Overview for the Development of Local Water Budgets

The Susquehanna River Basin Commission (SRBC) manages and protects water resources in the Susquehanna River Basin to ensure adequate supplies for domestic, agricultural, and industrial uses, as well as for recreation and the protection of instream uses. In areas with documented high water use and limited water supplies, SRBC encourages steps to be taken to better manage and allocate the region's water resources. Among the important steps is for local governments to participate in local and regional water resources planning efforts. These planning efforts may include the preparation of water budgets that assess water supply availability for the communities in particular watersheds and groundwater basins. SRBC supports the application of a water-budget approach in these areas.

Unique watershed characteristics, coupled with a wide range of potential management approaches, preclude the use of one methodology for all water budget studies. However, to assist parties interested in conducting a water budget, SRBC developed this "Overview for the Development of Local Water Budgets" to present important considerations in the conduct of water budget investigations.

A water budget is an accounting of the water resources within a watershed and groundwater basin. Like a financial budget, a water budget includes:

- sources and quantities of water income (rain, snowmelt, etc.);
- water savings (storage); and
- water expenses (water uses).

As in financial accounting, water budgeting allows for the planning and management of water resources in a sustainable manner. A water budget is an important first step in planning to meet future municipal, agricultural, industrial, recreational, and instream flow needs. Managing water as a sustainable resource also contributes to the preservation of water quality and aquatic habitat.

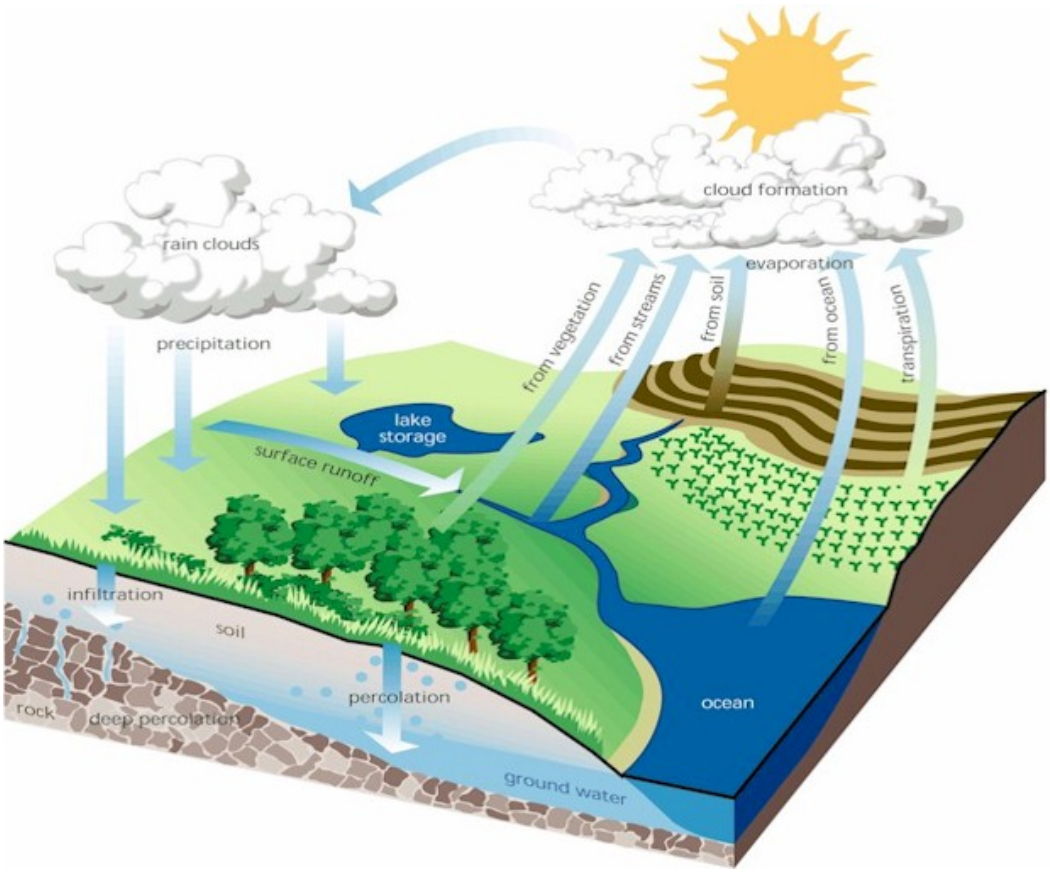
Basis for Water Budgets: The Hydrologic Cycle

The water resources in a given area are a product of the hydrologic cycle. The hydrologic cycle is the name given to the cyclical movement of water from the atmosphere to groundwater and streamflow, to the oceans, and back to the atmosphere.

Precipitation is the dominant source of water 'income' for the land-based portions of the hydrologic cycle; surface water and groundwater. Upon reaching the surface, precipitation becomes surface flow, soil moisture, or groundwater. Most of the precipitation that becomes soil moisture is

slowly utilized by plants or evaporates (evapotranspiration). The runoff and groundwater components move through the watershed towards areas of lower elevation. (See hydrologic cycle diagram below taken from the Federal Interagency Stream Restoration Working Group (10/1998), Stream Corridor Restoration: Principles, Processes, and Practice; ISBN-0-934213-59-3.)

Diagram of the Hydrologic Cycle



Runoff from a precipitation or meltwater event is concentrated into streamflow, where it forms a flood wave. The flood wave moves rapidly through the watershed and, for small watersheds, exits within hours to a few days.

By comparison, the flow of groundwater is relatively slow, typically only a few to several feet per day. During a precipitation event, water is received by the aquifer more rapidly than it can flow away, resulting in a rise in the water table. The amount of groundwater is not constant, but increases in response to recharge and decreases in response to discharge, as seeps and springs. The discharge of groundwater to streams sustains the flow between periods of high runoff (floodwaves and meltwater events). The amount of streamflow between high flow events (i.e., most of the time) is equal to the amount of groundwater released from aquifers within a watershed. The groundwater contribution to streamflow is called base flow. The base flow is not constant, but gradually declines following a precipitation or meltwater event.

Seasonal variations in precipitation cause variations in the amount of groundwater and surface water available in a watershed. Therefore, water resource planning must either consider

development based on the amount of water available during a low-flow period with conservation measures when the resource drops below the planning level, or develop a plan based on the amount of water available during higher flow periods, with seasonal cuts in production rates. Maintenance of sufficient instream flows also is important to protect fishery resources, water based recreation, and water quality during low-flow events.

While some uses are seasonal, most occur during the summer, when the amount of water available is commonly the lowest. Therefore, most water planning is usually developed based on the amount of water available during a drought with a relatively long recurrence interval. This both minimizes environmental impacts and the frequency of periods requiring mandatory conservation.

The available water resources are fundamentally limited by the amount of precipitation an area receives by the area of water collection (watershed/recharge area), and by the volume of groundwater storage. Other important factors include soil and aquifer characteristics, topography, vegetative cover, and land uses that alter the ability of the surface materials to accept precipitation and recharge. Impervious cover such as paved parking areas, roads, and buildings causes an increase in the amount of runoff and a corresponding decrease in groundwater storage and flow. While the amount of water flowing through the watershed remains essentially unchanged, flood flows are increased and base (groundwater) flows are decreased.

Water Use and Management

Water is used for a variety of purposes including municipal, industrial, agricultural, and residential. Some uses simply utilize the water, treat it, and return it to the watershed as treatment plant or septic system discharge. Such uses typically return about 90 percent of the water withdrawn. Natural streamflow is essentially maintained downstream from the point of treated water discharge. However, the area of withdrawal and the point of discharge are often widely separated, leaving the intervening stream reach with a reduced flow that may affect other water users and aquatic habitat. Uses for which only a fraction or none of the water is returned are called consumptive. Examples of consumptive use include irrigation, evaporative cooling, bottled water, and water incorporated into food products. Water used consumptively is not returned to the watershed, leaving a depleted reach below the point of taking.

Water Budgets

The development and utilization of water resources must be managed in a sustainable manner if instream, recreational, municipal, agricultural, and other uses are to be accommodated. A water budget analysis starts with an evaluation of the existing water resources (water income), and then subtracts the existing water uses (water expenses) to arrive at the current water budget.

The scale (i.e., sophistication or level of effort) of the water budget study is determined by the requirement that all major factors in the water budget be included within the area of study. The study area must include the recharge area for all major (greater than 100,000 gpd) groundwater withdrawals. Midbasin studies require inflow-outflow data for the study area.

Some watershed characteristics that are important to the development of a water budget include basin area, topography, the number, lithology, geologic structure, area and location of aquifers, soil properties, size and location of developed areas, location and magnitude of water withdrawals and returns, and climate. The amount of existing information on these will determine the amount of fieldwork required and have a significant impact on the cost of the study. Watersheds differ widely in nearly all of these characteristics. The methods and level of effort required to

develop a water budget must be appropriate to the conditions in the study area, and the amount of information available.

The development of a water budget will generally require most, if not all of the following information:

1. The amount and seasonal distribution of precipitation;
2. The variation in precipitation due to year-to-year climatic variability;
3. The amount and seasonal distribution of streamflows;
4. The variation in streamflows due to year-to-year climatic variability;
5. The amount and seasonal distribution of stream base flows;
6. The variation in stream base flows due to year-to-year climatic variability;
7. An evaluation of riparian and aquatic habitat; and
8. A topographic map and/or database with:
    a. Locations and magnitudes of water withdrawals;
    b. Locations and magnitudes of water returns;
    c. Capture area for all high capacity wells;
    d. Wellhead protection areas;
    e. Areas of impervious cover;
    f. Soil drainage characteristics;
    g. Land use planning and zoning;
    h. Locations and nature of water quality problems;
    i. Total Maximum Daily Loads (TMDLs) for all streams;
    j. Aquifer types;
    k. Aquifer structure;
    l. Water table configuration; and
    m. Storage facilities.

Uncertainties in the water budget due to lack of data on the basin surface water and groundwater flow may require the acquisition of additional information from a network of surface water and groundwater monitoring points for an extended period. In some cases, this information will be available from similar, nearby watersheds, and can be scaled to the watershed under study.

The area to be included in the study is determined by the hydrogeomorphic setting, and the location of large withdrawals and discharges within that setting. It is essential to include the capture area and area of contribution for all surface water and groundwater withdrawals of 100,000 gallons per day or greater and all consumptive use withdrawals of 20,000 gallons per day or greater.

Who Needs to be Involved?

A water budget study will generally require the involvement of county, state, and federal agencies, watershed groups, and other stakeholders. Professionals specializing in groundwater, streamflow, aquatic and riparian habitats, climate, engineering, and planning also will be needed. Much of this expertise is available from state and federal agencies, and municipalities, industries, and authorities within the watershed, as well as regional consulting firms.

A professional with expertise in the development of water budgets will be required to coordinate the study effort, evaluate the information, and produce a report. An advisory committee composed of representatives from local municipalities, industries, professionals, and other stakeholders is often of considerable help. The report must present the information, analyses, and conclusions of the study, and provide recommendations for the sustainable and equitable

management of the water resources in the watershed. Copies of the report should generally be provided to the SRBC, appropriate state and federal agencies, water authorities, municipalities, libraries and other interested parties within the watershed.

What Comes Next?

A water budget study is generally performed in order to provide a factual basis for water resources management and land-use planning. The results of a water budget study present the current water resources availability, location, and degree of utilization. The results provide a factual basis for planning growth and infrastructure development.

The water budget study will allow the management of water resources in a sustainable manner by:

1. Quantifying the amount of water that can be developed and be sustainable;
2. Identifying areas nearing or exceeding the sustainable amount of water available;
3. Identifying areas where water resources are currently underutilized, allowing potential well and reservoir sites to be 'banked' for future development; and
4. Identifying areas that are essential to the replenishment and sustainability of the resource (local subwatersheds and groundwater recharge areas).

Water budget study results also form the basis for monitoring and tracking water resource availability and future development impact. A surface water and groundwater monitoring network allows tracking of the water resources as they are developed and land use changes occur.

For more information on water budget studies, please contact Mr. Robert Pody of our staff at (717) 238-0425, ext. 218. The following federal, state, and regional agencies also have expertise in water resource planning, and may be able to assist in providing additional information related to water budgets:

Environmental Protection Agency	http://www.epa.gov/
U.S. Army Corps of Engineers, Baltimore District	http://www.nab.usace.army.mil/
U.S. Geological Survey, Pa. Office	http://wwwpah2o.er.usgs.gov/
U.S. Geological Survey, N.Y. Office	http://ny.usgs.gov/
Maryland Dept. of Natural Resources	http://www.dnr.state.md.us/index.asp
Maryland Dept. of the Environment	http://www.mde.state.md.us/
N.Y. State Dept. of Environmental Conservation	http://www.dec.state.ny.us/
Pa. Dept. of Conservation and Natural Resources	http://www.dcnr.state.pa.us/
Pa. Dept. of Environmental Protection	http://www.dep.state.pa.us/
Capital Region Water Board	http://www.crwb.org/
Delaware River Basin Commission	http://www.state.nj.us/drbc/drbc.htm
Interstate Commission on the Potomac River Basin	http://www.potomacriver.org/
Chester County Water Resources Authority	http://www.chesco.org/water_cov.html