A consensus is evolving among researchers and leading edge practitioners that significant changes to urban water management must be implemented to achieve more sustainable outcomes. A consensus is also evolving among these same professionals concerning the elements of the evolving system. These evolving systems have two principal objectives: (1) to use water more efficiently and (2) to reduce resource consumption associated with urban water management. The system components contributing to these two objectives are described in the following two sections.

**Increased Water Use Efficiency**

Increased water use efficiency offers the potential to meet urban water needs and maintain and/or enhance current living standards while dramatically reducing the reliance on imported water (dramatically increased use of local water resources). Three principal elements contribute to increased water use efficiency, and a fourth reduces its cost. The three principal elements include:

1. Water conservation
2. Stormwater management and rainwater harvesting
3. Water reclamation and reuse

Source separation of water supply and wastewater represents the fourth element which can reduce cost.

A wide range of water conservation technologies are available and are increasingly being applied. These involve water-using appliances (i.e. washing machines), toilets, showers, and water faucets. Significant opportunities exist to reduce in-door water use using these technologies. At the same time, irrigation represents a significant proportion of urban water use in many of the more arid areas. New approaches to landscaping (xeriscape) and irrigation (i.e. drip) can also reduce net water use. Net water consumption is further reduced if potable and non-potable water requirements are separated and met using different water sources (such as rainwater/stormwater or via water reclamation and reuse, as will be discussed immediately below).

Rainwater/stormwater is increasingly being recognized as an important source of water in urban areas, especially for non-potable uses such as irrigation and toilet flushing. Rainwater/stormwater can be stored in either constructed storage facilities or in local aquifers (aquifer storage and recovery, ASR). These technologies generally involve the management of stormwater on a distributed basis, which offers added benefits including increased pollutant removal (resulting in increased environmental protection) and reduced infiltration and inflow into wastewater collection systems (resulting in both environmental benefits and cost savings).

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1 Prepared for the Aspen Institute Dialogue on Sustainable Water Infrastructure.
Water reclamation and reuse is a well proven approach for extending local water supplies. Non-potable reuse for irrigation and similar uses is very well established in arid regions. Indirect potable reuse is also well proven and is the approach which is most consistent with a single (potable only) water distribution system. Selection of either approach depends on whether a single water supply is provided throughout the service area (which by definition will be a potable system) or whether a dual water supply system will be provided.

Numerous examples exist of the successful implementation of these system elements. Distributed stormwater management is being systematically implemented in locations such as Seattle, Portland, and Philadelphia where stormwater management is an urgent urban water management issue. Water conservation has been and is currently being implemented in nearly all urban areas facing water supply shortages. Water reclamation and reuse is a well established practice in both historically arid locations but also in locations where water supply issues are developing. Wastewater “scavenging” or “scalping” facilities to produce non-potable water for a variety of uses is a common practice in many locations such as California, Arizona, and Florida, and it is even being considering in locations like Seattle. Modern developments such as the Soliare in New York City and Dockside Green in Victoria, BC are also increasingly incorporating water reclamation and reuse. Indirect potable reuse is also well established. The Upper Occoquan Sewage Authority (UOSA) in Centreville, VA and the Orange County (CA) Water District have been supplementing drinking water supplies for more than 30 years. The Republic of Singapore perhaps represents the most forward-looking approach to modern water management and is positioning this island nation for water independence. Thus, these practices are not “experimental” but are well demonstrated and established. What is needed is their consistent integration into urban water management systems.

Reduced Resource Consumption

Reducing resource consumption has always been an objective of urban water management systems as the use of resources represents costs which must be funded by the system users. Energy for water resource development and for the distribution of treated water represents the principal resource consumed for water supply systems. For example, it is estimated that 7 percent of total energy use in the State of California is used to transport water from Northern to Southern California. Energy usage for wastewater management is largely for treatment, but energy can and has historically been produced through the production of biogas by the anaerobic digestion of waste sludge. Wastewaters also contain significant quantities of nutrients (nitrogen and phosphorus) which can cause deleterious effects when discharged to the aquatic environment and which are needed in agriculture. The historic practice of the land application of biosolids allows a modest portion of the nutrients in the wastewater stream to be recycled to agriculture. However, this practice is under increased pressure and is expected to decline in the future. Furthermore, only a fraction of the nutrients in the wastewater stream are accumulated in the biosolids, limiting the overall effectiveness of this practice.

Several new approaches are becoming available to reduce the resources consumed in water supply and wastewater management. Increased water use efficiency, as described above, is a significant element as energy use is reduced whenever less water must be removed from the environment. Energy associated with home water use, such as water heating, is also reduced significantly when total water use is reduced. In fact, the increased energy use
required for modern water reclamation and reuse systems can be more than off-set through the reduced energy needed to supply water to the urban area.

Opportunities exist for increased energy production from the organic matter contained in the wastewater stream. Applicable technologies include increased anaerobic treatment, thermal treatment for energy production, and the evolving technology of microbial fuel cells. The wastewater stream can also serve as a heat source/sink in district heating and cooling systems, thereby reducing energy requirements for these domestic and commercial needs. Likewise, new technologies are being developed and implemented to not just remove nutrients from the wastewater stream but to also recover them in forms which are usable for a variety of purposes, including as fertilizers. An enabling technology is source separation at the household level. Separation of grey water allows water to be recycled with much less energy than required if the entire wastewater stream is to be treated for water reclamation. Moreover, concentration of the organic matter and nutrients in the blackwater stream facilities more efficient energy and nutrient recovery. The separation of urine from blackwater creates further energy nutrient recovery opportunities as the majority of the nutrients are concentrated in the urine stream. These technologies and approaches are just being implemented full-scale but show significant promise which should be considered when implementing improved urban water management systems.

Supplemental References

The text above provides a brief summary of the evolving approaches to urban water management. Further elaboration of these concepts and supporting background information is presented in the three papers attached to this brief summary. The first is a summary paper which will be published in the near future in the Bridge, which is the magazine of the National Academy of Engineering (NAE). The second is a paper which will be presented in October of this year at the annual WEFTEC conference as the AEESP Lecture. The third is a paper presented in 2007 at a conference in Japan on sustainable water management.

