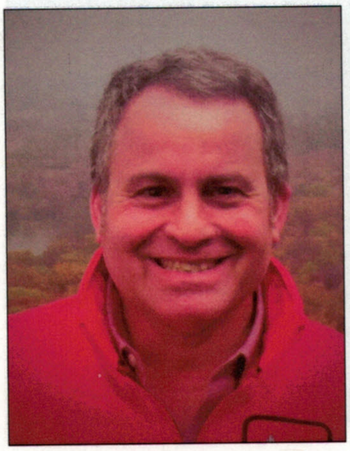
Low Impact Development Stormwater Retrofits in Zhenjiang, China – Part Two



By Steven D. Trinkaus, PE

Steven D. Trinkaus, PE, is the principal engineer for Trinkaus Engineering, LLC. Mr. Trinkaus has more than thirty-five years of experience in the land development field. He is an internationally recognized expert in the application of Low Impact Development (LID) strategies. He has been an invited presenter in Taiwan, China and South Korea on stormwater and LID topics. He also has been a consultant to Pusan National University, Land and Housing Institute and HECOREA in South Korea for various aspects of LID.

Low impact development (LID) is a new technology in China, one that holds much promise for the country. The China Water Industry held a conference this past May in Zhenjiang that featured LID experts from the United States, which was the subject of Part One of this series. In this second article, author Steven Trinkaus discusses his involvement with subsequent design and applications of LID in the Zhiye New Town Area of Zhenjiang, China.

At the Request of Dr. Nian She of Shenzhen University, Mr. Trinkaus was invited back to the City of Zhenjiang, China at the end of June 2015. He was tasked with designing Low Impact Development (LID) stormwater retrofits for the Zhiye New Town Area.

Project Background

The Zhiye New Town Area is located in the eastern portion of the City of Zhenjiang, China. The Zhiye New Town Area is approximately 2.6 hectares (6.5 acres) in size and contains thirteen residential apartment buildings, concrete driveways and parking areas. There are some green space areas of various sizes between the buildings. In many of these areas, the residents are maintaining small garden areas to grow produce for their own consumption. The area is served by a municipal sanitary sewer and structural stormwater management system. For the most part, the stormwater management system is separate from the sanitary sewer system, although there are numerous catch basins which are connected directly to the sanitary sewer system.

The Yangtze River is located to the north of the Zhiye New Town Area. As is common in urban areas both in China and the United States, the structural drainage system conveys the stormwater runoff directly into the river. As the watershed for the Yangtze is very large, when it rains - even two and a half centimeters in twenty-four hours - the water surface in the river can rise by three to four feet. This elevated water surface submerges the outlets of the many urban

Figure 1 - Aerial view of Zhiye New Town Area

Figure 2 - Typical apartment building and driveway/parking area

drainage systems, so backwater conditions occur, resulting in localized flooding in the low lying urban areas. Please see Figures 1 – 4 included with this article that illustrate the location of the area in need of LID practices. Figure 1 shows an aerial view of the Zhiye New Town Area. It has a high percentage of impervious area with some small green spaces between a few of the buildings. The only vehicle ingress and egress point is shown in Figure 1. Stormwater is conveyed via a conventional pipe system to the northeast corner of the area.

Figure 2 shows the typical arrangement of the building to the driveway/parking area. There is very limited parking within the entire project area. A part of the stormwater retrofit project, it was a desired goal to increase the availability of parking for the residents.

Green space existed within the project area. Figures 3 and 4 show some of the landscaped areas within the site. In general, the plants, particularly the large shrubs and trees, had not been well maintained. Many tree branches were overhanging the internal driveways, reducing ingress and egress as well as parking availability.

Designing for LID

In evaluating options for the stormwater retrofits, these landscaped areas were the primary focus. It was proposed to modify these landscaped areas into bioretention systems to accept runoff from the adjacent impervious areas.

In addition to using bioretention systems, a couple of parking areas on the site already had interlocking concrete permeable pavers or open cell concrete pavers with topsoil and grass. These areas had not been maintained and clearly were not infiltrating any runoff. It was proposed to remove them and then to reinstall these paver systems, making them functional and effective.

One section of the pavers is shown in Figure 5. It easily can be seen that the soil within the open cells was compacted, resulting in no infiltration of rainfall. In addition, as a result of the soil compaction, very little grass was able to grow in these pavers.

The soils were a significant challenge on the site as well, as they have a high silt and clay content. The observed infiltration rate was 0.25 centimeters/hour (0.1 inch/hour) and the seasonal high groundwater was approximately three meters (ten feet) below existing grade.

The Governmental Environmental Agency, which would be funding these LID retrofits, required that the following performance requirements be addressed with the design.

1. First, the design needed to facilitate reduction of annual pollutant loads by filtering runoff to allow physical, chemical and biological processes to occur to reduce these loads.
2. Second, the design needed to reduce runoff volume from the site to the maximum extent practical. Since surface runoff is responsible for most urban flooding, reducing the volume by infiltration would have a positive benefit on the residents.

To address pollutant loads found in the non-point source runoff, the bioretention systems needed to contain the runoff from 65 millimeters (2.6 inches) of rainfall in twenty-four hours as surface storage volume. The bioretention systems also needed to contain, without overflowing, the 150 millimeter (6.0 inch) rainfall event. For areas where a permeable paver system would be used, both the 65 millimeter and 150 millimeter events needed to be contained within the stone reservoir area as a fixed storage volume. Both the bioretention and permeable paver systems were designed with an elevated underdrain that was located at the top of the stone reservoir layer.

Figures 3 and 4 - Landscaped area between apartment buildings

Figure 5 - Area of open cell pavers for parking

The Environmental Agency also desired no increase in the runoff volume associated with the 210 millimeter (8.4 inches) event. This goal was not achievable due to site limitations, limited available area for the LID stormwater retrofits and the extremely slow native infiltration rate.

After inspecting the site and assessing what type of LID systems could be implemented, it was time to start the design process. The first step was to delineate the watershed areas which would be tributary to each LID treatment system. After delineating the watershed areas, the Water Quality Volume (WQV) was calculated for each area using the 65 millimeter rainfall event for sizing purposes. The Water Quality Volume was calculated using the following equation:

WQV = (Rainfall) (Runoff Coefficient) (Area)/1000, where:
Rainfall = Water Quality Event in millimeters
Runoff Coefficient = Rv = 0.05 + 0.009
(Impervious area in square meters)
Area = Watershed area in square meters

For the entire project, there is a total of 13,046 square meters (3.22 acres) of impervious area, or approximately fifty percent of the total site area. The calculated WQV is 805.59 cubic meters (28,449 cubic feet) for the site.

The design specifies ten bioretention cells which will provide a fixed storage volume above the soil media surface of 663.65 cubic meters. The permeable paver systems will provide a storage volume of 517.44 cubic meters within the stone reservoir layer below the outlet invert of the elevated underdrain. Therefore, the LID retrofits will provide a storage volume of 1,181.09 cubic meters, approximately forty-six percent larger than the calculated WQV. This result was accomplished by design to provide additional storage volume for the 150 millimeter event when considering the slow infiltration rate of the underlying soils.

In addition to the bioretention cells and permeable paver systems, one building will be retrofitted with an extensive modular green roof system. It was not feasible to direct the leader drains from this building to either a bioretention or permeable paver system.

In Figure 6, the location of the proposed LID retrofits can been seen. The bioretention systems will, for the most part, handle runoff from the building roofs and some adjacent parking areas. The permeable paver systems will accommodate rainfall that falls directly onto them as well as some adjacent impervious areas.

The owners of this apartment complex are in agreement with the LID retrofits and have retained a landscape architect to develop attractive and appropriate plant palettes for the bioretention cells. It is hopeful that construction of these LID retrofits will occur in 2016.

Figure 6 - Design of LID Retrofits