicator of the quality of water treatment facilities, it is notable that many of the most serious recent outbreak in North America, at Walkerton, Canada, was as much about poor source water protection as about poor facilities management.[1] Seven people lost their lives when the water system in Walkerton, Ontario was contaminated with *E. coli* O157 bacteria and many more became ill.

These two measures together make up part of the indicator of the human well being as related to water.

Figure 4.11.2

Reported Incidence of Waterborne Disease: Number of outbreaks, etiologic agent, and source of waterborne exposure—1971-1998



*Acute gastrointestinal illness of unknown etiology.

Adapted From: Surveillance for Waterborne Disease Outbreaks - US, 1997-1998 (2)

Accessible at: http://www.cdc.gov/mmwr/preview/mmwrhtml/ss4904a1.htm

Why is this Indicator Important?

The percent of the population living without access to potable water and sanitation is an accepted international indicator of quality of life. Indeed, the United Nations Children's Fund (UNICEF) has correlated the percentage of the population with potable water and sanitation with deaths per 1,000 for children under five years old in 20 nations[2]. Their research shows that the greater the access to potable water and sanitation the lower the incidence of early child mortality. Even if people have access to piped water, the question still remains whether the water that is coming out of the tap is potable. This can be measured by the trend in outbreaks in of waterborne disease. This information is collected periodically by the Center for Disease Control (CDC).

What Do The Data Show?

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[1] Hrudy, Steven. 2004. Safe Drinking Water – Lessons from Recent Outbreaks in Affluent Nations. London: International Water Association Press.

[2] UNICEF, ***State of the World's Children 2000***

In the United States, the U.S. Census long form survey has the number of people who say they have water and sanitation in the home since 1950. The percentage of the population lacking either plumbing has diminished steadily from 27 percent in1950 to .64 percent of the population in 2000. As is clear from the map above, however, the distribution of those lacking plumbing services is not even across the United States. Alaska, Arizona and New Mexico carry disproportionate percentage of those lacking plumbing services. Viewed by ethnicity, Native Americans and Hispanic-Latino/as are disproportionately likely to be living without water and sanitation.[3]

The numbers additionally show that there has been a steady decrease in the population impacted by waterborne disease, although Figure 11.2, above, shows a slight spike in 1998. It is notable that CDC itself believes that there are methodological problems with the way that they currently count the incidences of waterborne disease, as they only track emergency room visits that are diagnosed as such.[4]

Conservation is a positive exercise of skill and insight, not merely a negative exercise of abstinence or caution...."

Aldo Leopold, 1949.

[3] http://www.rcap.org/resources/basics.html, accessed October 4, 2005.
[4] http://www.cdc.gov/ncidod/eid/vol7no3_supp/hunter.htm, accessed October 4, 2005.

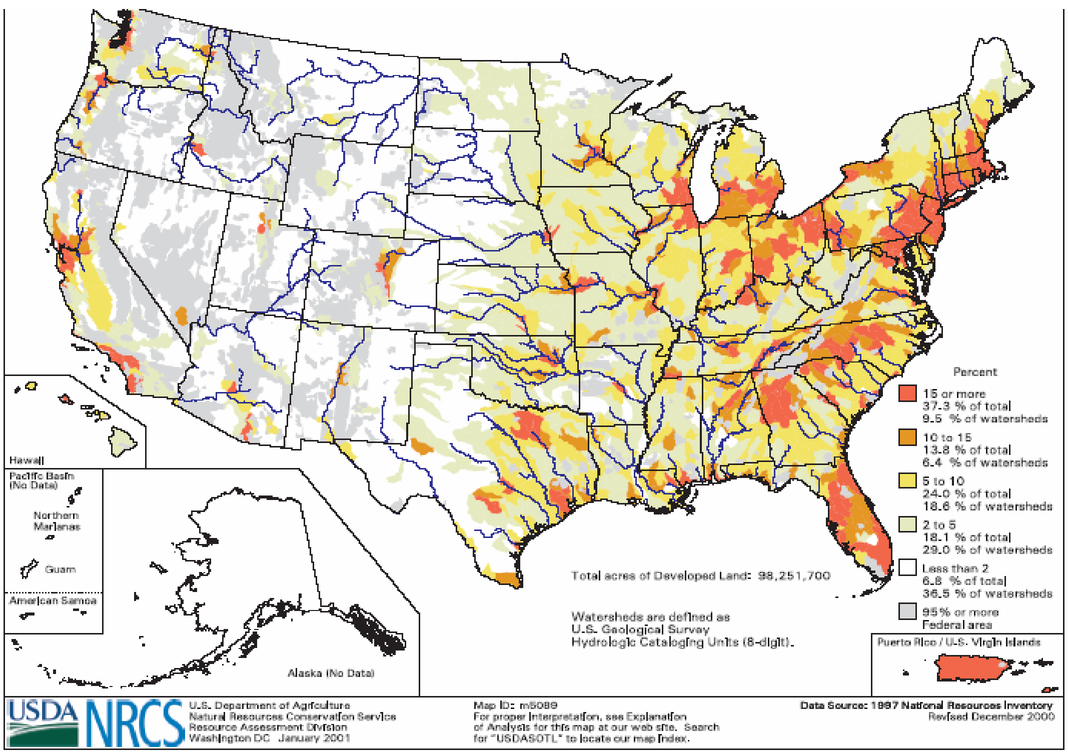
Indicator #12: Land use

What is This Indicator?

This indicator addresses the important elements of land use – developed land and cropland – that affect water quality and quantity. The developed land measure includes small-urban, large-urban, and built-up areas, as well as highways, roads, railroads, and associated right-of-ways in rural areas. The cropland measure shows the watersheds that have the highest potential for sediment, pesticide, and nutrient runoff, as well as pesticide and nitrogen leaching to groundwater. The data for both measures is presented on a watershed basis using the U.S. Geological Survey's 8-digit hydrologic cataloging unit.

Other indicators of land use warrant consideration, including measures of general distribution of land cover and of specific hydrologic or ecological functions, such as the extent of watershed impervious surface or tree canopy. The National Land Cover Database, under development by a consortium of agencies, is expected to make of such indicators possible in the near future.

Figure 4.12.1
Percent of Hydrologic Unit in Developed Land, 1997



The developed land map is posted at: http://www.nrcs.usda.gov/technical/land/meta/m5089.html The maps for both measures were developed by the Natural Resources Conservation Service and partners based upon the NRCS 1997 National Resources Inventory, a statistical sampling of various data sets. The cropland maps are posted at: http://www.nrcs.usda.gov/technical/land/lgif/m1737l.gif

Figure 4.12.2
Watersheds with a High Potential for Soil, Pesticide, and Nitrogen Runoff

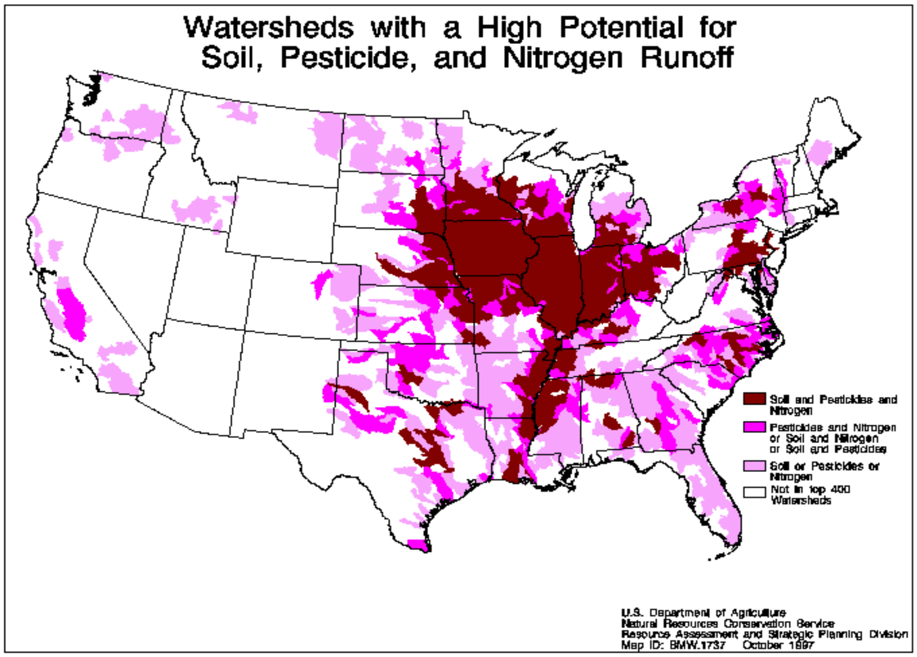
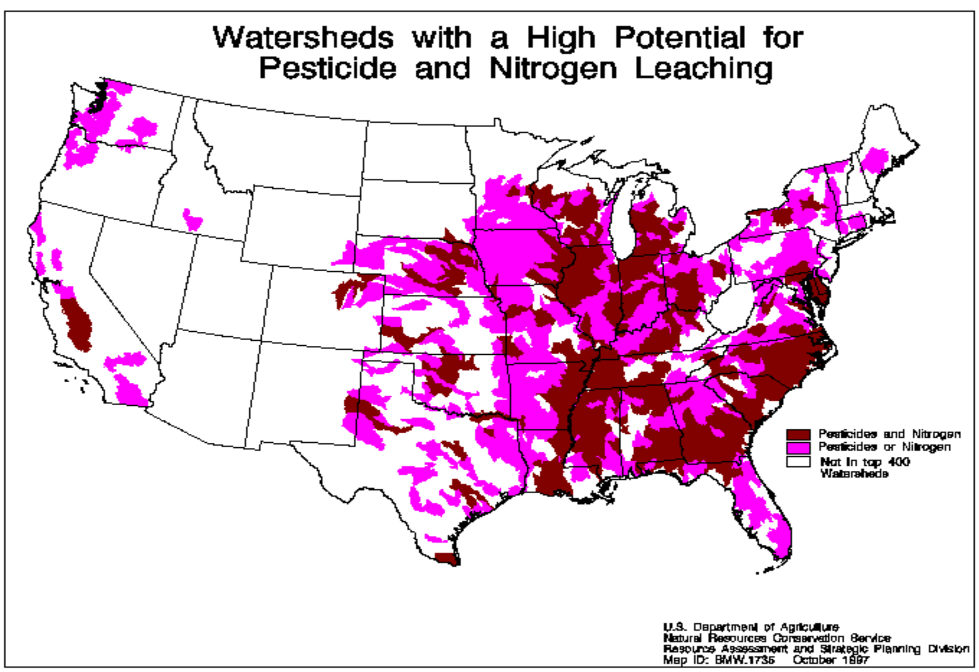


Figure 4.12.3
Watersheds with a High Potential for Pesticide and Nitrogen Leaching



Why is This Indicator Important?

The way people, business, and government use land profoundly affects water resources. It affects the timing and magnitude of surface water flows, the recharge of ground water, the demand for water and the resultant discharge of wastewater. Further, the chemicals put on the land end up in the water thus affecting water quality. Land use also directly and indirectly affects wildlife habitat and other valued, water dependent ecosystem features.

What Do the Data Show?

As shown in Figure 4.12.1, in 1997, over 98 million acres of land in the 48 contiguous states are considered developed. Nearly 10 percent of the nation's watersheds have at least 15 percent of their land in a developed state. The extent of development is greatest in the Northeast, the Southeast Piedmont, Florida, the Industrial Midwest, including the Great Lakes states, and parts of the West Coast. While the measure is useful with implications for a broad range of water-related concerns – from timing of flows to water quality, quantity, use and habitat destruction – it does not directly measure these factors.

As shown in Figures 4.12.2 and 4.12.3, from one-third to one-half of the watersheds in the 48 contiguous states show high potential for pollutant runoff and infiltration from cropland. This assessment is based on a determination of the top 400 watersheds for each factor. The greatest concerns were evident in the Midwest and Southeast.

Example of Land Use Impact on Water: Abandoned Mine Drainage (AMD)

The Abandon Mine Lands (AML) fund distributes funds to states impacted by mining. Figure 4.12.4 outlines how many people are impacted by abandoned mine lands per state and the per capita benefit each state receives. Reclamation funds are granted to states based on their current production, not historic production numbers. It is estimated that high priority restoration projects throughout the country would cost over $3 Billion to complete. Additional measures such as Clean Water Act Compliance documents such as the 303(d) and 305 (b) lists of streams not meeting their intended use and reasons why streams don't attain their designated uses illustrates problems created by AMD.

The Office of Surface Mining (OSM) estimates that 3.5 million Americans live within one mile of a health and safety concern associated with abandoned coal mines. OSM cites the following health dangers associated with abandoned mines: underground fire potential, highwalls and steep inclines, subsidence from underground mining, open mineshafts, and polluted water. OSM reports, though a countrywide system isn't available for quantifying human risk, Pennsylvania has reported 45 deaths and 19 injuries in its anthracite region in the past 30 years. In addition to the human risk potential, AMD impacts aquatic life, human health, recreation and tourism revenues, as well as reducing property values. Growing evidence links metals contamination of water by AMD with health problems such as colorectal cancer and renal failure. Numerous health institutes are now quantifying the health impacts correlating to this metals exposure.

Figure 4.12.4
Impact of Acid Mine Drainage Lands

Available data shows that AMD is a complex occurrence resulting from iron sulfide (pyrite) interacting with air and water. This chemical process creates an acidic condition that further breaks down pyrite, exacerbating the situation. There are numerous passive and active methods for treating AMD. Dominant metals such as iron, aluminum, and manganese can be precipitated out of these discharges by pH adjustment. Scientific research conducted by Chuck Cravotta of the USGS indicated there are over 27 difference elements present in AMD.

Although AMD has occurred since the dawn of the Industrial Revolution, great strides have been made to understand the phenomena and its treatment. Resource Recovery, extracting mineral assets from the water, has gained popularity and with proper market development could assist in offsetting treatment costs. New technology and better understanding of chemistry and kinetics also helps engineers design smaller and more efficient treatment systems. Underground mining has created vast underground storage for water and new initiatives revolve around the concept of beneficial use of this stored water for municipal supplies and for generation of electricity.

End Notes

Summary Report: 1997 National Resources Inventory (Revised December 2000), U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C.

Potential Priority Watersheds for Protection of Water Quality from Nonpoint Sources Related to Agriculture. Poster Presentation at the 52nd Annual SWCS Conference. Toronto, Ontario, Canada, July 22-25, 1997 (Revised October 7, 1997) Robert L. Kellogg, Susan Wallace, and Klaus Alt (retired), Natural Resources Conservation Service and Don W. Goss, Texas Agricultural Experiment Station, Temple, Texas.

Indicator #13: Residual Flows

What is This Indicator?

This indicator reports the flow of water and wastes back into the water environment after human use and, possibly, treatment. These flows can originate from either point or non-point sources.

Why is This Indicator Important?

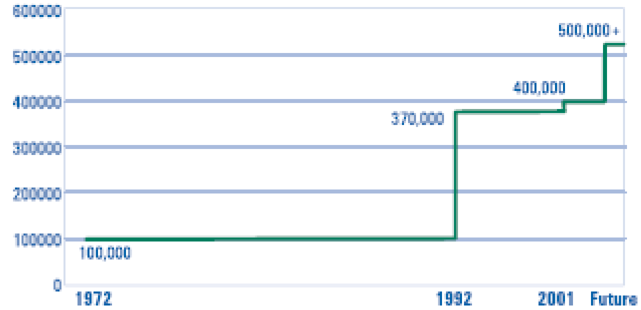
Residual flows are important because they may contain chemical and biological constituents detrimental to the environment, or have physical properties (such as temperature) that impair the environment.

What Do the Data Show?

An important source of data on wastewater discharges to the water environment is provided by the National Pollutant Discharge Elimination System (NPDES), which is administered by the U.S. EPA. NPDES is a national system for permitting of wastewater discharges that was created under the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 (further amended in 1977 as part of the Clean Water Act). Under NPDES, all facilities that discharge pollutants from any point source into waters of the United States are required to obtain a permit. Pollutants are defined broadly by the NPDES regulations and litigation and include any types of industrial, municipal, and agricultural waste discharge into water. Municipal sources are publicly owned treatment works that receive primarily domestic sewage from residential and commercial customers. While provisions of the NPDES Program do address certain types of agricultural activities (such as concentrated animal feeding operations), the majority of agricultural facilities are define as non-point sources and are exempt from NPDES regulation [1] As shown in Figure 4.13.1, as of 2001, more than 50 categories of industry (including several hundred thousand businesses) and the nation's network of more than 16,000 municipal sewage treatment systems comply with standards implemented in NPDES permits.[2]

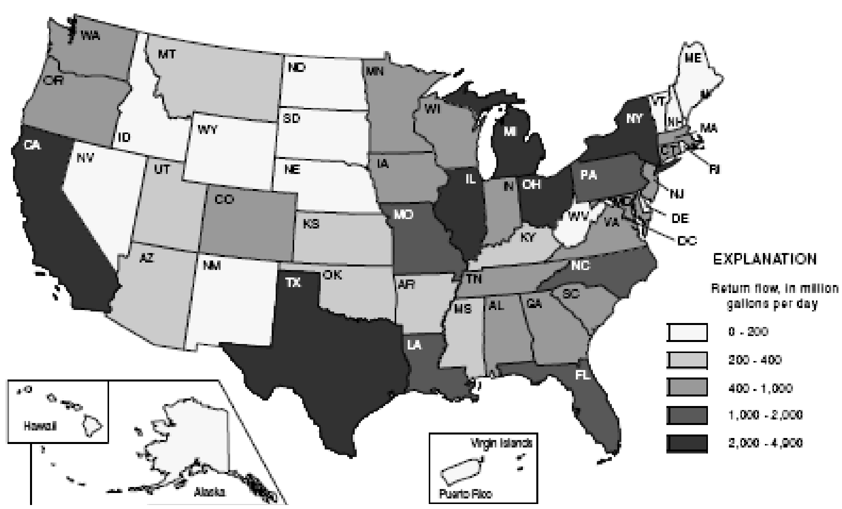
As shown in Figure 4.13.2, the USGS reported total releases of some 41,000 million gallons per day of treated wastewater from about 16,400 publicly-owned treatment facilities nationwide during 1995.[3] The return of treated water generally is to surface waters, although over two percent of the treated wastewater that was released was reclaimed for beneficial uses such as irrigation of golf courses and public parks. Illinois and Ohio, which have large public supply withdrawals, reported the largest releases of treated wastewater; Florida, California, and Arizona reported large uses of reclaimed wastewater.[4]

Figure 4.13.1
Growth of the NPDES Program
(number of facilities or sources)



(Source: USEPA, 2001)

Figure 4.13.2
Wastewater treatment return flow by State, 1995



(Source: Solley and others, 1998)

End Notes

1. U.S. Environmental Protection Agency, Office of Wastewater Management, 2005, Water permitting 101: http://www.epa.gov/npdes/pubs/101pape.pdf, Sept. 22, 2005.

2. U.S. Environmental Protection Agency, Office of Water, 2001, Protecting the Nation's waters through effective NPDES permits—A strategic plan, FY 2001 and beyond: http://www.epa.gov/npdes/pubs/strategicplan.pdf, Sept. 22, 2005.

3. Solley, W.B., Pierce, R.R., and Perlman, H.A., 1998, Estimated use of water in the United States in 1995: U.S. Geological Survey Circular 1200, 71 p.

4. Ibid

Indicator #14: Social and Economic Processes

What is this Indicator?

This indicator measures the systems people and organizations develop to influence water resources and sustainability. One of several measures to assess the extent to which systems have been developed to influence water resources sustainability is the extent to which water resources planning institutions have been developed at the state level.

One of the critical asymmetries of water planning in the United States is that political jurisdictions have rarely followed hydrologic boundaries. As a result, planning, policies and regulations that impact water quality are decided by institutions with responsibility for geographic areas that either cut across or are contained within hydrologic areas. Water resource sustainability is potentially threatened because decisions are made and systems put into place that make sense at the county or township level, but would not have if thought through at the watershed level.

We are able to count the number of states that have developed water planning entities that are designed to harmonize water resources issues with the other planning goals of the planning authorities. This count can be disaggregated by type (watershed planning, conservation planning) and the models for management tested for impacts on water resources sustainability. We do not necessarily assume that a greater number of water planning entities represents social and economic processes that are more sustainable. It does indicate processes that tie water resources to economic and social decision making.

Why is this Indicator Important?

While the Federal Government has a significant role in management of interstate waterways, much of the management and regulation of water quality is still left to states[1]. One of the critical asymmetries of water planning in the United States is that political jurisdictions have rarely followed hydrologic boundaries. As a result, planning, policies and regulations that impact water quality are decided by institutions with responsibility for geographic areas that either cut across or are contained within hydrologic areas. Water resource sustainability is potentially threatened because decisions are made and systems put into place that make sense at the county or township level, but would not have if thought through at the watershed level.[2]

What Do the Data Show?

To different degrees, some states attempt to develop planning and regulatory authorities that operate on a watershed basis. Examples include Massachusetts, Maryland, and California. Others empower regional planning authorities to implement water quality and quantity planning and management guidelines. No list currently exists of water planning and management institutions at the state level and such data needs to be developed to complete this indicator.

End Notes

1. Kemmis, Daniel. 2000. "Learning to think like a region." *High Country News*, April 10, 2000.

2. Rogers, Peter. 1996. *America's Water: Federal Roles and Responsibilities*. Boston: MIT Press.

Indicator #15: Health of Ecosystem Processes

What is this Indicator?

This indicator measures ecosystem processes that govern water resources and sustainability.

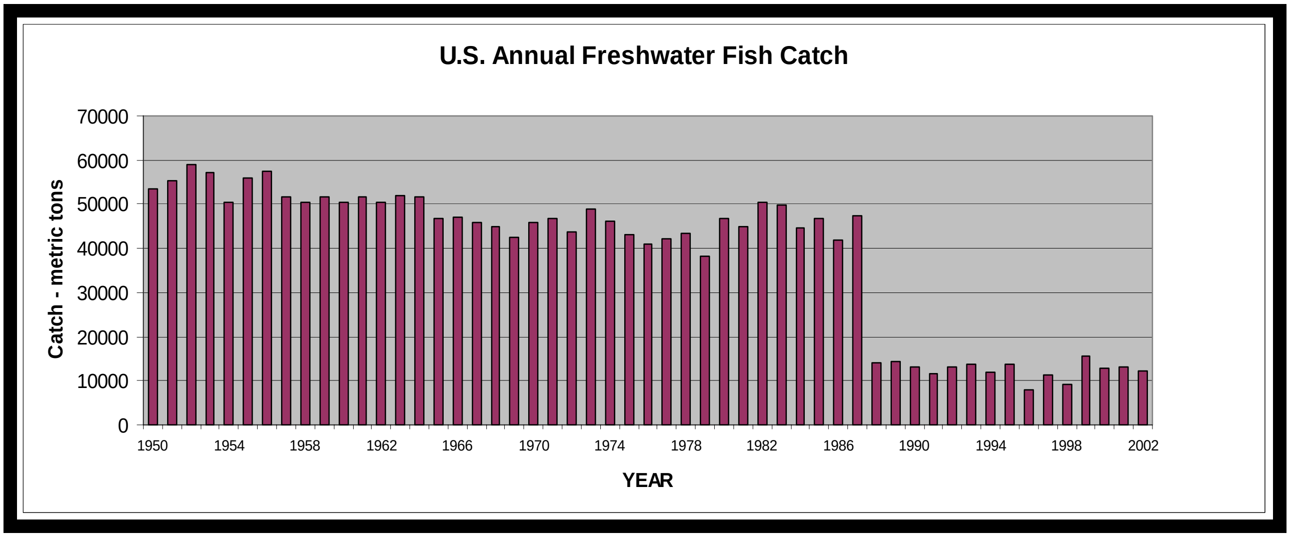
Fresh water Fish Catch (as measured in fish catch amount per year)

The integration of biological productivity in an aquatic ecosystem through a measure like fish production, can demonstrate the health of that ecosystem's different interrelated processes. If there are no fish to catch in a particular body of water, one could assume that this system is much less productive (less healthy) than a body of water that allowed fisherman to catch 10 lbs of fish per man-hour of fishing. The measurement of fish productivity in ecosystems from the measurement of fish catch is a good indicator of aquatic ecosystem health because:

- Fish populations and individuals generally remain in the same area during summer seasons.
- Communities are persistent and recover rapidly from natural disturbances.
- Comparable results can be expected from an unperturbed site at various times.
- Fish have large ranges and are less affected by natural microhabitat differences than smaller organisms. This makes fish extremely useful for assessing regional and macro-habitat differences.
- Most fish species have long life spans (2-10+ years) and can reflect both, long-term and current water resource quality.
- Fish continually inhabit the receiving water and integrate the chemical, physical, and biological histories of the waters.

Fish represent a broad spectrum of community tolerances from very sensitive to highly tolerant and respond to chemical, physical, and biological degradation in characteristic response patterns.

Figure 4.15.1
U.S. Annual Freshwater Fish Catch



(Source: The World Resources Institute Earth Trends Report, *Capture by Species: Fresh water Fish* (http://earthtrends.wri.org/searchable_db) as reported by the Food and Agricultural Organization of the United Nations, 2004 (http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp)

What Do the Data Show?

As shown in the U.S. annual fresh water fish catch graph illustrated above, 53 years of annual fish catch data show a major decline in catch after 1987. This decline is so sharp and large that one might conclude the data before and after 1987 might have been collected or reported in different ways. Since the data was all collected by the same organization (FAO of the UN) it could reasonable be presumed that there were no major shifts in collection or reporting method. If so, then the steep decline for fish catch after 1987 might suggest an indication of less fish production in fresh water ecosystems in the U.S. related to declining health of these ecosystems. But alternative interpretations of the data can also be made, especially because the decline in annual fish catch also somewhat mirrors the decline in fishing participation by humans as illustrated in Indicator #8 of this report that addresses resources and conditions.

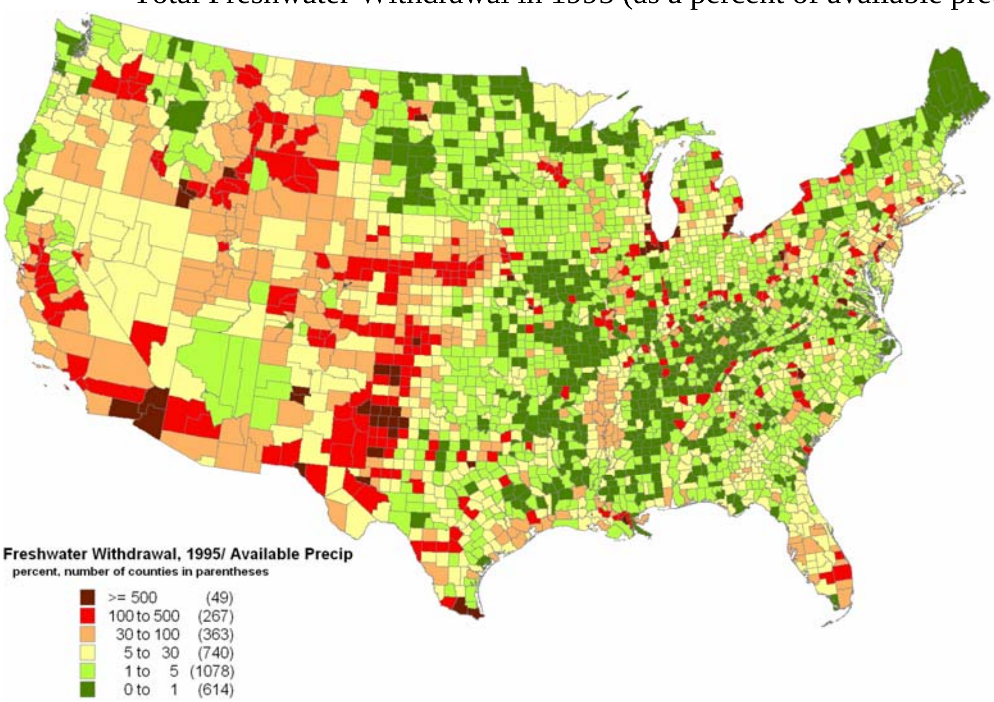
Indicators #16: Water Use Sustainability

What Is This Indicator?

Water use sustainability requires meeting the needs of humans and nature over the long term at a variety of scales, from local to national to global. This indicator reports the total amount of fresh water withdrawn for human uses as a percent of available precipitation (shown as gross water availability, or (total precipitation minus potential evapotranspiration, in Indicator 1). As a gross measure of long term sustainability, people can only withdraw as much fresh water overall as is eventually renewed by net precipitation and is not required to support ecosystems.

This measure does not account for flows of water from one area to another. In many populated areas and dry agricultural counties, more water is withdrawn than falls as precipitation. That water is either drawn from other areas conveyed by ground water, surface water or built infrastructure, or alternatively, is mined from local ground water.

Figure 4.16.1
Total Freshwater Withdrawal in 1995 (as a percent of available precipitation)



Source: Paper presented at SWRR meeting at EPRI, Palo Alto, 2004, S. Roy, K. Summers and R. Goldstein, using USGS data,) Roy, S.B., Ricci, P.F., Summers, K.V., Chung, C.-F., and Goldstein, R.A., 2005,Published as Evaluation of the Sustainability of Water Withdrawals in the United States, 1995-2025; Journal of the American Water Resources Association, 41(5):1091-1108, October 2005

An indicator of water use sustainability should ideally be map based at a fine enough resolution to be useful at the different scales needed for water supply planning. But in neither of the example indicators shown have we reached the ideal. That will require a, mapable quantification of the extent of renewable water supplies across the nation, the variable and fluctuating needs of ecosystems, and the needs of people for water today and for the long term future.

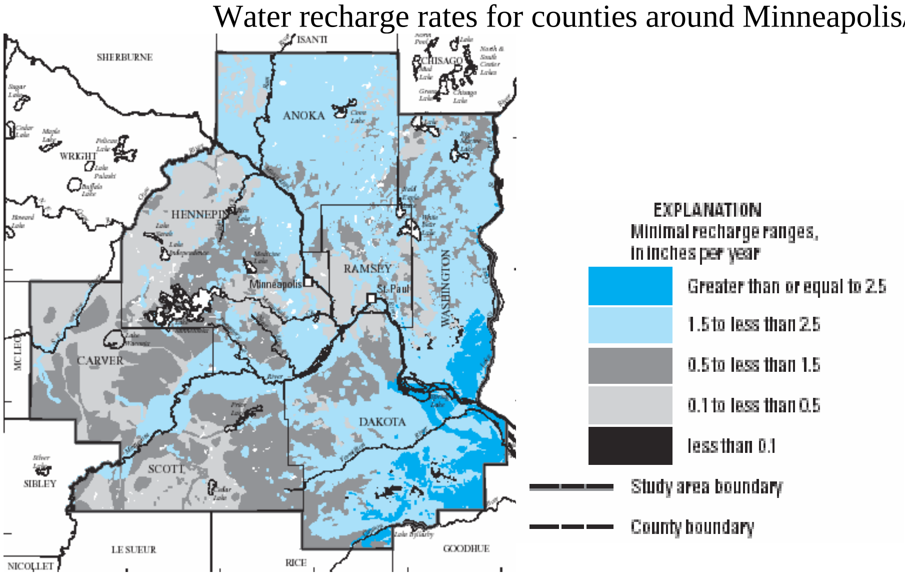
Why is This Indicator Important?

Water use sustainability is a key indicator because it helps us understand when and where water needed for human and ecosystem uses may exceed available supplies. In many regions of the US and the world, water is used at rates that cannot be maintained. Being aware of where these trends exist will support development of the information, programs and policies required to avoid critical water shortages in the near and long term.

Kanivetsky and Shmagin have looked at how the recharge/discharge rates of ground water and surface water flows vary with the bedrock and quaternary (surface and soil) geology. From such analyses, they define recharge and discharge parameters that can help quantify the limits of sustainable water use.   Figure 4.16.1 presents results of such an analysis for the Twin Cities, Minnesota.

Figure 4.16.2

Water recharge rates for counties around Minneapolis/Saint Paul



(Source: Roman Kanivetsky, Minnesota Geological Survey, 2001)

What Do the Data Show?

The United States has renewable supplies of water larger than the rate of use, but it is not evenly distributed. Many areas use more water than can be considered sustainable. Nationally, water resources appear ample but this is an indicator for which the nationwide average is not meaningful. Locally, the situation varies widely. In all the red and dark maroon areas on Figure 4.16.1, water use exceeds the total available precipitation. This excess is made up by drawing water from other areas or drawing down water supplies. This may not be ecologically, economically or politically viable for the long term.

End Notes

Shmagin, B. and Kanivetsky, R., 2002, System analysis to estimate subsurface flow: from global level to State of Minnesota: Environmental Geology, v.42, no. 2-3, p. 259-269.

Indicator #17: Water Quality Sustainability

Responsibility for monitoring of water quality is held by many diverse government agencies at the federal and state level. Each state submits 305b reports on water quality to the Environmental Protection Agency but they are not useful as a source of national-level water quality information because states have different standards, different mechanisms of interpreting those standards, and inconsistent commitments to reporting the results of their assessments. The scale used for the reports is the 8 digit HUC watersheds which are convenient for mapping the country but too large to reflect the scale of most of the projects that an agency would implement to improve water quality.

In addition to the problems with measures of surface fresh water, to get an overall indicator of water quality we would need to integrate or include data on groundwater, wetlands, estuaries and coasts that based on compatible methodologies and comparable assessments.

The National Water Quality Monitoring Council, like the SWRR a subgroup of the Advisory Committee on Water Infromation is working with many agencies to identify, examine, and recommend monitoring approaches that facilitate collaboration and yield comparable data and assessment results.

In a time of tight budget constraints the funds to expand monitoring and analysis of water quality may not be readily available. The SWRR will support efforts to make good data available so that in the future good indicators of water quality can be developed.

Alaska Salmon Stream
David Berry

4.18 Applications of Indicators at Regional and Local Scale

The leaders of nations can't keep track of every family, species, business or lake. But actors down the line, in the family, near the lake, need detailed information to keep their part of the system functioning well.

Indicators and information Systems for Sustainable Development by Donella Meadows, September 1998

The Issue of Geographic Scale

The struggle for sustainable management of water-related resources takes place at every scale, from the neighborhood to the nation and from the smallest watershed to the largest basin. While Minnehaha Creek in Minnesota has a lot in common with the Mississippi River, the differences in their size mean different numbers and levels of interested governments, different social, economic and ecological issues and perspectives about what's important and, therefore, different types and ways of presenting the indicators people need.

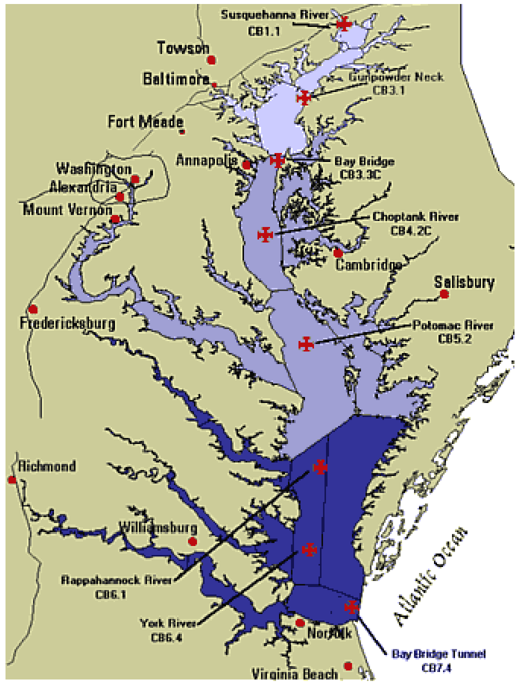
The citizens and managers of Minnehaha Creek, an urban-suburban stream, want to understand how urban storm water runoff affects dissolved oxygen and the stream's bass fishery. People focused on the Mississippi River may have an interest in dissolved oxygen and fish, but the scale of their interests dictates that they begin their review with a different screen. They'll need information that helps place concern with dissolved oxygen and fisheries in perspective, both geographically (i.e., where the problems exist) and topically (what other problems compete for their attention). In addition, the state, interstate and national levels of government that might have interest in the Mississippi's management needs, are more likely to focus on broader policy and funding questions than they are contacting riparian landowners to solve a specific runoff problem. That might lead a Mississippi interest to look for indicators that sum up the problem and rank it in comparison to others, like systems degraded by agricultural practices.

Depending on its location on the Mississippi and its connection to the river, each state along the way from Lake Itasca to the Gulf of Mexico is likely to have its own unique perspective about the river. A trip up the Mississippi's largest tributary, the Missouri, would take one through states of still greater distinction, with different climates, habitats, economies and water law. Scale determines focus; the people and resources at a given scale determine the issues that gain prominence and the indicators they require.

Local and Regional Scale: An Example of the Chesapeake Bay

The Chesapeake Bay Program combines characteristics of local geographic scale in a unique water resources region of the nation. (See http://www.chesapeakebay.net/.) Figure 4.18.1 depicts the bay.

Figure 4.18.1
Chesapeake Bay with Main Tidal Rivers



(Water Quality is Collected at Representative Stations Shown.)

Table 4.18.1 summarizes the most important water indicators developed for the bay, organized along the lines of the major categories used in the program: *Animals & Plants, Habitat, Water Quality, and Pollutants*. Additional categories are not described here.

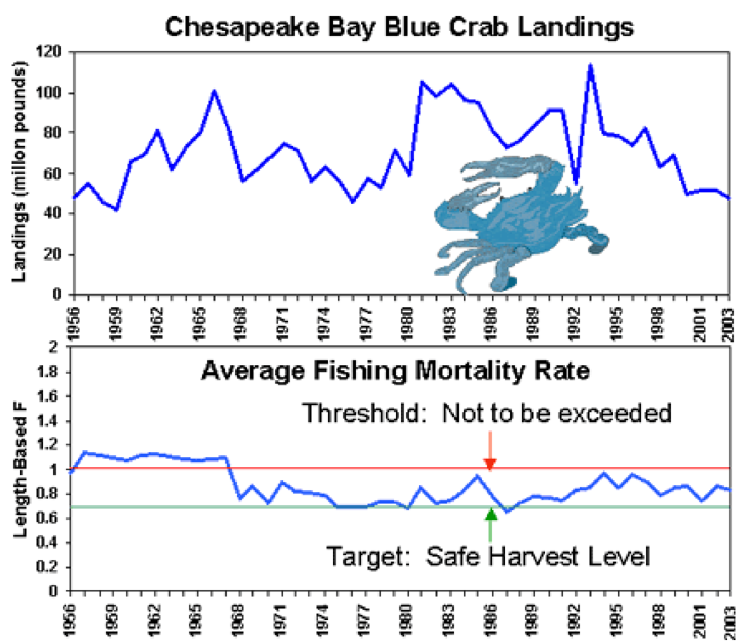
Table 4.18.1
Selected Generalized Water Indicators Used in the Chesapeake Bay Program, by category

Animals & Plants	Dissolved Oxygen
Bay Grasses	Nitrogen
Birds	Phosphorus
Crabs & Shellfish	Sediment
Fish	Suspended Solids
Benthos	Submerged Aquatic Vegetation Area
Habitats	Temperature
Stream Miles for Migratory Fish	SalinityChemical Contaminants
Wetlands Protection	Pollutants
Oyster Bed Restoration	Air Pollution
Water Quality	Nutrient & Sediment Loads
River Flow	Wastewater Flows
Chlorophyll *a*	Population
Secchi Depth	

The 64,000 square mile Chesapeake Bay watershed extends from New York to Virginia, and from West Virginia to Delaware. Many of the issues throughout this watershed are related to water quality and for that reason the indicators chosen as important tend to reflect this concern. For example, the Chesapeake Bay Program conducts analyses from provisional data collected by Maryland's Department of Natural Resources and Old Dominion University for surface temperature, bottom dissolved oxygen, water clarity and surface salinity. The program also tracks average monthly river flow data provided by the United States Geological Survey.

While Table 4.18.1 shows only a list of indicators, a deeper understanding of how measures can contribute to understanding real-world conditions is provided by Figure 4.18.2. The Chesapeake Bay is the largest producer of crabs in the country; it's estimated that more than a third of the nation's catch of blue crabs comes from Bay waters. Commercial harvests in a good year can yield close to 100 million pounds annually. There is concern about the blue crab fishery due to increased harvest pressure. The 2003 harvest of approximately 48 million pounds is below the long-term average and near historic lows. The 2003 fishing mortality rate did not exceed the "over fishing" threshold, but is above the desired target. The indicator tells a story about the Chesapeake Bay blue crab fishery and raises important questions that water managers and policy makers need to answer.

Figure 4.18.2
Blue Crab Commercial Harvest Statistics



Sources: Landings - National Marine Fisheries Service, NOAA
Mortality - Chesapeake Bay Stock Assessment Committee

Geographic scale has a great influence on the kind of water indicators people need and expect. Some indicators, like water use and dissolved oxygen, tend to appear in some form at many scales. But others appear at the level of a locality or region. Indicators developed for specific regions like the Chesapeake Bay, Everglades, Great Lakes and the arid Southwest might be particular to a region and might not recur elsewhere (for example, Blue Crab statistics for the Chesapeake Bay). The SWRR recognizes the importance of such regional efforts to painting the national picture of water sustainability.