

# **Flood Control and Infiltration is a Hole in One**

**By Mary L. Paist-Goldman, P.E.<sup>1</sup>**

<sup>1</sup>Princeton Hydro, LLC, 1108 Old York Road, Suite 1, P.O.Box 720, Ringoes, NJ 08551; PH (908) 237-5660; FAX (908) 237-5666; email: mpaist@princetonhydro.com

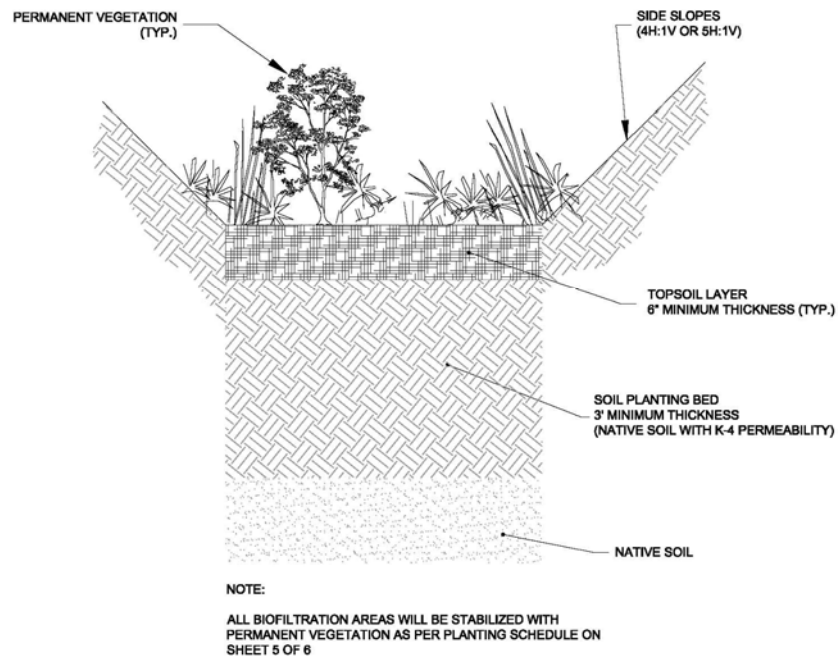
## ***Background***

The Riverton Country Club, built in 1900, was constructed where two former stream channels once existed. For more than 100 years the course was plagued with continual flooding and frequently had interrupted play as a result of ponding water. Some attempts at stormwater management on the course had been undertaken; however, none provided long-term solutions to the flooding problems. Often the vegetation was in need of replacement due to the heavy flooding on the course. Prior to the completion of the project the site had limited stormwater infrastructure installed and stormwater runoff sheet flowed across the course to a downstream irrigation pond. Additionally, the stormwater runoff on the subject site did not receive any water quality treatment.

## ***Design***

In the summer of 2005, Princeton Hydro was contracted by the Riverton Country Club to design a stormwater system that would provide a solution to the problems plaguing the course. The project site is located in Cinnaminson Township, Burlington County, New Jersey and has slopes that are relatively flat. Princeton Hydro conceptualized and engineered a system that would provide much needed flood control and a groundwater recharge benefit. The system designed was a series of five (5) shallow rain garden/biofiltration pools and a stormwater pipe collection system that discharges to an existing irrigation pond. The rain garden biofiltration pools were carefully laid out to balance flood control with the active play areas on the course and took into account existing fairways, roughs, utilities, cart paths and known drainage problem areas.

Rain gardens and biofiltration pools were selected for the design because of their relatively straightforward construction and their ability to dissipate the energy of the high flows anticipated on the subject property and to provide increased levels of infiltration. The biofiltration pool concept was utilized to maximize infiltration and minimize runoff through the system. High-density polyethelene (HDPE) pipes were designed to handle larger rain events and yard inlets were placed 6" above the invert of each pool to allow smaller rain events to infiltrate and other storms to discharge directly to the irrigation pond.



As detailed in the above figure, the biofiltration pools designed include a six-inch topsoil layer, a three-foot deep planting bed with organic content and native soils, and side slopes of 4H:1V or 5H:1V depending on the pool location.

### *Hydrology*

In order to address the water quantity problems on the current site, it was necessary to develop pre-developed and post-developed stormwater models to predict the resulting peak discharges for the 1-, 2- and 5-year Type III Burlington County NRCS design storms using the DELMARVA unit hydrograph as required by the Burlington County Soil Conservation District. The proposed stormwater basins were modeled using Haested Methods PondPack Version 9.0.

The site was analyzed using one (1) Point of Analysis (POA). The POA was selected at the existing irrigation pond onsite. Two (2) offsite drainage areas converge on the subject site (Drainage Areas A1 and A2) and additional runoff generated on the course (Drainage Area A3) was also analyzed. These drainage areas were established using topographical information provided by Riverton Country Club and supplemented with the topographical information from the 7.5 Minute United States Geological Survey (USGS) Quadrangle Maps.

Pre-development hydrology was calculated utilizing the Natural Resource Conservation Service (NRCS) TR-55 methodology. The calculations took into account the new 24 hour rainfall amounts as released by the New Jersey Department of Agriculture State Soil Conservation Committee in Technical Bulletin 2004-4.0. The existing land cover was

established utilizing the 2002 false color infrared orthophotographs prepared by NJDEP as well as the 1995/1997 Land Use/Land Cover GIS data available from NJDEP. The soils onsite are comprised of Sassafras loamy sands. Both soils are classified as Hydrologic Soil Group “C” as identified in the Burlington County Soil Survey. Weighted curve numbers were established for the drainage areas and times of concentration flow paths were established.

The pre-developed hydrographs for the 1-, 2-, 5-, and 10-year storms were analyzed in detail as the maximum storm event the system could handle was the 5-year. In summary, the peak discharges at the points of analysis under pre-developed conditions are as follows:

Drainage Area	Design Storm Event	Peak Discharge (cfs)
A1	1	35.17
	2	50.08
	5	79.51
A2	1	23.11
	2	35.95
	5	62.28
A3	1	5.26
	2	8.45
	5	15.21

*Hydraulics*

Stormwater runoff generated in the two drainage areas entering the project site is directed to the proposed biofiltration ponds for all rain events up to the 5-year design storm. Runoff from storms in excess of the 5-year storm will sheet flow across the site as it currently does. The pipe networks were sized utilizing the Rational Method for the 5-year design storm. The rainfall intensity was obtained from the NOAA Precipitation Frequency Data Server’s Pont Precipitation Frequency Estimates from NOAA Atlas 14. Additionally, the existing swale areas were modeled using the North American Green Erosion Control Materials Design Software Version 4.11 to check for stability.

As previously indicated PondPack 9.0 was utilized to model the proposed stormwater management system. The existing swales were modeled hydraulically using the Muskingum-Kunge methodology.

*Soils*

The soils on the property are Sassafras loamy sands, which are identified as Hydrologic Soil Group “B” in the Burlington County Soil Survey.

To retrieve subsurface data, Princeton Hydro observed the progression of 9 macro-core probes, completed September 2, 2005, and ranging in depth from 8'0" to 12'0". Princeton Hydro located the test probes in the field utilizing a Trimble XRS Pro™ global

positioning system (GPS) unit within the footprint of the proposed bioretention areas. The probes were progressed with the use of a Ford F-350 pick-up truck mounted GH42 - Geoprobe 5410 owned and operated by Environmental Remediation Contractors (ERC), LLC.

Macro-samples were advanced with 1.75-inch diameter acetate tube in a 2-inch diameter direct push steel sampler. A Princeton Hydro geotechnical technician logged all retrieved samples including geologic descriptions and collection of macro-tubes. Final subsurface logs are presented in Appendix C.

The samples revealed two distinct stratum in the subsurface:

Stratum I - consists of fine to medium sand with little silt, generally orange-brown. This material was of uniform thickness throughout the golf course. Consistency is estimated to be loose and moist;

Stratum II - consists of orange sand with trace silt, generally tan-brown. This material was observed to continue beyond the bottom of the investigation in all probes advanced. Consistency is estimated to be medium dense and moist.

These stratum are generally in conformance with the soil types mapped on site.

Representative samples from Stratum I and II were collected and testing for permeability utilizing Rigid Wall (Constant Head) permeability conforming with ASTM Standard D2434 (Latest revision). The hydraulic conductivities determined as a result of testing were utilized as the maximum allowable and half of the infiltration rate was utilized for design purposes. All tests completed indicate that the permeability rate would vastly exceed 20 inches per hour. As such, the design calculations assumed that 20 inches per hour infiltration would be achieved by the pools on average.

### ***Construction***

Construction on the project site was undertaken in April 2006 and completed by the early summer of that same year. All biofiltration pool areas were laid out by Princeton Hydro personnel and verified by multiple field walks with representatives from the golf course to verify that all were in agreement on the pools in areas of active versus in-active play. The pool locations were selected carefully in areas where runoff was known to collect and around existing golf course infrastructure, utilities, and fairways. The construction was completed for approximately \$350,000. Construction modifications included the use of beehive grates on the catch basins since the flat catch basins were clogging in several of the basins.

## ***Conclusions***

Although the system was designed to handle only the five-year flood event, there have been no flooding problems on the course since the system has been in place. Vegetation originally proposed for the systems has not performed due to the inundation some of the pools receive regularly. Additionally, debris accumulation in the form of sediment has been a problem in the upstream most pool. As such, long-term the project may require some modification to ensure functionality will continue as an infiltration system. Enhancement plantings were recently added and a monitoring program is underway to determine appropriate vegetation and infiltration capabilities achieved by the system.

## ***References***

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