In August 2011, World Monuments Fund received the good news that the US Department of State's Ambassadors Fund for Cultural Heritage would provide additional support to WMF's collaborative project with APSARA at Phnom Bakheng. This news allowed WMF and APSARA to agree on expanded scope of conservation, as well as advancement of site management planning activities and improvements to the visitor experience. The goal of the project is a sustainable presentation of Phnom Bakheng to protect the temple and accommodate tourists, local residents, and worshippers who visit the site throughout the year. The project addresses stabilization and waterproofing of the five terraces of the sandstone pyramid through structural consolidation and partial reconstruction of the most serious decay patterns at the site, which include water induced deterioration of the live rock substrate, displacement of portions of the sandstone façade, and resulting collapse of corners and corner sandstone shrines. The conservation program entails partial dismantling of unsound portions of the wall, disassembly of the fragmental preserved pavement, and removal of loose debris and soil from the structure. Decayed or missing portions of the natural live rock that built the foundation of the temple are replaced with new laterite blocks, and threaded stainless steel rock bolts are installed to reconnect detached portions. The walls are reassembled with consolidated original stone blocks and anonymous stone blocks from the site that are reused in the repair of the wall replacing missing stone units. The gap between bedrock and sandstone facade wall is filled with new laterite blocks which are shaped to fit perfectly into the opening and to improve bonding. The terraces are worked to establish the necessary pitch to insure proper water runoff and repaired original and new terrace pavers are reset enclose to each other to minimize water penetration. A PVC waterproofing membrane is installed under the pavers hidden from sight to act as a secondary line of defense to prevent water infiltration.

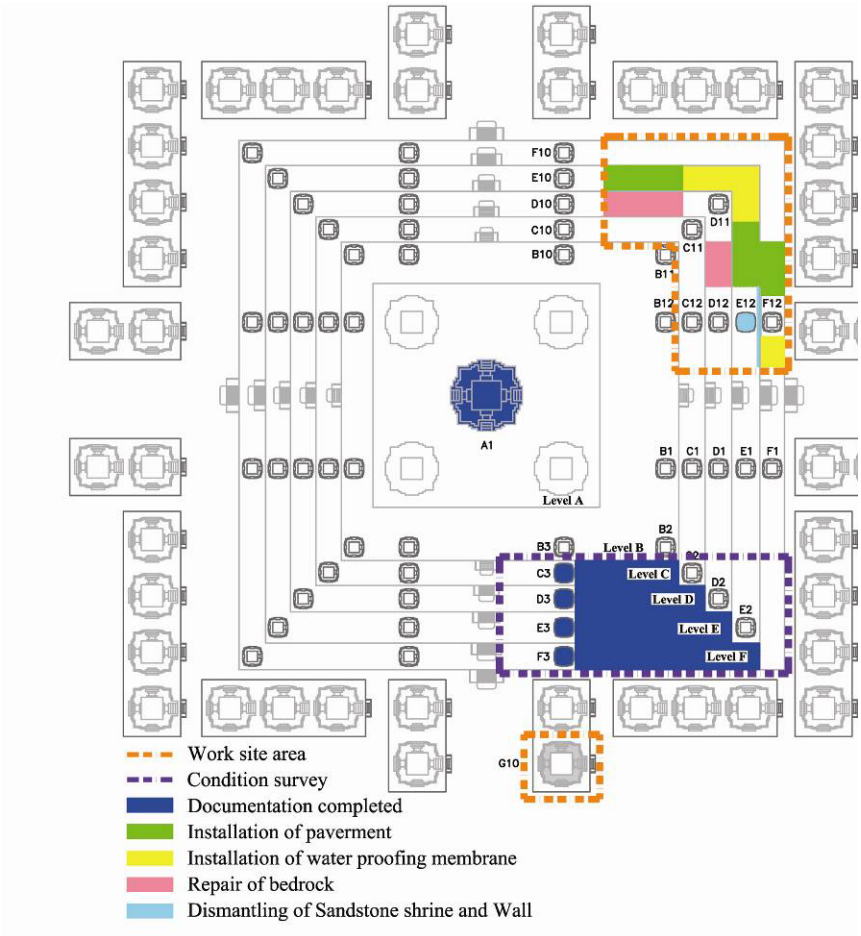

Fig 1: Project activities during the reporting period

The restoration of the northern half of the east elevation and a portion of the returning wall to the north has progressed. At level F of the northern half of the eastern elevation the bedrock repair has been completed, the waterproofing membrane has been installed, and pavers are being reset. Blocks of sandstone shrine F12 have been consolidated and foundation work in preparation of reassembling the shrine is underway. The waterproofing under the shrine is being reviewed and refined to meet special requirements of this delicate location. To provide higher resistance to the weight applied to the PVC membrane by the shrine and to prolong the durability of the waterproofing material - given the fact that a future repair of the membrane at this location will be difficult. Based on WMF's conservation work at Churning of the Sea of Milk Gallery at Angkor Wat, members of UNESCO's Ad Hoc Experts suggested WMF consider utilizing a sheet of lead in addition to the membrane. Upon finalizing the technical details in the coming month sandstone shrine F12 will be reassembled. To blend in the new sandstone units installed at the Northeast corner at level F, the surfaces are tooled to imitate original tool marks.

Fig 2: Work at the northeast corner **Fig 3:** Surface tooling northeast corner level F

The reassembly of the wall at the northeast corner at level E is complete and 480 laterite blocks were installed at this corner and 422 sandstone blocks were reassembled, Continuing WMF's commitment to utilize original materials when possible, 128 blocks are reused stone blocks salvaged from the temple area and surrounding hill. The bedrock at the northeast corner was repaired and pitched in preparation for the installation of the waterproofing membrane. When this process is complete pavers will be reset in this area..

Fig 4: Wall reassembly northeast corner level E **Fig 5:** Resetting pavement northeast of level E

The sandstone shrine E12 is being dismantled and stone blocks transferred to storage for documentation and stone conservation. Dismantling of unsound portions of the wall near the eastern stairs is commencing to facilitate cleaning of bedrock at this location.

Fig 6: Documentation of Shrine E12

At level D, bedrock repair continues and reassembly of the wall at the east elevation has commenced.

Fig 7: Bedrock repair at the north of level D

Fig 8: Bedrock repair at the northeast of level D

All work activities are accompanied by detailed documentation of each step. Before dismantling, each stone block is documented and surveyed to categorize and number the blocks, and to diagnose present conditions. Stones that require repair are transferred to the workshop for stone conservation, which according to the needs of each stone, includes cleaning, desalination, and structural consolidation by the insertion of fiber glass pins set in epoxy based adhesives to reconnect detached fragments. Decayed wall units and pavers that are no longer usable are replaced with new or salvaged stones. Blocks that are in good condition are transferred to storage where blocks are organized using a numbering system that reflects the way stones were removed, facilitating their proper return to the temple.

Fig 9: Micro-sandblasting to remove salt crusts

Fig 10: Insertion of fiber glass pins

While choosing potential blocks to be reused at the reconstruction of the corners, original stacking patterns of walls and pavers are considered in the new design to ensure that repairs blend in well with the original surrounding.

Fig 11: Documentation of scattered stones to be reused for temple repair

Recent improvements to the pace of work include expansion of the work area, the erection of fencing to protect workers, fragile historic materials and the public, and the installation of a new generator and a second tower crane. Scattered stone blocks in front of the southern half of the east elevation and the eastern half of the south elevation were documented and moved to clear space for storage, equipment and transportation of materials. Excavation for documentation and conservation preparation was conducted in front of the southeast corner to expose bedrock to prepare the foundation for the tower crane. The crane was transported up the hill, set up, and connected to the generator.

Fig 12: Transportation of the crane up the hill

Fig 13: New tower crane in front of the eastern half of the south elevation

To prepare for the disassembly of level F, existing documentation is being reviewed as the documentation team completed a unit by unit condition survey of all walls, pavers and stone shrines at the southeast corner and the eastern half of the south elevation.

Fig 14: Condition survey and documentation of the south elevation

WMF and APSARA are implementing a conservation pilot project at one of the brick shrines at Phnom Bakheng to establish a plan for brick structures at the site and for similar buildings in Angkor Archaeological Park. The structural consolidation of the foundation by replacement of rotted material with new laterite blocks has been completed. A survey to locate missing sandstone plates that originally encased the platform of the shrine is underway to reconstruct one corner as an illustration of the original configuration. The rest of the foundation repair will remain exposed so it harmonizes with the existing overall appearance of the brick shrine. This design of the foundation repair will be presented to the ICC Ad Hoc Experts during the next Technical Session in June 2012.

Fig 15: Resetting sandstone blocks at the southeast corner foundation of G10

Fig 16: Brick shrine G10 northwest corner view

The consolidation of the brickwork at the northwest corner has been completed. A lead sheet was installed hidden from sight under the last layer of bricks to act as cap flashing to prevent water from entering into the repaired structure and to aid water drainage to the exterior. Four more layers of bricks were installed on top of the lead sheet in a stepped configuration to obtain a soft finishing line of the repair that blends well with the surrounding area.

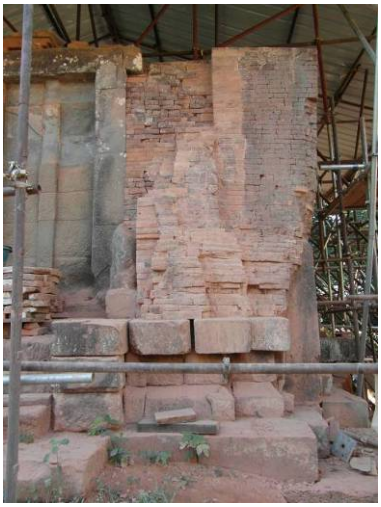

Fig 17: Northwest corner of brick shrine G10 after conservation

Fig 18: Top of the northwest corner after repair

Fig: 19: Southeast corner of brick Shrine G10 during consolidation

Fig 20: Inside southwest corner of G10

A circulation plan has been implemented and visitation to the central temple pyramid is limited to two platforms with a maximum number of 300 people at one time. Wooden stairs have been installed over the north and south original stairs, one to ascend and the other to descend, and barriers have been set up to identify restricted areas and to protect fragile carvings at the upper platforms. A special APSARA guard unit has been assigned to control and manage tourism flow. Fiftenn guards are now posted on-site after 2pm. On request of APSARA National Authority, WMF proposed several locations for the installation of additional sunset viewing platforms. These locations were reviewed by H.E. Bun Narith, Director General of APSARA National Authority who was accompanied by the Directors of the relevant APSARA Departments during a site visit when the location above the western laterite stair was approved to be best suited for effective management of the site and visitor enjoyment.. In collaboration with APSARA WMF will install the platform shortly.

Fig 21: Wooden stairs at the south for ascending

Fig 22: Wooden stairs at the north for descending

Fig 23: Barriers at the upper two platforms of the temple pyramid

Fig 24: On-site meeting with H.E. Bun Narith, Director General of APSARA to review additional sunset viewing location

Visitors are encouraged to explore other areas of the temple complex and to use the panoramic viewing platforms installed along the pathway and atop the hill. These platforms provide views of the 10th century brick shrine temple Baksei Chamkrong to the north of Phnom Bakheng, the Western Barray and the Cambodian countryside to the west, and to Angkor Wat to the south. Trees have been trimmed to improve the view and additional viewing locations have been opened at the southeast side of the plateau along an extended walkway leading to the eastern portion of the site. In October 2011 APSARA National Authority held an official meeting with all concerned stakeholders to describe the improved visitor circulation plan and new restrictions to protect the temple and assure visitor safety. Tour operators were informed of these changes and encouraged to bring groups to other less visited temples within Angkor Archaeological Park that also provide excellent opportunities for enjoying sunset at Angkor..

WMF is working on a new signage program for Phnom Bakheng to provide visitors with updated information on the history of the site, ongoing conservation activities , and the new regulations about visiting Phnom Bakheng. Educating visitors is an important element in site presentation.

To address site erosion and improve water management at the site a hydrological survey was completed in September 2011 resulting in an initial report with recommendations for further studies and ways to improve water management at Phnom Bakheng. The hydrological engineers will return to the site in January 2012 to continue their review of terrain of the hill on which Phnom Bakheng temple is located and to analyze the bedrock configuration, hydrological patterns, and related erosion at the site. Results of the January 2012 hydrology studies will be presented to the ICC during the next Technical Session in June 2012. In coordination with APSARA and 7 other international teams working in Angkor, a LIDAR survey is planned for spring 2012, which will provide very precise topographic data that will be helpful for improved water management, erosion control and landscape options for Phnom Bakheng.