Town Brook and Cannonsville Reservoir Watersheds, New York
(An ARS Benchmark Research Watershed, one of 24 CEAP watershed projects.)

Characteristics
The Cannonsville Reservoir, one of the major reservoirs of New York City’s water supply system, has been designated as phosphorus (P)-restricted due to algal blooms that interfere with the non-filtered water treatment processes desired. Dairy agriculture, the dominant land use within the watershed, is thought to be a major source of the P affecting the reservoir, with this P loss occurring in both soluble and sediment-sorbed forms. The Watershed Agricultural Council (WAC; www.nycwatershed.org) and Delaware County, NY (www.cce.cornell.edu/delaware/watershed.html) are attempting to reduce P inputs to the reservoir by implementing a comprehensive whole-farm planning process and associated Best Management Practice (BMP) strategy over the contributing watershed area. The WAC is a non-profit organization funded by New York City, USDA Forest Service and other federal and foundation sources whose mission is to support the economic viability of agricultural and forestry through the protection of water quality and the promotion of land conservation in the New York City watershed region.

In the most basic sense, land use planning is focused on reduction of P loss to the Cannonsville Reservoir. The whole-farm planning and implementation process, a major component of the Watershed Agricultural Program (WAP) administered by the WAC and implemented by the WAC and Delaware County, contains education, extension, and technical assistance components to accomplish this goal. The technical assistance component of the WAP consists of BMP design and installation under a 100% cost share program.

The 917-km² Cannonsville Reservoir Basin (CRB) is the source of water for the Cannonsville Reservoir. The CRB is a portion of the Northern Delaware River 8-digit HUC (02040101). There is a history of data collection at multiple scales and some limited research within the CRB, but more intensive data collection and research has been conducted within the 37-ha Town Brook Watershed (TBW), a representative upland subarea of the CRB. The TBW lies within the 11-digit Upper West Branch Delaware River HUC (02040101010).

Watershed topography is characteristic of the Glaciated Central Region Physiographic Province. Within the CRB, the rolling hills and low, rounded mountains forming the major watershed divides are at elevations of approximately 1000 m (msl). Elevations of the upland watershed valley floors are on the order of 600 m, while those of the alluvial valleys are about 400 m.

Climate is continental; average annual temperature is about 7°C, with average January temperature of about -4°C and average July temperature of about 20°C. Average annual precipitation is about 1070 mm, with about 180 cm of snow. Average annual runoff is approximately 600 mm.

Glacial deposits over the watershed are typically few to several meters thick, and are the primary source of ground water and subsurface flow to the streams. The underlying bedrock is not considered to be a major source of water. Soils within the upland watersheds, such as the TBW, typically have fragipans and are members of the well-drained, steeply-sloping Willowemoc, Lackawanna, and Mardin series and the
somewhat poorly drained, gently sloping Onteora, Volusia, and Norwich series. In the alluvial valleys of the larger CRB, soils are formed in deep, coarse-textured alluvial deposits and are typified by the nearly level, well-drained Barbour and Chenango series.

Land use within the CRB consists of cropland (2% corn and alfalfa), pasture (48% pasture and hay), agro-forestry (49%), and other (1% built-up and roads). There are approximately 230 animal feeding operations within the CRB (roughly 2/3 dairy and 1/3 beef), and seven major animal operations within the TBW (6 dairy and one veal production), with no concentrated animal feeding operations. In total, these farms represent about 13,000 dairy cows and 1,200 beef cattle. Most of the dairy farms operate as confined or semi-confined operations – there is currently minimal emphasis on managed grazing. The seven primary farms within the TBW are enrolled in the CREP and/or the EQIP programs. Within the CRB, approximately 160 of the 230 farms are now actively participating in the whole-farm planning process, and of these, there are currently about 60 enrolled in the CREP program and 40 enrolled in the EQIP nutrient management credit program. The goal of the WAC is ultimately to have 85% participation. Extensive education activities are conducted in association with the whole-farm planning process, and technical assistance consists of design and installation of approved BMPs under a 100% cost-share program supported directly by New York City.

**Environmental Impacts**

Environmental concerns are, most simply, water quality and soil quality. The specific water quality concern is phosphorus loss from dairy agriculture as it impacts eutrophic status of the Cannonsville Reservoir. An important subset of this concern, erosion from corn silage land use, unaddressed to date in the whole-farm planning effort, is now becoming of major concern to the planners. An ancillary, but critical, concern, is sustainability and economic viability of the farms as they are impacted by P management measures.

**Management Practices**

Management practices either in use as part of the whole-farm planning process, being studied in detail for their individual effectiveness, or being considered as part of future, more comprehensive BMP implementation strategies within the CRB are listed following. Numbers in parentheses are their NRCS designations.

1. Conservation cover (327)
2. Conservation crop rotation (328)
3. Contour buffer strips (332)
4. Cover crops (332)
5. Fencing (382)
6. Filter strips (393)
7. Forage harvest management (511)
8. Grassed waterways (412)
9. Nutrient management (590)
10. Prescribe grazing (528)
11. Residue management (329a)
12. Runoff management system (570)
13. Stream bank development (580)
14. Use exclusion (472)
15. Vegetative barrier (601)
16. Waste utilization (633)
17. Waste storage facility (313)
18. Waste treatment lagoon (359)

**Research Objectives**

**General:** The research focus is on quantifying the loss of P from dairy agriculture, evaluating the effectiveness of the current BMPs and conservation practices in reducing this loss, and development of new or improved BMP/conservation practice strategies.

**Specific:** The research emphases are on: 1) efficacy of structural BMPs, 2) evaluation of the CREP program in reducing impacts of cattle in the streams, 3) reduction of the P imbalance at the farm scale by increased use of homegrown forage, 4) reduction of erosion from land in corn silage to reduce sediment-sorbed P loss, and 5) development of techniques for cost-effective targeting of BMPs at farm and watershed scales to derive maximum benefit at minimum cost.

**Approaches**

The primary watershed agricultural planning activity is development and implementation of whole-farm plans to address actual and potential problems relative to P loss to the environment. The plans consist of an on-farm assessment of P balance, modification of farm activities that are perceived to result in excessive P loss to the environment, and development of comprehensive BMP and nutrient management strategies tailored for each farm to reduce the perceived P loss. More recent activities are focusing on reducing the P imbalances at the farm level by improved feeding strategies and increased use of homegrown forage; farm- and watershed-scale research and demonstration efforts related to these activities are either planned or now underway. All land within the watersheds is under private ownership, but because of the excellent working relationships between the watershed planners and the farmers though, research is easily implemented on most farms.

High-quality GIS data layers are available related to all aspects of the watersheds, including a 10-m DEM, hydrography, soils mapped and digitized at the SURGO level, farm and field boundaries also mapped and digitized, and land use and management by farm and field updated annually. Further, comprehensive whole-farm plans for most farms, including both already-implemented and proposed BMPs, are also available. Streamflow, sediment, and phosphorus data are being routinely collected at the CRB and TBW outlets. Climate data is being collected to compliment these observations. Additionally, one agricultural and one forested subwatershed of the TBW are being monitored, and a bi-weekly synoptic sampling effort is underway at all major stream confluences within the TBW. As part of the whole-farm planning process, soil test P levels are measured once every three years on all agricultural fields within the CRB, and the whole-farm plans, which include rough estimates of the farm-scale P balance, are also updated at this same three-year interval.

The SWAT model is now being applied to the TBW and the CRB to characterize present levels of P loss. A unique part of this work is coupling SWAT with a BMP tool developed by ARS at University Park, PA to evaluate reductions in P loss expected as a result of implementation of the BMP strategy. The SWAT modeling results are also being used in association with mathematical optimization techniques to determine specific areas of the watershed where implementation of BMPs could realize maximum reductions in P loss at minimum cost.
Selected References
3. Gitau, M.W., T.L. Veith, and W.J. Gburek. Farm-level optimization of BMP placement for cost-effective pollution reduction. Trans ASAE. (accepted, 8/20/04)

Collaborators and Cooperating Agencies and Groups
ARS at University Park, PA is leading a multi-agency research and demonstration effort within the CRB. Collaborators are the WAC, NRCS, New York State Department of Environmental Conservation, New York City Department of Environmental Protection, Cornell Cooperative Extension, and the Delaware County Soil and Water Conservation District.

To date, ARS, representing a coordinated research group consisting of personnel from Cornell Agricultural Engineering, USGS, and New York City DEP, has received a total of $750,000 in Safe Drinking Water Act funds through New York State. The highly effective collaboration with the WAC, NRCS, and the Extension and County planning entities allows our research and demonstration results related to effectiveness of BMPs to be implemented and evaluated at field, farm, and watershed scales under real-world conditions. Because of this same collaboration, we also have the ability to track the effectiveness of the BMP implementations with time at all scales in both near and distant future.
Cannonsville Reservoir Basin and its 31 sub-basins. Town Brook is subbasin 41.