

**Conservation of Phnom Bakheng
Angkor Archaeological Park, Cambodia
June 2012**

World Monuments Fund's work for the conservation of Phnom Bakheng site has progressed significantly in the first half of 2012. Much of the field work has continued to focus on the overall waterproofing of the site and the demonstration conservation project of one of the brick shrines. Nearly all fieldwork is carried out by the Khmer professional staff and workers. In the first half of 2012, several American consultants worked at the site for specific tasks: Vincent Liot returned to the site to inspect the waterproofing work; Andrew Earles, a water management specialist, undertook significant investigations on hydrology; Warren Wilford was asked to oversee the installation of the second crane at the site; and Glenn Boornazian made several trips to review work priorities with the Khmer staff and prepare for WMF's presentations to APSARA and UNESCO's Ad Hoc Experts. WMF entered into a partnership with the University of Sydney to capture LIDAR for Phnom Bakheng. This work was completed in spring 2012 and processing of the data continues. The resulting images will prove valuable for understanding topographical changes to the site over time. Highlights of recent work are described in this report.

Conservation of the northeast corner of Phnom Bakheng



The repair of unstable and decayed bedrock is one of the core interventions that WMF is implementing at the temple. Since January, more than 120 new laterite blocks have been inserted in the foundation of level D to improve stability. To stabilize walls, both laterite and sandstone blocks were inserted where missing. Work included inserting new stones as well as utilizing older stones found at the site that were usable. This method provides a more harmonious look to the outer walls, as the stones have a more consistent patina from age.

The waterproofing of the temple is the most critical intervention at Phnom Bakheng. To improve drainage, a waterproofing membrane has been installed at level F and E. The membrane was cut and fitted into each level in a way to conform to the irregular shapes of the stones, requiring significant skill and attention to detail. When Vincent Liot was on site, part of his work included extensive training sessions on methodology for installing the membrane with the Khmer workers.



The waterproofing intervention at level E included the complete dismantling of stone shrine E12, which will enable specialized waterproofing where the shrine and central temple intersect. The procedure for dismantling is the same as the one previously used with stone shrine F12 at level F, which is considered the prototype intervention for all stone shrines at the temple. The position of each sandstone block has been measured and after meticulous documentation, each block was properly numbered to allow the correct reassembly of the sanctuary. With the use of the crane, the stones have been moved to the conservation workshop or storage area depending on the condition and treatment needs.



After the installation of the waterproof membrane and the lead sheet underneath stone shrine F12 (left), the reassembly of this sanctuary started in February (right).



The reassembly of the pavers of level F has been completed and 120 pavers were installed. For the blocks used for the wall of the same terrace, the surface has been tooled to blend the look of the stones for a more harmonious presentation.



Conservation of the southeast corner of Phnom Bakheng



To increase worker safety and advance the work a second crane was erected at the south east corner. Today two crews are implementing the approved conservation, stabilization and waterproofing plan. To insure long term waterproofing of the terraces, if membrane maintenance is required under the pavers little effort is need to address the work. If maintenance is required under a stone terrace shrine the effort will be significant. After careful consideration, World Monuments Fund has added an extra measure of waterproofing in strategic areas by inserting a thin lead sheet under the stone shrines. This lead panel system that sits between the stone terrace shrine and the approved membrane will extend the life of the waterproofing program significantly. The work at the southeast corner included the removal of sandstone blocks at level E and F, through the use of the second crane, installed in January to accelerate the work at the temple. Cleaning of the bedrock was a major focus in winter 2012, which involved primarily the removal of accumulated soil and vegetation so that condition surveys, measurement, analysis and treatments could be carried out on clean surfaces. This work began in April 2012 and continued through June. .

Conservation of Brick Shrine G10



A detailed study was carried out to design a mock-up for the original configuration of the platform around the brick shrine. It will be put in place after the excavation of the foundation (right).



World Monuments Fund gained valuable information from its collaboration with Giorgio Croci, an international specialist in preservation engineering and a member of UNESCO's Ad Hoc Experts for Angkor. The hydraulic jacking recommended by Professor Croci worked only under limited conditions. Thus a combination of techniques was required to conserve the brick shrine and address cracking and weaknesses in the structure. To protect the upper wall sections from water infiltration lead sheets were installed and covered with a few additional layers of brick. Finally Mr. Sarith the APSARA Archeologist who has been working with our team located brick shrine platform base units from around the site. This will help the visitor understand the method of construction of a typical brick shrine and visualize how it might have looked with its original platform base in place.



The brick consolidation at the northeast corner of the brick shrine (left) included the insertion of new bricks and the resetting of the original bricks in the masonry. Brick masonry consolidation has progressed in 2012. Once this work is completed, waterproofing of the shrine will be carried out through the insertion of lead at the top of G10 and capping the masonry. The pitch is also important to shed water properly. Work in progress on G10's northwest corner is seen at right



LIDAR



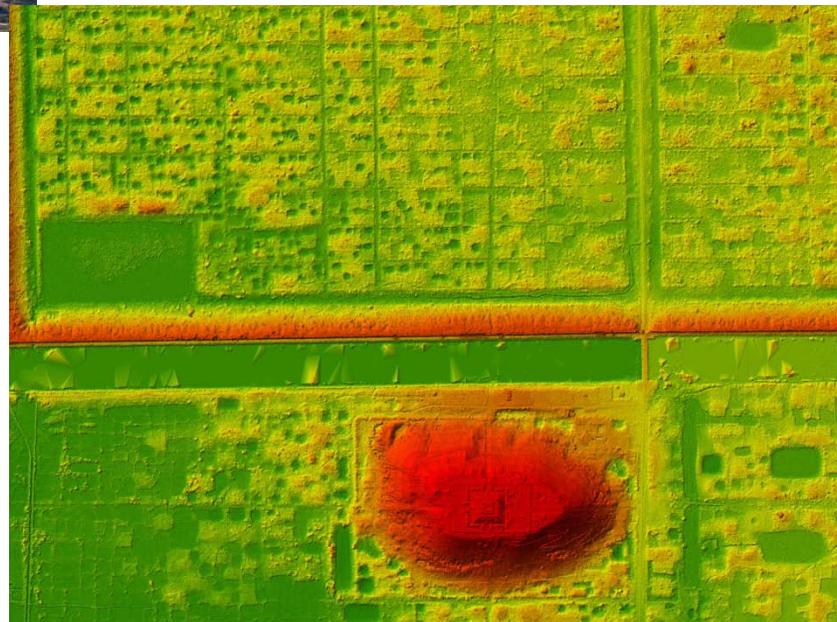
Damian Evans of the University of Sydney carried out an extensive LIDAR survey at Angkor in 2012. WMF contributed to this project and in return will receive detailed LIDAR for the Phnom Bakheng precinct in Angkor Archaeological Park. This section of the report contains representative preliminary screen shots of the data collected. An aerial

view of Phnom Bakheng with high resolution photography layered onto the LIDAR is at left.



At left is a photograph of the helicopter flying over Angkor on capturing LIDAR as part of the collaborative project between several international teams. The project was organized by the University of Sydney. APSARA National Authority will be given all the data collected. Each international team that participated in the project will receive approximately one terabyte of data for its site.

At right is a screen shot of LIDAR of Phnom Bakheng. As this raw data is processed, it will provide a wealth of information about the topography of the site. Preliminary analysis has already shown that ancient paths no longer seen when walking up the hill show up on the aerial photography and LIDAR. This will be very valuable for addressing water run off issues at the site and erosion of the hill that is causing conservation challenges.



UNESCO ICC meeting, June 2012

In June 2012, World Monuments Fund hosted the UNESCO ICC Ad Hoc Experts on site to review the work of the last year. In particular, the work completed at G10 was reviewed. WMF focused much energy in 2012 to improving the visitor experience at Phnom Bakheng. In 2010 and 2011, WMF conducted site management planning workshops to address many of the vexing issues of overcrowding at the site at sunset. In 2012, WMF was able to improve the path leading up the hill by regarding the terrain, designing and installing wooden barriers, creating a series of viewing platforms, and moving the elephant staging area at the top of the hill so that people and elephants are not getting in each other's way as in the past. APSARA assigned more guards to the site to improve

visitor safety and monitor the number of visitors more carefully. These activities and a close collaboration with APSARA National Authority have meant there is now a significantly improved situation at the temple.

An additional priority stemming from these site management workshops was greater attention to the water erosion conditions at the site. To this end, WMF engaged Wrightwater, an engineering firm in Denver with a specialization in archaeological sites. Andrew Earles of Wrightwater made several trips to Phnom Bakheng and presented his findings to the ICC Ad Hoc Experts, who have asked for some additional information to be presented at the fall 2012 ICC meeting. Mr. Earles presented some potential solutions for improving drainage, capturing water more effectively in channels and directing it more specifically away from the central shrine and surrounding brick shrines. The Ad Hoc Experts felt more research was required and asked for a more fully worked out set of proposals for the next presentation.