G|PRO

PLUMBING

TEST YOURSELF QUESTIONS: Answer Key

CHAPTER 1: Green Plumbers Needed

1. **How are plumbers uniquely positioned to help the environment?**

   Green building is the construction industry's response to issues of environmental pollution, diminishing natural resources, and economic pressures. Green building improves human and environmental health, and decreases energy and water consumption through better design, siting, construction, operation, and disposal.

   Efficient plumbing contributes to the conservation of water. As water use is reduced, there are also reductions in the heating, treatment, and pumping of water- all of which use energy. Using less water reduces the amount of sewage that in turn needs to be treated. This decreases pollution, energy use, and the costs associated with treatment thereby helping the environment, public health, and economy. *(See page 1).*

2. **How do the four main benefits of green building relate to the plumbing industry?**

   The four main benefits of green building are jobs, environment, health, and economy.

   Green building will increase the amount of **jobs** for plumbers. Green developers and the government continue to implement water-use reduction measures for buildings. This will increase the amount of projects available for plumbers knowledgeable in water efficient strategies. There is also new work available in retrofitting existing buildings with on-site water recycling systems and high-efficiency fixtures. Water efficient plumbing is beneficial to the **environment** because it decreases the amount of water being used. This decreases the energy needed to move and treat water, the need to dam rivers and drain aquifers, and the amount of pollutants carried in the water that need to be treated. Plumbers play a role in the health of workers and building occupants in regards to indoor air quality. Choosing low-VOC materials to weld and glue contributes to the **health** of the people in the building. The combination of green job creation and cost reduction from decreased water and energy use are good for the **economy**. *(See pages 2-3)*

3. **Why are our current water use practices not sustainable?**

   The continent's population has increased significantly, and so has the demand for water and sanitation. The supply of freshwater above and below ground is

diminished. Regions of North America are facing severe water shortages in the future as these resources are depleted. There is more reliance on chemicals in agriculture, which travel to and pollute the waterways. The high amount of impervious surfaces prevents absorption of stormwater. Stormwater and CSO events contribute to water pollution. Aging water infrastructure exposes water to pollutants and limits supply. *(See page 3)*

4. **Why does the current cost of water not reflect its true cost?**
   The current price of water is falsely low. It does not reflect the true cost that local governments pay to extract or treat water, and does not recognize the environmental consequences of continually extracting water. Historically, the price of water has been kept low because it was plentiful and relatively cheap to obtain. However, that is no longer the case. Local water infrastructure is outdated, local water sources are running dry, and our population is growing; therefore, the price of water will soon have to rise to reflect the real cost to society. *(See page 4)*

5. **How do humans fit into the hydrologic cycle?**
   The hydrologic cycle is the natural process by which water is cleaned and replaced. Humans need to have an integrated role in the natural cycle. It is important to be conservers of water, to clean and reuse it smartly and safely instead of wasting it. *(See page 4)*

CHAPTER 2: Sustainability in Plumbing Systems

1. **How does the whole-building approach apply to sustainable plumbing systems?**
   A greater level of sustainability can be achieved by integrating water savings and reuse elements to create a coordinated plumbing system dedicated to water reduction. For example, a rainwater harvesting system will reduce the need for potable water for landscape irrigation. *(See pages 6 and 7)*

2. **What are the issues that a plumber might be involved with on a green job?**
   - Reducing water consumption by installing high-efficiency fixtures
   - Installing water reuse or reclamation systems, such as greywater, blackwater, and rainwater where it is allowed
   - Increasing energy efficiency by installing high-efficiency water heating systems and appliances
   - Improving indoor air quality by using low-VOC products, and providing proper ventilation during installation
   - Installing solar water heating systems
   - Remove items from the waste stream through recycling or reuse
     (See pages 6 and 8)

3. **Describe LEED, WaterSense, and ENERGY STAR.**

   The U.S. EPA created WaterSense. Its goal is to promote water efficiency. WaterSense labeled products are more water-efficient than standard products.

   ENERGY STAR is a voluntary labeling program jointly administered by the U.S. EPA and the U.S. DOE. Its goal is to protect the environment by promoting energy-efficient products and practices. It is primarily an energy-reduction program, but ENERGY STAR water products also use less water than standard products.

   LEED, or Leadership in Energy & Environmental Design, is a green building certification program. There are multiple LEED categories that address plumbing issues. *(See page 8)*

CHAPTER 3: Saving Water by Reducing Demand

1. **What are the benefits of high-efficiency fixtures and appliances?**

   High-efficiency fixtures and appliances provide the same level of service as standard products, but use less water and energy. By conserving water, the fixtures and appliances protect valuable potable water resources and help maintain healthy aquatic environments. They also reduce water and sewer bills for building owners and eliminate the need for municipalities to expand wastewater treatment facilities. Less energy is spent pumping, heating, and treating water. *(See page 16)*

2. **What are the benefits and concerns of installing low-flow showerheads?**

   Because the maximum flow rate of showerheads manufactured and sold after January 1st, 1994 is 2.5 gpm, they are much more efficient than older showerheads. This creates a significant opportunity to cut both water and energy costs by upgrading old showerheads.

   However, plumbers must be careful when replacing a showerhead on a valve that is not designed for the new low-flow rate. Traditional mixing valves were designed to work at a certain flow rate. If the flow rate is reduced, they may not adjust properly, and this will result in an output of scalding hot water or very cold water that could injure the user. *(See page 20)*

3. **What are issues associated with tempered faucets? What are measures that can be taken to make tempered faucets more efficient?**

   Tempered faucets mix hot and cold water automatically. Running the faucet while waiting for the water to become warm can cause waste. Water loss is doubled by the hot and cold water streams going down the drain, while waiting for the hot stream to become warm. Strategies to make tempered water faucets more efficient are to have the circulating hot water close to the faucet, or to have a heat maintenance cable run

from the circulated line to the faucet (must be done only if the pipe and heat maintenance cable are well insulated). *(See pages 19 and 20)*

4. **What are the differences between low-consumption (LC) toilets, high-efficiency toilets (HETS), and dual-flush toilets?**

   Low-consumption toilets use 1.6 gallons per flush (gpf). High-efficiency toilets (HETs) are the newest and most efficient toilets available. Their hydraulic design allows them to flush using 20% less water, using only 1.28 gpf or less. Dual flush toilets offer two different flush levels: a full bowl 1.6 gpf flush for solid waste, or smaller flush using only 0.8 gpf for liquid waste. *(See page 22)*

5. **What is the concern with high-efficiency fixtures and drain-line carry?**

   Drain-line carry is the distance that water can float or carry solids down horizontal runs. There is concern that there will be drain-line carry problems with older pipes because high-efficiency fixtures use much less water than the drainage systems were originally designed for. *(See page 23)*

6. **How do waterless (no-flush) urinals work?**

   The secret of how waterless urinals function is in their trap seal fluid. Oil is less dense than water and will always float on top of it. Waterless urinals work by retaining a quantity of oil in the fixture trap, where it acts as a seal that keeps sewer gasses from entering the building. Some waterless urinals have an integral trap, while others use a disposable plastic cartridge. When urine enters the trap, it passes through the oil and emerges on the other side in the drain line. Because the trap oil is less dense than urine, it remains behind and creates a seal. *(See page 24)*

7. **What new technologies exist that contribute to landscape irrigation efficiency? Why is landscape irrigation efficiency important?**

   Installing a high-efficiency landscape irrigation system that uses emitters, foggers, micro-bubblers, and/or stream jets is available. Drip systems and smart valves are highly water efficient. Smart valves automatically open and close separate watering zones, and can be set to certain times of day or specific moisture amounts. They use sensors that can measure the moisture level and rainfall amount, and can be linked to process weather data.

   Efficiency in landscape irrigation is important because the irrigation of constructed landscapes uses a lot of water, and has a significant impact on natural resources. Planting native plants, which are adapted to the local landscape and therefore need much less irrigation, can dramatically reduce water use. *(See pages 25 and 26)*

8. **What opportunities are out there to make fire protection green?**

   Sustainable fire protection systems can be used in both commercial and residential settings; water for both can be sourced from reclaimed or recycled sources.

Water-mist systems apply a very fine mist of water that can quickly suppress fire. This decreases water use. The mist system reduces the size and amount of piping used, and thus is more cost-effective. Mist systems also reduce the amount of runoff that enters the groundwater and nearby streams and lakes. This runoff can contain chemicals and toxins from the building.

Depending on local building codes, residential fire protection systems may use the existing potable water system rather than creating another piping system within the house. A multi-purpose pipe system that shares the domestic water system can reduce the amount of piping needed to supply a residential fire protection system. Combined with a mist system, the reduction in water and material use is significant.

There are opportunities to save or recycle water during fire protection systems' required annual test. This water can be recaptured, and used again for testing or as supplemental water for fire protection.
(See pages 27 and 28)

CHAPTER 4: Improving Water Distribution Systems

1. **Why is it important to insulate hot water piping and cold water piping?**
   It is important to insulate hot water piping so as to keep the energy used to heat the water from dissipating needlessly. Insulating cold water piping prevents condensation from accumulating in the building's internal systems, and to prevent the pipes from becoming thermal sinks that take energy from hot water piping and the building's heating systems. *(See page 31)*

2. **How does the trunk-and-branch method of piping contribute to the wasting of potable water?**
   Trunk-and-branch piping is the most popular method of installing water piping. This design contributes to the wasting of potable water because people run appliances while waiting for the water to become warm. Large trunk lines move cold water to water-heating equipment, and when heated, smaller branches move the water to the appliances. The hot water stays in the line until it is used, and eventually it begins to cool. When the user goes to access the warm water, they must run the fixture down the drain until it is warm again. *(See page 32)*

3. **How is hot water circulation piping designed in the construction of new or larger buildings? What measures can be taken to increase efficiency?**
   In larger and new buildings, hot water circulation piping is often designed with a dedicated return line from the fixtures furthest from the water heating equipment. The heated water is piped back to the equipment and continuously circulated by a pump. The recirculation line is connected to the water heater near the cold water inlet, the

circulating pump is installed near the water heating equipment on the return line, and pumps water through the hot water piping and back to the heater on the return line.

When the circulating pump runs constantly, it wastes energy. The circulating pump can be controlled thermostatically by an aquastat (a switch that turns on and off, depending on water temperature) or set with a timer (to run at specified intervals or scheduled times). *(See page 33)*

4. **What are the benefits of water metering?**

   Water metering is an effective way to reduce water consumption. It provides an incentive for reducing usage and helps identify system leaks. In urban environments, some large buildings are installing meters to individual tenant's supplies. This allows the building owner to divide the cost of water among tenants, therefore discouraging water waste. Meters on water-consuming equipment can provide operators with information on water use, or changes that may indicate problems. *(See page 35)*

5. **Describe benchmarking.**

   When benchmarking, a building manager typically establishes a baseline of water use over the course of a full year, then compares future annual patterns of use against it, although it's also common to benchmark usage against average usage in similar buildings. By using water meter measurements to track, monitor, and assess water use in this manner, the process of benchmarking helps building managers identify potential savings and prioritize necessary improvements.

   The first step in benchmarking is to measure your building's use of water. Using information readily available on your water bills for a period of at least 12 months, you can track the total gallons used per month. If you are creating a comparison to other buildings in your portfolio, you will translate usage into gallons per month per square foot. *(See page 37)*

CHAPTER 5: Stormwater Control and Diversion

1. **What problems are associated with stormwater?**

   Untreated stormwater can negatively affect the environment and local communities. Uncontrolled stormwater can also threaten lives and property. Stormwater washing over roads and parking lots picks up motor oil and fuel. Agricultural stormwater runoff carries away fertilizers and pesticides, which also contaminate water resources.

   Stormwater can overwhelm combined sewer systems. During a heavy rainfall, the large amount of incoming stormwater overwhelms the system causing a Combined Sewer Overflow (CSO). This is when the overwhelmed system releases the water and sewer contents into local rivers, lakes, and even city streets instead of treating it. CSOs are responsible for a variety of problems, including contaminating drinking water, polluting fishing areas, and closing public beaches. *(See page 39)*

2. **How do municipalities use treated stormwater?**

   In places where groundwater sources may have been depleted, municipal wastewater can be used to replenish groundwater in aquifers. This adds water to the local or regional natural water cycle. Replenishing groundwater is accomplished indirectly through infiltration basins or directly through injecting or pumping water into the aquifer.

   Treated municipal wastewater can also be routed directly to water treatment plants, where it then gets treated to potable water standards. This bypasses the step of releasing water back into rivers, lakes, or oceans, and directs millions of gallons of water immediately to the water treatment plant. *(See page 40)*

3. **What are the differences between stormwater retention and detention?**

   With stormwater retention, the stormwater is captured and held until it's absorbed into the soil and/or evaporates.

   With stormwater detention, the stormwater is captured, retained, and then slowly released over time to the storm drain. *(See page 41)*

4. **State the different methods of controlling stormwater that use bioretention.**

   Systems that use bioretention include rain gardens, bioswales, stormwater planters, permeable pavement, and constructed wetlands. Bioretention uses soils and plants to remove pollutants from stormwater runoff and slow its flow. *(See page 43)*

5. **How do blue roofs and green roofs contribute to stormwater management?**

   Roof systems can help manage stormwater by containing and slowing water flow.

   Blue roofs detain rainwater in order to manage stormwater. This engineered roof system captures rainwater on the roof and temporarily stores it there, then slowly releases a controlled flow through the storm drainage system at a pre-determined rate.

   Green roofs can be designed to retain rainwater. The roof landscaping naturally captures rainwater and allows it to slowly infiltrate plantings. This decreases the amount of water entering the storm drain. *(See page 43)*

6. **Describe the different forms of constructed wetlands.**

   Exterior wetlands can be categorized as surface or subsurface:

   Surface flow wetlands, also known as a free water surface (FWS) system, consist of shallow basins that allow wastewater to slowly flow from basin to basin, eventually clarifying the waste, which is then released.

   Subsurface flow wetlands, also known as a vegetated submerged bed (VSB), allows waste to flow through a substrate, such as sand and gravel, in order to clarify the

wastewater and eventually release it as clear water. Subsurface flow wetlands can further be divided into vertical flow wetlands and horizontal flow wetlands.

Wetlands can also be constructed within buildings. One type of constructed indoor wetland that purifies wastewater is a *Living Machine*®. A Living Machine® is a trademarked system for on-site wastewater treatment. *(See page 44)*

CHAPTER 6: Alternative Water Sources

1. **How is rainwater different from stormwater?**

   Rainwater is precipitation that is collected from a rooftop or other catchment surface. Stormwater is any precipitation (rain and snow) that contacts a surface at or below ground level, and then runs off into drains or waterways.

   Stormwater should not be confused with rainwater. The difference between the two is important because they carry different types and amounts of pollutants — rainwater picks up organic waste on roofs, while stormwater picks up more pollutants, including chemicals, from the ground. *(See pages 38, 39, and 47)*

2. **Describe rainwater harvesting systems and their typical components.**

   Rainwater harvesting systems collect and store rainwater for the intended purpose of beneficial use. Effective rainwater catchment can reduce consumption of potable water for non-essential uses, such as landscape irrigation, sidewalk washing, HVAC cooling towers, water closets, and urinal flushing.

   Typical components include:
   - Roof washer/first flush diverter: an arrangement of piping, or a manufactured device, that redirects the first few gallons of rainwater and debris away from the system or onto the ground
   - Cistern/storage tank: the central component of the rainwater catchment system. It stores the captured rainwater for later use.
   - Water purification system: purifies harvested rainwater so it can be used for non-potable use.
   - Low-water switch: connects to an alternative potable water source in times of low rainfall to prevent system failure.
   - Overflow piping: discharges excess water during times of extreme rainfall.

   (See pages 47 and 48)

3. **Describe greywater systems, and how the greywater is purified and used in buildings.**

   Greywater is a form of treatable wastewater. It is water that has been used in households and does not contain bio-solids or fecal matter. It is collected for treatment and reuse in non-potable systems.

The greywater is filtered to remove solid particles, combined with a disinfecting agent, and then neutralized with ultraviolet light in combination with a pre-filter. The pre-filter is usually a reverse osmosis (RO) filtration system. The greywater is kept in a storage tank to be used in household appliances that reuse the water (ex. toilets), and irrigation. *(See page 50)*

4. **Describe the three main types of biological digestion.**

   The three types of biological digestion are aerobic, anoxic, and anaerobic. Aerobic digestion processes treat wastewater in an environment with oxygen. Anoxic digestion processes treat wastewater in an environment without free oxygen. It involves a different type of bacteria than aerobic, which is able to access oxygen through chemical reactions. Anaerobic digestion involves a third group of bacteria that does not need oxygen and releases methane gas. It is commonly used in large municipal sewage treatment plants where the methane fuels power generation. *(See page 54)*

5. **What are the typical processes involved with blackwater treatment?**

   Blackwater treatment systems use the aerobic/ anoxic process to treat waste. The treatment process involves the following steps: collection, screening, biological treatment, ultrafiltration, ultraviolet disinfection, and chlorination. *(See page 55)*

6. **What are the risks associated with reused water?**

   The greatest risk posed by reused water is the potential for cross-connections with and contamination of the potable water supply. Despite the effectiveness of treatment and chemical contaminants, pathogens could still be present in the water. Contaminants may include heavy metals, volatile organic compounds (VOCs), and prescription medications thrown down the toilet or sink.

   The greatest risk posed by reuse of wastewater is the potential for cross-connections with potable water. It is critical to make sure you are never tapping into a non-potable line for potable uses, and to provide visible labeling on any non-potable lines you install. *(See page 56)*

7. **What are the differences between blackwater systems and reclaimed (recycled) water systems?**

   Reclaimed (recycled) water systems are similar to blackwater systems, but are used at the municipal level rather than the individual building level. The system treats sewage. Sewage contains substances that blackwater does not, such as industrial process waste. Blackwater is strictly on-site sanitary waste that contains organics and human waste.

   Blackwater treatment systems use the aerobic/ anoxic process, while typical sewage treatment plants use the aerobic/ anaerobic process. *(See page 57)*

CHAPTER 7: Domestic Water Heating

1. **Explain the differences between direct and indirect water heating.**

   Water heating systems are divided into two categories: direct and indirect heating equipment. Direct water heaters burn fuel or use an electrical resistance coil to provide the primary source of heat for the water directly. Indirect water heaters rely on external energy sources to heat water. Heat is transferred to water through a heat exchanger, which acts as an interface between the two systems. *(See pages 62 and 66)*

2. **What are the uses of heat traps in storage water heaters? What forms do they come in?**

   In storage water heaters, there is a tendency for hot water to circulate out of the storage tank and into the risers that carry both hot water and cold water. Because hot water is less dense than cold water, convection causes the hot water to rise up the supply pipes. This can also lead to substantial efficiency losses.

   These losses can easily be avoided by installing heat traps on both the hot and cold pipes connected to the water heater tank. Heat traps can be simple loops of pipe that prevent convection or, if space is limited, heat trap nipples that only allow water to flow in the desired direction. (Heat trap nipples can use either balls that float or fall in the water's path, or rubber flappers that accomplish the same end.) *(See page 63)*

3. **What are the benefits and drawbacks of condensing water heaters?**

   In condensing systems the vapor condenses and releases the energy to heat water, making them very efficient water heaters. Condensing technology can be used in domestic water heating or commercial heating systems.

   Condensing units have important venting requirements that are different from conventional units. When water vapor condenses, it combines with products of combustion in the flue gases to form weak sulfuric acid. This causes corrosion in flues made out of conventional materials. Condensing equipment should only be vented to a conventional stack if it is re-lined for this purpose. Special flue materials must be used for the flue of a condensing unit. Additionally, the drip of corrosive condensate water from the unit should be treated in order for it to be safely added to the sewer drain. Most municipalities require that it be neutralized before being drained to the sewer. *(See pages 63 and 64)*

4. **What are the issues to be aware of with on-demand water heaters?**

   The power input requirements for electricity (kW) or gas (Btu/hour) for instantaneous water heaters are higher than conventional storage-type equipment because the units need high-powered burners to heat water quickly. To meet these high power requirements, there may need to be increases in the gas or electrical infrastructure serving the units. Some instantaneous gas-fired water heaters are the condensing type, and require flue venting and condensate issues. *(See page 64)*

5. **What are the benefits of cogeneration?**

   Cogeneration (cogen) is a method of producing useful electrical and thermal energy from one machine using fossil fuels. Even though it uses fossil fuel, cogen is considered a green building strategy because it uses waste heat to heat water.

   In addition to the electrical or mechanical power produced, the heat is recovered and used for other purposes, such as domestic hot water heating, space heating, or other thermal energy applications. The use of a cogen system's waste heat not only makes the unit much more efficient, but also makes it more cost-effective. *(See page 70)*

6. **What are the forms of energy recovery and how do they work?**

   The forms of energy recovery are drain-water heat recovery and steam heat recovery, and condenser heat recovery.

   Drain-water heat recovery captures the heat from water entering drains; this energy can preheat cold water in all forms of water heaters.

   Steam heat recovery stores the steam condensate in a tank and uses it to preheat domestic hot water through a heat exchanger.

   Condenser heat recovery captures heat from the air- conditioning systems of larger buildings. These systems will reject heat through the condenser to a water loop that carries the hot water to cooling towers on the roof. This hot condenser water can be reclaimed, and used to preheat the cold water supply to the domestic water heater. *(See pages 71 and 72)*

7. **Describe and compare flat-plate collectors and evacuated-tube collectors.**

   A flat-plate collector is a solar collector that contains a flat absorber mounted with attached flow tubes within an insulated and glazed framed enclosure.

   An evacuated-tube collector is a solar collector that uses a glass tube to enclose an absorber plate or fin and attached tubing.

   Flat-plate collectors are the most commonly used collectors for solar water heating systems. Flat-plate collectors are not as efficient as evacuated tube collectors in certain conditions that are less than ideal, such as cooler weather conditions or on cloudy days. This is because flat-plate collectors are subject to a greater ambient temperature loss through the framed enclosure, even with double- glazing.

   Flat-plate collectors are more efficient than evacuated-tube collectors in ideal conditions, such as full sunshine and when loadside temperatures are not high. One type is not necessarily better than the other; end use, cost, and local climate must be analyzed. *(See pages 75 and 76)*

CHAPTER 8: Managing Green Projects

1. **Why is code compliance important on green projects?**
   Building and health codes and other local laws often define materials and methods permitted for construction or retrofit work. Staying current with building codes will ensure you are able to comply with them, but also will help you actively support new standards that improve sustainability in the plumbing industry. *(See pages 81 and 82)*

2. **What are the indoor air quality work practices specific to plumbers that need to be followed to ensure sustainability?**
   To ensure sustainability, plumbers must use low-VOC materials, air sealing, and moisture control on projects.

   Using low-VOC materials is important in ensuring the health of the building occupants, and there are LEED specifications involving the amount of VOCs permitted; not following the correct procedure could lose the project its LEED rating.

   In regard to air sealing, fire stopping at pipe sleeves and borings must be sealed. This increases HVAC efficiency because it reduces air infiltration between floors and zones.

   Protecting against water leaks (moisture control) during installation and line testing is critical to ensure that absorbent building materials do not experience water damage. Water damage leads to mold growth and poor indoor air quality. *(See page 83)*

3. **Explain the two forms of construction and demolition waste management: sorting and co-mingling.**
   Sorting recyclable materials involves separating construction and demolition waste into separate containers based on the composition of the recyclable (ex. bins for metals, plastics, wood, etc.).

   Commingling waste involves using a single dumpster for all recyclable materials. These materials are sorted and at an off-site facility where their weight tallies are taken for each category of materials. *(See page 84)*

4. **What work practices should the plumbing contractor be aware of in regards to commissioning, LEED documentation, and value engineering?**
   In regards to commissioning, the process may impact the work schedule. Commissioning involves the plumber's coordination with the commissioning agent. The plumber may have to be present for pre-functional and start-up testing of the installed equipment important for HVAC functioning, greywater or blackwater systems, or energy-efficiency systems like solar water heaters and microturbines.

The plumber may be required to participate in troubleshooting or complete punch lists and corrective work based on commissioning outcomes.

On a LEED project, there may be additional documentation that must be submitted to the Green Building Certification Institute (GBCI) at project closeout to verify compliance with the green specifications such as proof that specified low-flow fixtures have been installed. Documentation requirements are generally minimal for the plumbing trades and the time required for supplying documentation is not likely to affect your schedule. However, if you have not met the material installation requirements, you may be liable for redoing work at a significant hit to your budget and schedule.

Value engineering generally happens in the design phase — before the plumber has bid on the job — but there are occasions when it may happen mid-project. As with a conventional project, plumbers may be required to provide cost estimates for proposed or determined changes. *(See page 85)*