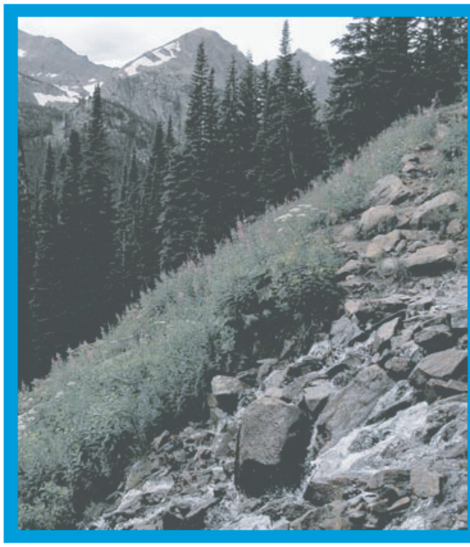
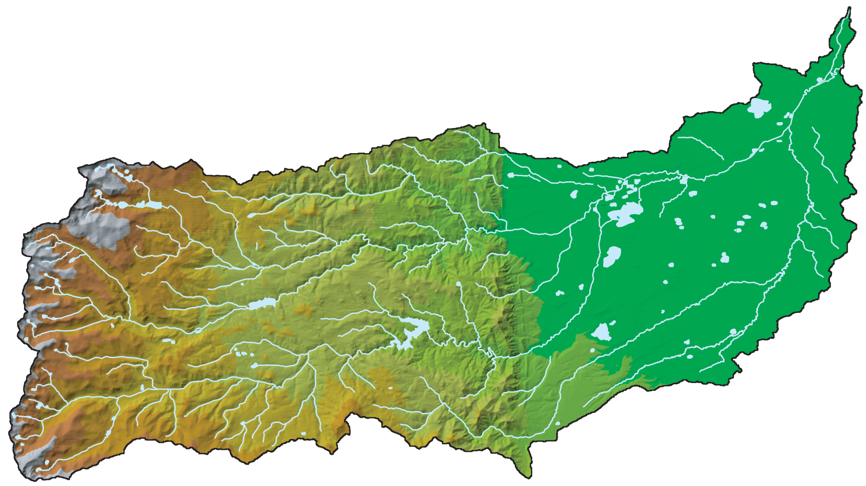
Comprehensive Water Quality of the Boulder Creek Watershed, Colorado, During High-Flow and Low-Flow Conditions, 2000

Water-Resources Investigations Report 03–4045





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

Comprehensive Water Quality of the Boulder Creek Watershed, Colorado, During High-Flow and Low-Flow Conditions, 2000

Sheila F. Murphy, Philip L. Verplanck, and Larry B. Barber, editors

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 03-4045

Denver, Colorado
2003

U.S. DEPARTMENT OF THE INTERIOR
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FOREWORD

A watershed is a feature of a natural landscape within which we can study the movement of water through the environment. The watershed delimits the river basin. In nature, if it were not for loss of water through evaporation to the atmosphere, transpiration by plants, or seepage into ground water, all water that falls within a watershed would flow downhill to accumulate in streams and eventually flow into a single stream or river. The volume of water moving through the single channel, the discharge, is one of easier watershed characteristics to measure. If we also measure the concentrations of dissolved and solid constituents in the water, we can calculate the mass flux (or load) of these constituents. For more than a century researchers have been measuring discharge and analyzing constituents to assess phenomena that may be influencing the water composition upstream. Today, we also do this to estimate rates of erosion, examine the introduction of contaminants, and judge the health of a river.

In the last three decades, a revolution has taken place in the study of river-borne material. With the rapid growth of computer-controlled instrumentation and sophisticated new technologies for detecting chemicals, elements, and isotopes, we can now measure a great variety of chemical constituents at very low levels, such as parts per billion (micrograms per liter) or even parts per trillion (nanograms per liter). We can now measure not only traditional water quality variables such as nutrients and trace metals, but also many of the pharmaceuticals and chemicals that we consume and excrete, the pesticides that we use, and compounds we use for cleaning our households.

This revolution in chemical analysis has been accompanied by a quieter revolution in water sampling and processing. The containers in which we collect water, filter out particles, and store the samples must all be clean. In the last few decades researchers have learned advanced techniques of cleaning and careful sample collection and processing. Many of the approaches and ideas were introduced, in the 1970’s, from the world of oceanography, where the research focused on estimating the input of materials to the ocean by rivers.

The U.S. Geological Survey (USGS) Water Resources Discipline has been at the forefront in developing both the more sophisticated analytical techniques and the clean-sampling methodologies. Research and development centers in two programs: the National Research Program and the National Water Quality Laboratory. Many of the researchers collaborate with university scientists, other public agencies, and international groups in these efforts.

The Boulder Creek Watershed in Colorado was chosen for one such collaborative effort by the USGS and the City of Boulder, with additional funding from the U.S. Environmental Protection Agency. This study was initiated through discussions at the Boulder Creek Watershed Forum, a monthly gathering of watershed residents, USGS scientists (located in Boulder and Lakewood, Colorado), city of Boulder personnel, and University of Colorado researchers. A need for a comprehensive water-quality investigation of Boulder Creek was identified. The study was then facilitated by the Boulder Area Sustainability Information Network (BASIN), a local collaboration that provides public access to environmental information in Boulder (www.basin.org). Scientists working for the National Science Foundation Long-Term Ecological Research Site in Green Lakes Valley and on Niwot Ridge contributed additional data for the headwaters of Boulder Creek.

Boulder Creek has features that make it ideal for assessing our ability to study natural and human-contributed constituents in water. The headwaters of the Creek include a protected watershed from which all but a few researchers are excluded. The Creek then flows through a progressively more urbanized region and finally a dominantly agricultural landscape until it discharges into Saint Vrain Creek.

Boulder Creek has another feature that is typical of many western rivers but quite unlike many rivers in the eastern United States that have been the focus of contaminant studies. In Boulder Creek, some of the water is transferred through pipes and tunnels from other watersheds, some on the other side of the Continental Divide. Moreover, in the dry climate of the Colorado Front Range, much of the water in Boulder Creek is diverted for municipal and agricultural uses. Little of the agricultural water returns to the Creek, while much of the municipal water returns after having been processed through the toilets, showers, sinks, washing machines, and small industries of the city of Boulder. The discharge of Boulder Creek after all the diversions is a fraction of its former volume. During dry parts of the year, most of the water in lower Boulder Creek has passed through a wastewater treatment plant. Groundwater inflows and storm water runoff from agricultural lands contribute more chemicals.

Such is the theme for water as it crosses the vast Mississippi River system, which Boulder Creek is a part of – intensive use with repeated passage through water-treatment facilities and growing agricultural contributions. Chemicals that are introduced into the municipal stream and which survive wastewater treatment and subsequent river transport will be part of the drinking water for those who live downstream. Little is known about what many of these chemicals do to humans or wildlife in small concentrations. Studies such as this one help us better understand which chemicals enter and persist in streams. This information is crucial to guiding future research on health and ecological effects of man-made chemicals. Effective management and protection of our nation’s rivers depends on accurate data. This study is an example of USGS efforts to improve knowledge of our nation’s natural resources to guide the stewardship of those resources.

Robert M. Hirsch
Associate Director for Water
U.S. Geological Survey

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CONVERSION FACTORS, DATUM, ABBREVIATIONS, AND DEFINITIONS

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6215	mile (ft)
	Area	
square meter (m^2)	10.76	square feet (ft^2)
square meter (m^2)	2.471	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
liter (L)	0.2642	gallon (gal)
cubic meter (m^3)	1.308	cubic yard (yd^3)
cubic meter (m^3)	0.000811	acre-feet
	Mass	
gram (g)	0.03527	ounce avoirdupois (oz)
kilogram (kg)	2.205	pounds (lb)
	Discharge	
meter per second (m/s)	3.281	foot per second (ft/s)
cubic meter per second (m^3/s)	35.31	cubic feet per second (ft^3/s)
cubic meter per second (m^3/s)	22.82	million gallons per day (mgd)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

$$°F = 1.8 (°C) + 32$$

DATUM

Vertical datum: Vertical coordinate information is referenced to the North American Vertical Datum of 1929 (NAVD 29).

Horizontal datum: Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

ADDITIONAL ABBREVIATIONS AND ACRONYMS

Å	angstrom
a.i.	active ingredient
amu	atomic mass units
ANC	acid neutralizing capacity
APHA	American Public Health Association
BASIN	Boulder Area Sustainability Information Network
CDPHE	Colorado Department of Public Health and Environment
CLLE	continuous liquid-liquid extraction
cols/100 mL	colonies per 100 milliliters
DBP	disinfection byproducts
DEM	Digital Elevation Model
DO	dissolved oxygen
DOC	dissolved organic carbon

DON	dissolved organic nitrogen
E	estimated
GC/MS	gas chromatograph with mass spectrophotometer
GFF	glass fiber filter
GIS	Geographic Information Systems
HPLC	high-performance liquid chromatography
IC	ion chromatography
ICP-MS	inductively coupled plasma-mass spectrometry
ICP-OES	inductively coupled plasma-optical emission spectroscopy
INSTAAR	Institute of Arctic and Alpine Research
kg ha^{-1} yr^{-1}	kilogram per hectare per year
kPa	kilopascals
kV	kilovolt
LRL	laboratory-reporting level
$\ln(a/\tan\beta)$	topographic index
MCL	maximum contaminant level
m/km	meter per kilometer
MDL	method detection limit
µg/L	micrograms per liter
µm	micrometer
µS/cm	microSiemens per centimeter
mA	milliamp
mg/L	milligrams per liter
mL	milliliter
mm	millimeter
nm	nanometer
NAPAP	National Acid Precipitation Assessment Program
NAWQA	National Water-Quality Assessment
ng/L	nanogram per liter
NIST	National Institute of Standards and Technology
NLCD	National Land Cover Dataset
NOM	natural organic matter
NTU	nephelometric turbidity units
NWQL	National Water Quality Laboratory
PRISM	Parameter-elevation Regressions Independent Slopes Model
QA	quality assurance
QA/QC	quality assurance/quality control
REE	rare earth elements
SA	specific UV absorbance
SC	specific conductance
SPE	solid-phase extraction
SRWS	standard reference water samples
STATSGO	States Geographic Soil Database
TOC	total organic carbon
TOX	total organic halogens
TDS	total dissolved solids

TSS	total suspended solids
THM	trihalomethane
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UV	ultraviolet
v/v	volume per volume
WWTP	Wastewater Treatment Plant
XRD	X-ray diffraction

DEFINITIONS

Water Year in U.S. Geological Survey reports is the 12-month period October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months.