ENVIRONMENTAL ASPECTS OF PLUMBING

WORLD PLUMBING COUNCIL

Many authors collaborated on the content of this paper with the compilation of the articles by:

Blane Judd,
The Chartered Institute of Plumbing & Heating Engineering, UK

Richard J. Prospal,
American Society of Sanitary Engineering, USA

TABLE OF CONTENTS

MISSION STATEMENT

The mission of the World Plumbing Council is: "*To unite the world plumbing industry and promote the role of plumbing in improving health and safeguarding the environment."*

One of the objectives of the World Plumbing Council is: *"To promote the plumbing industry's role in safeguarding the environment through proper management, care, reuse and conservation of natural resources."*

This paper will key in on that role of the Plumbing Industry to protect the environment.

This paper will mirror and complement, and sometimes overlap, the previous publication by the World Plumbing Council and the World Health Organization – **"Health Aspects of Plumbing."**

FOREWORD

One of the roles of the World Plumbing Council is to promote the link between good plumbing and the environment and I am delighted to welcome this new publication which demonstrates that the plumbing industry has a significant role to play in so many aspects of environmental protection.

Whether it is in relation to the use, conservation and reuse of water or in the work which is increasingly being done to recognise that fossil fuels must be used more efficiently and supplemented or replaced by the use of renewable sources of energy including the sun, wind, air and water, then the plumbing industry is a major player.

Many politicians and others take the view that the move towards greater environmental awareness will create a new industry. In reality, many of the new technologies are simply an extension of the work of the plumbing industry- this publication aims to explain the role which the industry plays.

Intended as a companion publication to “Health Aspects of Plumbing”, WPC hopes that “Environmental Aspects of Plumbing” will become a valuable resource for use both by people working inside the plumbing industry as well as those interested in the use of the technologies described in this publication.

WPC acknowledges the considerable effort which has gone into the preparation of this publication and our thanks go in particular to Executive Board Directors Richard J Prospal and Blane Judd who have led the work.

Robert D Burgon,
Chairman,
World Plumbing Council
April 2010

EXECUTIVE SUMMARY

Water is essential to life. We, as a human race, are consuming this planet's water at alarming rates. The fresh water we use today has been around for millions of years. It is a finite supply; there is no way to make any more. Nature has a way of recycling that water for our reuse, but that is a very time consuming action. The plumbing industry must learn from these natural processes and assist nature in using this most essential natural resource wisely.

The plumbing community which includes engineers, designers, plumbers, manufacturers, health officials, code officials, trade organizations and others are all committed to the basic premise to provide safe drinking water and sanitation through proper management, care, reuse and conservation of our natural resources. One of the principal objectives for the founding of the World Plumbing Council is to promote the plumbing industry's role in protecting the environment citing this very premise. The plumbing industry recognizes the tenuous balance mankind must maintain to guarantee its very existence and embraces efforts to ensure we are preserving every drop possible.

In many countries of the world, the plumbing community contributes to the development and installation of heating systems and recognizes that we cannot continue the reliance on the increasing demand for fossil fuels for this purpose. We must also develop, promote and install energy efficient products and renewable systems to provide sustainable heating, safe drinking water and sanitation to the world.

The World Plumbing Council is developing the "Environmental Aspects of Plumbing" publication to create an awareness of the changes that must be made, both at individual household levels and through widespread governmental sponsored programmes. This publication will become a living, ever changing compilation of case studies from around the world, which identifies both successes and failures to solve the environmental issues at hand. Among the topics/issues to be reported are Water Supplies, Sanitation, and Renewable Energy Systems.

WATER EFFICIENCY

The promotion of water efficiency is a very effective way of reducing water usage and can have a tremendous overall effect on the environment. The less water we use and sewage that must be treated, the less energy must be expended which plays a major role in lowering the overall carbon footprint. Preservation and conservation of the water that we have at our disposal are tantamount to water efficiency. Alternative supplies for some of the water uses are a core component of balancing water use and demand.

Water efficient fixtures and appliances can contribute to the reduction in water use of fittings. There are many programmes around the world that endorse and label efficient fixtures and appliances; e.g. the WELS programme in Australia, Waterwise in the UK, and Water Sense in the USA.

WATER REUSE

For most water reuse systems there will be some form of treatment. This can range from a simple leaf filter to a membrane bio-reactor and UV light. The degree of treatment will determine the use that the treated water can be put to.

Rainwater harvesting is one of the simpler forms of water reuse. It can be as simple as collecting the rainwater from the roof of your house or as complex as collecting rainwater at a commercial or industrial complex of buildings. There are many methods and systems to complete this task and many more in the development stages.

Grey water systems separate and treat wastewater from showers, clothes washers, sinks and similar fixtures for reuse as flush water for toilets and urinals, for irrigation and other limited uses.

DESALINATION

Desalination of sea water has been used very effectively in many parts of the world, a process that has previously been cost prohibitive and detrimental to the environment. The two most common methods that are widely used today are reverse osmosis and thermal distillation. Researchers continue to discover and develop newer, more efficient means for converting salt water to drinkable fresh water.

SANITATION & SEWAGE DISPOSAL

The principal objective of sanitation should be to protect peoples' human dignity and promote human health and at the same time provide a clean environment.

Basically, sewage treatment facilities can be classified in one of two ways; improved or unimproved. Essentially, improved systems are those that collect, dispose of and treat the sewage before discharging the effluent. Unimproved systems unfortunately miss the critical elements of treatment and disposal that would make them environmentally sound.

Untreated waste and wastewater is one of the root causes of environmental damage, not to mention illnesses and death. In all cases, whether sewage is treated or untreated, the effluent eventually returns to our source water for consumption. Therefore, the more treatment that sewage receives the less contamination it has on the environment.

SOLAR WATER HEATING

Active and passive solar heating systems can supply hot water for personal use, for space heating or both. A passive system depends on the hot water rising and cold water falling for the circulation while an active type uses a circulator pump to move the water through the system.

Solar systems are now applicable in many countries as modern collectors will work with diffuse and indirect sunlight.

New technologies for the different types of collectors, controls and storage are increasing the energy efficiency of these systems.

BIOMASS FUELLED SYSTEMS

Many recent technological advances are giving biomass, a renewable energy source, the potential to contribute strongly toward lowering the overall carbon footprint. The use of biomass as a fuel source in heating systems is beneficial since it uses wood and plants in the form of agricultural, forest and urban waste residue to produce heat and/or electricity. As plants absorb carbon during their growth, mulch fuel can be considered carbon neutral and hence biomass can reduce the effect on the environment.

HEAT PUMP SYSTEMS

A geothermal (ground source) heat pump is a central heating and/or cooling system that pumps heat to or from the ground. It uses the earth as a heat source (in the winter) or a heat sink (in the summer). These designs take advantage of the moderate temperatures in the ground to boost efficiency and reduce the operational costs of the heating/cooling systems.

An air-source heat pump uses outside air as a heat source or a heat sink. A compressor, condenser and refrigerant system are used to absorb heat at one place and release it in another. When properly installed, an air-source heat pump can deliver one-and-a-half to three times more energy than the electrical energy it consumes.

ENERGY EFFICIENCY

The water heater industry has increased the efficiency of their products through technological advances. The tankless water heater (Combination-boiler) is a good example of one such advance. Manufacturers are developing appliances *i.e.* dishwashers, clothes washers, boilers that use less water and less energy. Many countries have labeling programmes to identify these appliances; in the USA the rating is *Energy Star.* All heating systems have optimum conditions where they are most efficient. The development of hybrid systems that can be used in a wider range of situations will improve the energy efficiency of future heating and cooling systems.

CONCLUSION

This publication is not intended to be a “how-to” guide, but rather a document that illustrates the role of the plumbing industry in environmental matters. It contains case studies of approaches being taken in particular countries and we intend to update this document on a regular basis as new examples and technologies become available.

INTRODUCTION

"Water, water everywhere and nary a drop to drink" an adage coined many years ago *by Samuel Taylor Coleridge* in the *Rime of the Ancient Mariner* could be a very valid claim today with drought striking many parts of the world and much of the clean water in peril from runoff pollution and misuse.

Water is an essential building block of our environment. Nothing in our eco-system can survive for very long without water. We can't. Our crops cannot. Our food supply would disappear without water.

Long ago some very wise people devised a way to deliver water where it was needed and then to take it away once it was used and no longer fit for consumption. This art or science became known as plumbing. Thus the connection of Plumbing and the Environment.

The plumber and the plumbing community are the people that:

- Install and maintain the systems that deliver the good quality water
- Install and maintain the sanitary systems that collect and take waste water to a disposal site
- Install and maintain the water reuse systems, whether they be rainwater harvesting, grey water systems or black water systems
- Help create an awareness of water conservation and pollution control

The challenges of providing drinkable water are found in every part of the world. In the developed countries, long periods of drought, population expansion to areas with little access to indigenous water and pollution of our streams and rivers create many challenges to providing good quality water. The developing and under-developed countries experience similar challenges along with those of an ever expanding population; a lack of infrastructure for distribution of drinkable water; and, in some instances, a lack of concern by the governmental officials to help solve the problem. The annual growth of the world's population exceeds 75 million people – this has major implications for water supply.

More than 17% of the global population lacks access to improved water sources. This is over 1.1 billion people with two thirds of them on the Asian continent.

More than double that number of people lives without access to improved sanitation.

Safe drinking water and proper sanitation should be considered a basic human right. Until the entire world accepts this principle, we will not be on our way to defeating the infectious diseases that plague the developing countries.

The scarcity of drinkable water is quickly becoming more than just an environmental issue; it is also a social and political issue around the globe.

This paper will address many of these challenges in order to, one, increase the awareness and, two, attempt to create the dialogue to promote the solutions to these challenges.

WATER, WATER EVERYWHERE

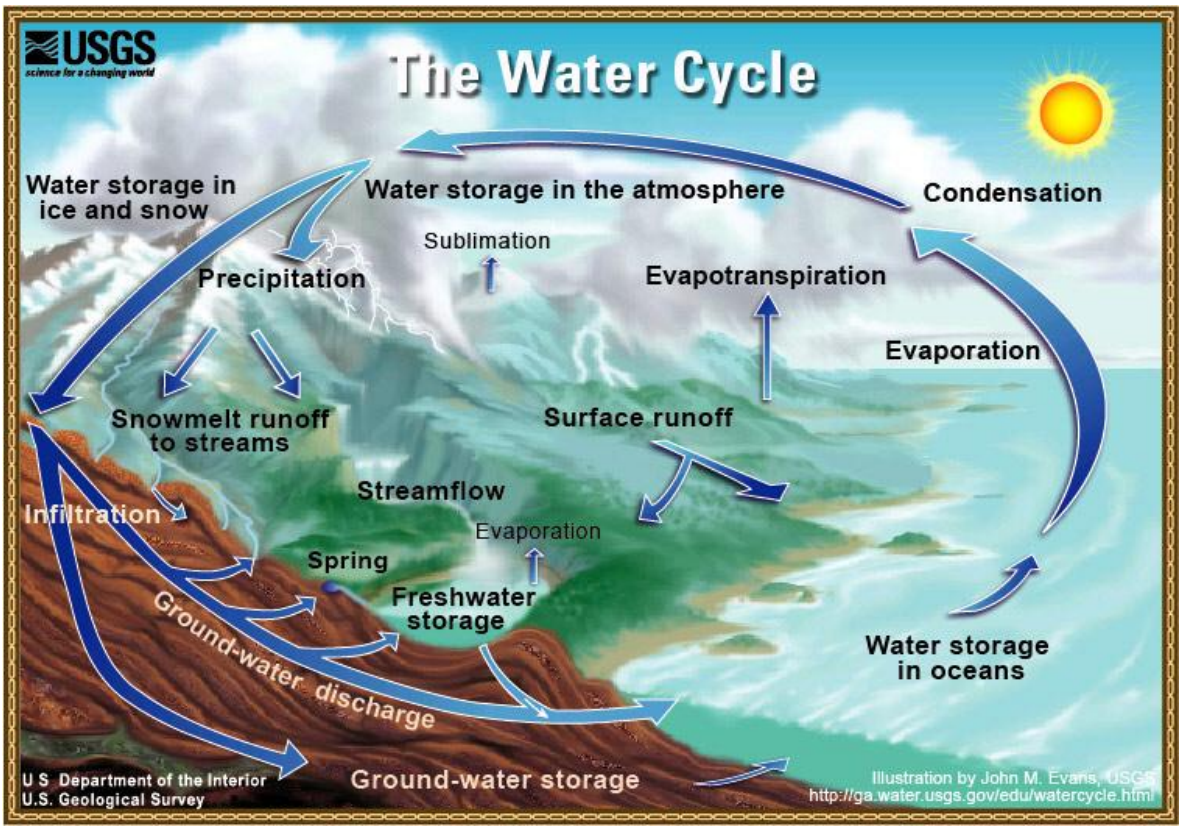
Where does it come from?

Our water, the water we drink, the water we bathe in, the water we sail upon, has been around for billions of years. Without water, life as we know it could not exist. There is just so much water; we cannot make any more, so, we must keep using it and reusing it over and over again. Water is in a continuous cycle always moving and changing states, from liquid to vapour to ice and back again. This is commonly referred to as the water cycle or the hydrological cycle.

There is no real starting point to the water cycle, but it is probably best to start with the vast oceans of sea water. Some of this sea water evaporates into the air as vapour. Ice and snow also contribute water vapour to the air by the process of sublimation. This vapour is taken up into the atmosphere by rising air currents. Water vapour transpired from plants and grasses and water evaporated from the soils add to this phenomenon. All of this vapour, exposed to the cooler temperatures, condenses and causes the formation of clouds. The air currents move the clouds around the globe. Under certain conditions this condensation falls from the sky as precipitation – rain or snow. The snow can accumulate as ice caps or glaciers, which can store frozen water for thousands of years. The snow pack in the more moderate climates eventually thaws and the melted water flows into the streams, rivers and lakes. Some of the snowmelt and rainwater seeps into the ground as infiltration to recharge the many aquifers and wells. Over time, much of this water finds its way back to the oceans where the water cycle ends to begin the cycle all over again. More than 96.5% of the world's total water supply is stored in the oceans. It is also estimated that the oceans supply about 90% of the evaporated water that goes into the water cycle. Freshwater represents only 3% of all of the water on earth.

More than 68% of that fresh water is trapped in the polar ice caps and glaciers; over 30% is in groundwater, leaving less than 1% in the lakes and rivers of the world. Nearly 20% of that lake water is in the Great Lakes system in the USA, another 20% is in Lake Baikal, Siberia, on the Asian continent with the balance in all of the lakes, rivers and streams throughout the world. Many of the greatest rivers of the world, like the Colorado and Rio Grande in the United States, China's Yellow River and the Indus in India, often run dry before they reach their terminus because of the many urban areas that use them as their water source and the extensive agricultural irrigation along the rivers' path.

This freshwater is the water that we, as members of the plumbing community, need to safeguard and protect. This is the only available water that we use every day for growing things, for drinking, for bathing, for washing and for sanitation.



1

Research has now established that the impact of climate change will be seen through changes to the water cycle which will lead to increased water scarcity and flooding. These changing conditions will pose huge adaptation challenges to the water sector and will considerably influence how it manages its assets and infrastructure.

Climate change is not someone's pipe dream or a passing fad. It is, however, a moment in our history (right now, today and tomorrow) that may be the turning point where we must get serious about our stewardship of the environment. It is about our taking care of the planet and its resources without going too far to the left and creating more negative impact.

[1] "U.S. Geological Survey: The Water Cycle" at http://ga.water.usgs.gov/edu/watercyclesummary.html

VALUE OF CLEAN WATER

The value of anything is only what people are willing to pay for it or are willing to give up for it. Water is life. Water is wealth. Right today, oil is the root cause of many economic discussions and most probably the cause for many battles and wars. In the future, we could very well see wars raged over the ownership of water.

In the developed countries, water is taken for granted because it's cheap and readily accessible; however, because it's priceless it should not be seen this way. There is a surprising connection between the quality and availability of water and healthful longevity of life. All over the world and throughout time, wherever you find the cleanest, drinkable water, you find a healthy, vibrant group of people. With our body being more than 70% water and the fact that water controls virtually every aspect of our life; we can begin to understand its importance.

"Water use increased six-fold during the 20th century, more than twice the rate of population growth. While water consumption in industrialized countries runs as high as 100 gallons/per capita/per day in the United States and 34 gallons/per capita/per day in Germany, in developing countries 5 – 7 gallons/capita/day are considered enough to meet basic human needs."[2]

"The U.N. Children's Fund says bad water and lack of proper sanitation is killing more than 1.5 million children under age five every year. A new report by UNICEF shows the world, generally, is on track to meet the U.N. goal of halving the number of people with unsafe drinking water by 2015, but will miss a similar goal for sanitation." [3]

As stated in a World Health Organization study, water can lead to great economic development for any region of the world. "Improved water supply and sanitation and water resources management boosts countries' economic growth and contributes greatly to poverty eradication. The required financing for improved water supply and sanitation and water resources management is a sound public and private investment strategy that boosts economies and that allows individuals and households to explore new livelihood opportunities as well as businesses to increase productivity and production and venture into new markets. Investments in the water sector – sanitation in particular – must be acknowledged for the economic benefits they generate. Seen this way, the economic benefits outweigh costs considerably." [4]

At the "International Emerging Technologies Symposium, August 19 & 20, 2008, Kamal Khokhani of Akar Info Media stated that India, as a country, at 1.1 billion persons and growing, has 16% of the world's population but yet only 4% of the world's fresh water. He stated that by the year 2020 that fresh water supply will run out if conservation and water efficiency measures are not implemented immediately.

[2] "Fact Sheet on Water and Sanitation" World Health Organization at www.un.org/waterforlifedecade/factsheet.html

[3] "UN: Poor Water, Sanitation Kills 1.5 Million Children a Year" by Lisa Schlein, Geneva 9/28/06

[4] "Water Sanitation and Health" – "Making water a part of economic development" by M. Sanctuary, H. Troop and A. Berntell, Stockholm International Water Institute (SIWI), Sweden and Ms. L. Haller, Dr. J. Bartram and Mr. R. Bos, WHO and H.O. Ibrekk, Norwegian Agency for Development Cooperation, , 2005

TYPES OF POTABLE WATER SYSTEMS

There are many types of water delivery systems. All have some good points and many have bad points.

- Municipal systems that receive their water from lakes, rivers, steams and reservoirs. These systems typically have filtration plants with an underground distribution system of piping, valves, pumps, etc. These types of systems are found throughout the developed countries of the world.

- Municipal systems that receive their water from aquifers (ground water) and deep wells (bores). These aquifers can be quite large, some being quite deep with others closer to the surface called surficial aquifers. These surficial aquifers are very vulnerable to contamination by pollutants (fuel spills, landfill discharge, industrial discharge, and saltwater) that can leach through the shallow limestone bedrock.

- Private wells (bores) can provide a water supply to a residential or commercial building or buildings. These systems are typically maintained by the user although the regional governmental agency or health departments, in some instances, are responsible for the quality of the drinking water. These wells (bores) are normally classified as shallow, less than 100 feet (30.48 meters) or deep. A deep well (bore) is generally considered to be a better source of water since it is less susceptible to contamination and the depth of the aquifer usually fluctuates less than the water in a shallow well. Well (bore) water is usually satisfactory for drinking because of the natural filtration created as the water passes through the geological formations. However, when there is an excess of dissolved minerals or gasses, treatment of the water becomes necessary.[5]

- In the undeveloped regions of Africa, India, Central America and China water sources are often a mile or more walk away and are usually muddied and undrinkable. There are many organizations that are drilling wells (bores) in these communities to provide good quality drinking water.

- Cisterns can be utilized to hold surface water, rainwater catchment or hauled in potable water. A cistern is a tank (usually underground) made of concrete, steel or plastics. Cistern water must have continuous chlorination for domestic water potable use. Cisterns may be the logical alternative for communities at higher altitudes since it becomes difficult to access the water table by drilling wells (bores) and pumping the water.

According to Sudhakaran Nair, President, Indian Plumbing Association, cisterns, both elevated and underground, have been in use in India for centuries and are still common place today. With the supply of clean water from the mains being intermittent, it is necessary to store water for use during those times when water is not available form the mains.

[5] American Society of Plumbing Engineers, Plumbing Engineering Design Handbook, Volume 2, Chapter 9 by Tim Smith, CPD

WATER TREATMENT

"The most simple and basic water treatment used around the world today is essentially not much different than that developed during the Roman Empire. Unfortunately, the ancient Romans knew nothing about many of the demands on today's water systems, such as how to treat waste from toilets, hospitals, laboratories, and industrial facilities. Combining extremely dirty waste from water closets with moderately dirty water from showers and sinks with clean rainwater and very clean air-conditioning condensate creates large volumes of wastewater that is only as clean as its dirtiest source."[6]

Primary water treatment differs based upon the source water. When the source is a lake, river or stream, etc., the water first passes through a screening process to remove fish and other large items. Then depending on the quality of the water, the source water passes through a series of treatments that can include aeration to remove undesirable gasses such as carbon dioxide, hydrogen sulphide and methane, clarification to reduce turbidity, filtration using deep bed sand filters to remove coarse suspended particulates, taste and odor control, introduction of fluoride and finally disinfection by means of chlorination.

Municipal systems that are supplied from aquifers and wells (bores) may or may not require many of the same treatments as above. Private well (bore) systems serving one residence, business or facility are usually satisfactory, without treatment, for drinking water because of the natural filtration by the geological formations that the source water must pass through. An excess of dissolved minerals or gasses in the source water can make treatment of the water necessary to make it drinkable. One of the most common problems with well water is hardness caused by an excess of dissolved calcium and magnesium. This can easily be remedied by a water softening process.

Depending on the use of the water, no matter what the source, further treatment may be necessary to increase the purity. These can include ultraviolet disinfection, distillation, deionization and reverse osmosis.

[6] "Reinventing Plumbing Technology to Meet Tomorrow's Needs" by Winston Huff, CPD, LEED AP Plumbing Systems & Design, July/August 2008

DESALINATION

Generally desalination is related to the process of removing dissolved minerals including salt from seawater but the same process could also be used for other salty or brackish water. The process is expensive and energy intensive when compared to capturing fresh water flows in dams or tapping below ground aquifers with wells (bores) and pumps. Of a number of desalination methods the two most commonly used for large scale municipal water supply are the thermal (distillation) method and reverse osmosis (RO).

Thermal distillation is the method where the feed water is heated to produce water vapour; the water vapour is then cooled to collect the distillate as clean water. Multi-stage flash distillation is the most popular method for large scale production. The world's largest plant, using multi-stage flash distillation, is in the United Arab Emirates and is capable of producing 300 Million Cubic Metres of fresh water a year. The distillation method uses more energy than the RO process and for this reason many distillation plants are co-located with other processes such as power stations where cheap electricity is available and the excess heat generated may be harnessed in the distillation process.

In the Reverse Osmosis process, seawater (or other feed water) is forced under high pressure through a membrane, removing salts and impurities and producing water suitable for drinking on the outlet side of the membrane.

Benefits:

- Unlimited supplies for communities on ocean coastlines.
- Not climate dependant.
- Depending on size and type of plant, production may be regulated to suit demand.
- Desalination does not impinge on the land environment in the way that major dam construction does but disposal of waste product such as the hyper saline discharge from the process requires careful consideration of the environment.

Energy Efficiency:

Although Reverse Osmosis technology has in itself become more energy efficient over recent years it is still a large user of electric power. The thermal distillation process unless co-located with other compatible processes is less energy efficient than the RO process.

Generation of electric power by renewable energy will reduce the environmental footprint of desalination but it will remain vastly less energy efficient than collecting rainwater in dams or even pumping ground water from deep aquifers

Disposal of by-products:

Disposal of the hyper saline waste water or brine into the ocean is relatively safe but care must be taken to adequately defuse the outfall so as the brine is suitably diluted without forming a plume of salt laden water that will not readily disperse. A careful study of prevailing currents must be undertaken to establish the most advantageous location for the outfall so as not to allow increased salinity levels to deplete oxygen levels in the area.

Disposal of saline waste water at inland locations presents further risks to the environment, depending on the size and type of desalination plant lined evaporation ponds could be used.

For seawater desalination the feed water intake must also be considered for its environmental impact on marine life from fish down to the smallest plankton.

Interest in desalination emerged at least as far back as the 1700s. As the United States Secretary of State, Thomas Jefferson considered a plan in 1790 to install desalination systems on ships, and a British patent was issued in 1852 for a desalination device. The first desalination plant on land was built on the island of Curaçao in the Netherlands Antilles in 1928. Saudi Arabia built its first plant in 1938.

Worldwide desalination capacity has gradually grown from almost nothing in 1960 to about 9.5 billion gallons (36 million m^3) per day in 2005, according to the Pacific Institute, a California-based think-tank focused on water issues. Half of this capacity is in the Middle East, where inexpensive energy makes the process more feasible; the U.S. is also one of the largest users of desalination.

While early desalination plants relied on evaporation and condensation (and many in the Middle East still do), most new plants rely on reverse osmosis (RO), a less energy-intensive technology using selective membranes. The largest desalination plant in the U.S. today—run by Tampa Bay Water, Florida's largest wholesale water supplier—produces about 25 million gallons (95 million l) per day using an RO system.

Desalination also produces brine with about twice the salinity of the source water. The concentrated brine also often contains elevated levels of constituents found in seawater, such as manganese, lead, and iodine, as well as chemicals from urban and agricultural runoff. When brackish groundwater is desalinated, the resultant brine is usually deposited into evaporation ponds, reinjected into the ground through deep wells, or piped to the ocean.

When seawater is desalinated, the brine is usually piped some distance out to sea, though it may be mixed with treated wastewater or power-plant cooling water first. If it is not diluted first, the desalination brine is denser than seawater, so it sinks, creating plumes of higher-salinity seawater on the ocean bottom—where sea life is concentrated.

WATER EFFICIENCY

Products & Conservation

Around the world there are many schemes to assist or enforce conservation of water supplies. The drivers for these schemes are many and include:

- Reduced runoff into municipal dams due to changing weather patterns.
- Population growth in areas with limited facility to increase water supply capacity.
- Reduced river flows due to increased irrigation of intense cropping for food production.

Advances in engineering and design are allowing household appliances and plumbing fixtures to operate on much reduced water flows thereby conserving water without loss of amenity to the user. Water efficiency or conservation schemes may target domestic/household use, commercial/industrial users or garden, crop and landscape irrigators.

Reduction in water use by crop irrigators may be as simple as providing timely and accurate weather forecasts coupled with ground moisture sensors and sensitive irrigation systems able to be easily and even remotely programmed to provide precise amounts of irrigation water only when needed. For systems that utilise open channels to convey irrigation water vast amounts of water is lost to evaporation, this may be reduced by covering the open channels or replacing them with pipes.

Urban dwellers often use water from the municipal drinking water supply to irrigate their gardens. Water conservation measures include grouping plants in zones depending on the amount of water they require and adjusting irrigation water delivery to suit each individual zone's requirement.

Inside the home the installation of water efficient fixtures, fittings and appliances may be mandated by government and water supply authorities. One such scheme introduced by the Australian Government in 2006 is the Water Efficiency Labelling and Standards (WELS) Scheme. Under this scheme, product suppliers are required to provide water efficiency information, and star ratings, to consumers for a range of products such as clothes washers, dishwashers, showers, taps, toilets, urinals and flow controllers. Industry must register these products with the WELS Regulator (a government department). The scheme is funded by the industry registration fees and contributions from Australian federal, state and territory governments.

Commercial/Industrial water users are encouraged to conserve water used in production processes by recycling waste water. Process water may be treated to reuse within the process cycle or partially degraded water may be used in other parts of the process or for such uses as dust suppression, truck and equipment washing or landscape irrigation. Staff amenities and washrooms may be fitted with water efficient plumbing fixtures to conserve water." [7]

In addition to the *WELS* programme in Australia, several other countries have introduced or are considering water efficiency labeling for products as a cost effective way of influencing purchasing decisions and changing consumers' water usage patterns.

"In the UK, *Waterwise* has launched an annual water efficiency marque to help consumers choose better products. A select number of *Waterwise Marques* will be awarded each year to products that demonstrate superior performance. WPC member, the Bathroom Manufacturers' Association (based in the UK) has also launched a Water Efficiency Product Labelling scheme.

The five Nordic nations – Denmark, Norway, Sweden, Finland and Iceland – have adopted the *Nordic Swan* eco-label, which is used to indicate that a product is a good environmental choice and to encourage manufacturers to develop environmentally friendly products and processes.

In Ireland a scheme to promote water conservation and help consumers to make informed purchasing decisions has been launched by the City of Dublin in collaboration with the Dublin Region Water Conservation Project. The voluntary *Water Conservation* label has been developed as a pilot scheme and initially covers dishwashers and washing machines. It is a unique scheme in that it has been introduced at a city level rather than across the country." [8]

The United States Environmental Protection Agency (USEPA) has implemented a partnership programme named Water *Sense* that makes it easy for American end users to save water and protect the environment by choosing efficient products. Its mission is to protect the future of the nation's water supply by promoting and enhancing the market for water-efficient products and services.

There's a reason that water has become a national priority in the US. A recent government survey showed at least 36 states are anticipating local, regional, or statewide water shortages by 2013. But by using water more efficiently, the aim is to help preserve water supplies for future generations, save money, and protect the environment.

If all U.S. households installed water-efficient appliances, the country would save more than 3 trillion gallons of water and more than $18 billion dollars per year! Also, when water is used more efficiently, the need for costly water supply infrastructure investments and new wastewater treatment facilities is reduced."[7]

"It takes a considerable amount of energy to deliver and treat the water you use everyday. American public water supply and treatment facilities consume about 56 billion kilowatt-hours (kWh) of electricity per year—enough to power more than 5 million homes for an entire year. For example, letting your faucet run for five minutes uses about as much energy as letting a 60-watt light bulb run for 14 hours.

By reducing household water use you can not only help reduce the energy required to supply and treat public water supplies but also can help address climate change. In fact:

- If one out of every 100 American homes retrofitted with water-efficient fixtures, we could save about 100 million kWh of electricity per year—avoiding 80,000 tons of greenhouse gas emissions. That is equivalent to removing nearly 15,000 automobiles from the road for one year!

- If 1 percent of American homes replaced their older, inefficient toilets with WaterSense labelled models, the country would save more than 38 million kWh of electricity—enough to supply more than 43,000 households with electricity for one month.

Depleting reservoirs and groundwater aquifers can put water supplies, human health, and the environment at serious risk. Lower water levels can lead to higher concentrations of natural contaminants, such as radon and arsenic, or human pollutants, such as agricultural and chemical wastes." [8]

[7] "Appliance Labels Deliver Savings in the Home" World Plumbing Review, July 2007
[8] www.epa.gov/watersense/

"Promoting water efficiency is a simple yet highly effective way of reducing water consumption which will have a wide range of knock-on environmental effects. Greater water efficiency could lead to a significant cut in water usage which would then have the added benefits of reducing energy consumption and therefore play a major role in reducing the overall carbon emissions of the sector." [9]

[9] "The Future of the UK Water Sector" All Party Parliamentary Water Group

INFRASTRUCTURE

The ageing infrastructure of underground water service piping in the developed nations allows for an unbelievable amount of clean drinking water to leak each and every day. This leakage is not only wasting our precious water supply but also adds to the waste of the imbedded energy that it took to treat this water.

"The world's limited supply of fresh water requires careful management. Yet according to the 2005 Report Card for America's infrastructure, prepared by the American Society of Civil Engineers, 'Each day, 6 billion gallons of clean, treated drinking water disappears, mostly due to old, leaky pipes and mains – enough water to serve the population of a state the size of California.'

Some of the factors contributing to the leakage include inadequate corrosion protection, older mains, faulty installation, material defects, excessive water pressure (and objectionable pressure surges), ground movement due to extreme weather conditions, and excessive loads and vibration from road traffic. When leaks prevent water from reaching end consumers, utilities lose revenue and incur unnecessary costs.

Because leaks follow the path of least resistance, leakage will often escape attention by flowing into an underground pipe such as a sanitary sewer, storm sewer, abandoned line or other subterranean geological structure." [10]

[10] www.waternetsurvey.com/Home.html

WATER REUSE

RAINWATER HARVESTING

"Rainwater harvesting has numerous means of collection and the harvested water has numerous uses. Rainwater harvesting may be simply contouring the ground to direct excess runoff to a dam for future use in irrigation of crops or for the watering of animals such as sheep and cattle. Water harvested in this way may also be directed to maintain wetlands or lakes so as to maintain the biodiversity of an area possibly surrounded by a built environment.

Rainwater harvesting on the large scale is the catchment areas for municipal dams supplying drinking water to large cities. Small Towns and Villages may utilise a sloping hillside suitably paved with impervious materials or large natural rock outcrops with suitable kerbing installed to direct the rainwater to a collection point for piping to the community water supply via dams or tanks. In all these cases the collection area must be kept clean and should be fenced to prevent straying livestock from fouling the area.

Rainwater harvested for use by individual households is usually collected from the dwelling roof and directed into tanks through roof gutters and pipes. Treatment of stored water at individual levels needs to be looked at.

Storage of Rainwater

Health Aspects of Plumbing has this to say about rainwater storage tanks: "*When rainwater is stored for domestic use the tanks should be of water-tight construction, covered with material that is weatherproof, insectproof and verminproof, ventilated and supplied with access for regular inspection and cleaning*"[11].

Treatment of Rainwater

The first important step in any rainwater collection and storage system is to maintain a clean catchment and collection system. The use of "first flush devices" on collection pipework allows the first portion of rainfall to flush the catchment area without entering the storage system.

"In rural areas for rainwater collected and stored in a clean environment it may be only necessary to boil water for use in food preparation or drinking, this may be more important for the very young or the elderly and persons with compromised immune systems such as those who are HIV positive or suffering from diabetes and the like." [12]

Disinfection of Rainwater Systems

Rainwater can be disinfected by chlorination, ultraviolet light irradiation or by boiling.

Chlorination

Regular chlorination of rainwater held in domestic tanks is not considered appropriate in most cases and is generally only recommended as a remedial action. The effectiveness of chlorine is short lived and it will only act on water in the tank at the time of dosing. Fresh run-off into the tank after chlorination will probably not be disinfected.

[11] Health Aspects of Plumbing, World Health Organization, 2006
[12] Acknowledgement to the Commonwealth of Australia – Health Council

Ultraviolet light irradiation

Ultraviolet (UV) light irradiation can be used to provide continuous assurance of water quality. UV light systems require relatively low maintenance and have the advantage of not involving addition of chemicals. The UV light could be installed in pipework delivering water from a tank to a dwelling or selectively to taps used to supply water for drinking and food preparation. UV light systems could be particularly suitable for community supplies.

Boiling

While rainwater should be safe for most people to drink, at times the microbial quality may not be as high as reticulated water supplies. People with lower immune responses, such as the very young or very old, cancer patients, people with diabetes, organ transplants or those who are HIV positive, should consider boiling the water before consumption.

Corrective action to improve microbial quality

Although there have been isolated reports of illness associated with consumption of tank rainwater, for most people rainwater from well maintained roof catchments and tanks represents a relatively low risk of illness.

If it is suspected that rainwater is contaminated or if additional precautions are sought in the event of illness, water used for drinking and food preparation could be boiled or the tank rainwater could be chlorinated.

GREY WATER SYSTEMS

Grey water systems separate and treat the wastewater from showers, clothes washers, sinks and similar fixtures for reuse as flush water for toilets and urinals, for irrigation and for limited industrial and ornamental uses. These systems require that proper installation methods are followed and require the involvement of the local authority having jurisdiction. The property owners are typically responsible for maintaining the systems in a safe and efficient manner. The prevention of a cross connection between a grey water and a drinking water system is of primary concern.

Storage of grey water should not be for long periods of time because the water usually contains a significant amount of organic matter that can begin to decompose over time causing odours and other concerns.

"Today, the ecological movement has become the mainstream of design, and 'green' architecture and engineering is all the vogue. Water has become a scarce and costly commodity everywhere, with water costs often exceeding electricity charges in major cities worldwide. More importantly, *everyone* is aware that conservation is essential in safegaurding our limited natural resources.

Grey water systems are dual water supply systems which capture, treat and recycle a portion of the waste water flow for use as a secondary, non-potable water supply in a building. This approach has the potential of reducing the total fresh water requirement by up to 50% and the overall sewage water flow by even more.

The early promise of grey water systems is being realized with many successful installations already in operation. As the drive for Green Engineering gains momentum, this engineering solution will gain importance. The current revolution in materials science will allow the development of new and improved treatment processes which will accelerate the application of these systems.

Grey water is a useful tool for solving water supply problems, a concern in even the most formerly 'well-watered' areas. The problem of public acceptance, an important consideration a decade ago, has been largely overcome. The main issue today is innovative engineering to improve economic feasibility. This leaves much latitude for excellence." [13]

Possibly, one the most difficult tasks ahead of the plumbing community concerning grey water systems is in educating the consumer that grey water is not grey. As well accepted as the term grey water is to the plumbing community, it may be time to coin a new term to put the stigma of grey behind us.

[13] "Grey Water Revisited" by Valentine Lehr, P.E., HPAC Engineering

SANITATION

"The lack of proper disposal of human waste is the biggest killer of infants and children in the world. This lack of sanitation degrades every aspect of their lives – health, social, economic and especially education.

In September 2000, the United Nations set eight Millennium Development Goals (MDG) to welcome the new millennium to be reached by the year 2015. The plumbing community is directly involved with two issues within the MDG's Target 10; the lack of access to clean, drinkable water and the lack of basic sanitation." [14]

The primary objective of any sanitation system should be to protect people and promote human health by eliminating sanitation related disease and at the same time, providing for a clean environment.

In 2000, several practical principles for successful sanitation were developed. They included principles that get to the core of the need. First, any approach to sanitation should center on human dignity, quality of life and environmental security at the household level. Next, all stakeholders should be involved, especially consumers and service providers. Waste should be considered a resource in the sense that it contains nutrients, fuel value, water-extraction and it should be handled to form a holistic management approach that integrates all of these items. Finally, in order to resolve environmental sanitation problems, the domain charged with solving the problem should be kept to a minimal size to better be able to manage, such as, household, community, town, city, county, district, etc.

[14] "Global Costs of Attaining the Millennium Development Goal for Water Supply and Sanitation, Guy Barton and Jamie Bartram, Bulletin of the World Health Organization, January 2008

SEWAGE TREATMENT

There are many types of sewage collection and treatment systems available today; from the most complicated that treat human waste for millions of urban dwellers to personal single treatment units that separate and process urine for fertilizer while isolating methane gas from the solids and utilising it for cooking needs.

It is extremely important to observe the basic criteria of sustainability when planning and then implementing a system for safe practical sanitation. Basically, sanitation treatment facilities can be classified in one of two ways; improved or unimproved.

UNICEF and WHO [15] have designated improved sanitation facilities as those that are not shared by others or those that are not considered public facilities. The most common types of improved systems are flush-type or sometimes referred to as pour-flush systems. Often they have fully piped systems to remove the waste and deposit it into pits or septic systems but not always. Pit latrines with slabs or without, whether improved-vented or not also fit into this category. Composting toilets and the like would also be considered improved.

Unimproved facilities vary in design but most are variations of the above listed improved type. Unfortunately they are missing one or more of the most important and critical elements that make them safe and environmentally sound, the collection and treatment of the waste. The excreta is flushed elsewhere but not actually flushed away. In other words, it is deposited in streets, ditches, open waterways and rivers. In many instances there are “hanging toilets” which describe facilities positioned over waterways and discharge directly into such waterway.

When designing an improved system or attempting to improve an existing system, several factors should be considered in whole. It is difficult to enhance or improve the system completely if all of these elements are not adhered to. ***Health, economic issues, environmental impact, social acceptance*****, and** ***functionality*** all are critical factors to consider.

Health, of course is key and the original purpose of such discussion. Protecting the current health of the public while improving the health of the target individual should be the ultimate goal of any sanitation system. This includes taking a careful look at the system from beginning to end--in other words, from the deposit into the collection device all the way through to the point of disposal or possible reuse. Finally, improving living conditions and downstream effects are paramount in developing a sustainable scheme.

The ***economics*** and financial impact of developing a system is also a key component of its success. This takes into account the feasibility of the community and individuals in the local economic region to pay for costs associated with sanitation system construction and maintenance costs. Although costs associated with the original investment, operation and maintenance must be calculated, consideration for the economic benefits must also be taken into account.

The preservation of the ***environment*****t** and its resources are another key component when developing a successful sustainable system. The effects the design will have on natural resources and the environment such as water usage, energy waste, natural landscape preservation, local materials for construction, potential emissions from construction and operations, and the possibility to recycle and reuse materials all are important considerations and must be accounted for. It can be as simple as returning recycled water back to the local environment or a calculation that trades the use of local wood for fuel for the return of some sort of biogas such as methane produced from solid excreta.

Social and cultural acceptance is another critical aspect. It must be appropriate for gender - related issues within the local culture. People are at their most vulnerable state when defecating

[15] United Nations Children’s Fund and World Health Organization

so safety and human dignity factors should also be taken into account. The new “culture” must have community acceptance and an education program explaining the benefits of such a different habit is crucial.

Functionality and technology is important. The ease of the system to be constructed with local materials, not to mention the human resources requirement of those charged with the day-to-day operation, maintenance and system monitoring must be incorporated. Local infrastructure and utilities already in place and their ability to adapt are crucial elements.

Although it is critical to take into consideration the elements just described above to attempt to construct a completely sustainable program, it is unlikely that a totally sustainable system exists for the very same reason. For instance, when considering the cultural and socio-economic element, it may not be accepted to utilize a particular construction method or material for religious reasons so a trade-off is made. There is no one-size-fits-all solution and a sincere attempt to provide a sustainable system must be made adhering as closely as possible to the five elements listed.

WASTE WATER TREATMENT & POLLUTION CONTROL

The most obvious method to control disease spread from waste and wastewater is to treat it properly utilising known principles to control deposit, transmission, treatment and reintroduction of treated human waste into the environment.

A proper system consists of a combination of processes that remove a large portion of the pollutants and disease-causing organisms in wastewater. The solid materials are filtered from the rest of the wastewater. The wastewater proceeds through a filtration, biological and chemical process. The sludge is treated by applying lime or chemicals, and dried. It is then burned, buried, disposed of in the ocean, or used as fertilizer. The liquid waste can be added to soil where most of the pollutants are, either removed, inactivated or filtered out before returning back to the groundwater. Usually the final step is to disinfect the wastewater being discharged from treatment facilities into surface water or groundwater.

Another critical component of safe environmentally sound sanitation systems is the network of piping that serves as the conduit to remove the soiled wastewater from its point of origin to the wastewater treatment facility or system. Properly installed plumbing systems utilising current design principles, an experienced and highly trained work force, certified products meeting the highest performance and product standards inspected and enforced by professional authorities make up the framework of a successful system.

Pollution Control is another facet of a sustainable system. Pollutants from rainwater collection systems, flooding, irrigation, storms and disasters cause debris, chemicals, fuels, contaminates and more to be forced into the ground and surface waters.

In order for the system to be sustainable it must be economically viable, accepted socially and culturally and also technically appropriate for the intended outcome. Affordability and acceptance can be easily overcome. It is when we add the final criteria of protecting the environment and the natural resources that it becomes a difficult task.

DRY DRAINS

A considerable amount of space within this paper is devoted to water conservation, water efficiency and other water saving practices. All of which are very good. But, all of this conservancy comes with a price - "dry drains". With the advent of low flush water closets and urinals, waterless urinals, low flow faucets and shower heads, water reuse systems and the various governments, around the world, pushing for water savings strategies, the subsequent waste water flow into the drainage system has been and will continue to be drastically reduced. So much so that many studies have been under way to look at the effects of this lower flow on the entire system. Not only within the internal plumbing systems of a building but also the external infrastructure serving that building.

The Australian and New Zealand Plumbing Regulators Forum (NPRF) met in 2007 to develop a study program to consider these issues of reduced flows and the effects on the drainage systems. "The Advisory Committee Chairman, Jeffrey Clark, who represents the South Australian Water Corporation, believes that some intervention is justified. 'We are concerned that if flushing volumes of fixtures are further reduced, there could be implications for our internal plumbing systems as well as the external infrastructure.' This would affect the way Australian standards are written – they could need to be substantially changed.

Plumbing regulators are dedicated to conserving water. However, Clark and other regulators also want to ensure that plumbing systems are not causing blockages that can lead to overflows and adversely affect the public health and the environment.

Other countries were facing similar problems.

Germany, in particular, has reduced its flow rates and water consumption to almost half the level of a typical Australian dwelling.

There is concern among the general community in the United Kingdom regarding government water containment initiatives. *Waterwise UK* head of research, Joanne Zygmunt, says sewers in many places have to be flushed with substantial amounts of water because flows from dwellings are insufficient. The UK Environment Agency is due to release a report title "Less Water to Waste: The Effects of Water Efficiency on Wastewater Flows". It is hoped it will shed light on water conservation methods and their effect on infrastructure.

The possibility of blockages, pungent odours and drain damage doesn't bode well for future water reductions, yet the results of test trails are still at least 18 months away and it would be prudent of any agency thinking about reductions to rethink its stance until all the evidence is in." [16]

[16] "Time For A Gravity System Redesign?" World Plumbing Review, March 2008

ENERGY EFFICIENT BOILERS

Traditional boilers account for 60% of all domestic carbon emissions. An energy efficient boiler, more commonly known as a high efficiency or condensing boiler works by retaining as much waste heat as possible which would otherwise be lost into the atmosphere from the more traditional flue of a convectional type boiler.

The condensing type boiler manages to utilise as much heat as possible by the extra large heat exchanger which in effect maximises the heat transferred from the burner whilst recovering as much heat as possible, which would otherwise be lost through the flue gasses.
As the flue gas temperature is reduced the droplets of water formed fall by gravity to collect at the base of the flue manifold. From here a condensate drain allows the liquid to run off and the remaining gases are expelled to the outside environment through a fan assisted balanced flue.

SOLAR THERMAL SYSTEMS

Solar Thermal Heating systems use solar panels, commonly known as collectors, and are usually positioned to receive the maximum available sunlight. They absorb heat from the sun and use that collected heat to warm water which is stored in a hot water cylinder, usually to around 60°C (140º).

Solar collectors are often mounted on a roof, although, the installation and design vary from country to country; they all make use of the same principles.

Solar thermal systems are generally designed to meet 90% of the heating demand in the period of highest resource (summer) when little space heating is required, and typically 50% of the heating demand averaged over the year.

HEAT PUMPS

A heat pump is a mechanical device that moves heat from one source to another location. Heat tends to flow naturally from a higher to lower temperature. A heat pump reverses this flow, by extracting heat energy from a cool source, a perfect example being the ground, and delivering the absorbed heat to a heating system for distribution.

Using the same mechanical principles as a refrigerator, in extracting heat from the inside of a refrigerator which keeps food at your chosen temperature, a heat pump absorbs heat from a source.

This source could be:

- Soil
- Ambient air
- Lake water
- Ground Water
- River Water
- Seawater
- Rock
- Wastewater etc.

A heat pump uses the concentrated heat to provide space heating and domestic hot water. Some air-source heat pumps do not work as well when temperatures fall below -5°C.

BIOFUEL UTILISATION

Biofuels are any liquid, solid or gaseous fuels produced from organic matter.

Biofuels are made up from living organisms or from what's known as metabolic by-products (food waste products and organic waste products). In order for a Biofuel to be classed as a Biofuel it must contain over 80 percent renewable materials. It is originally derived from the photosynthesis process and can therefore be referred to as a type of solar energy source.

Below is a list of Biofuel examples:

- wood, wood chippings and straw
- pellets or liquids made from wood
- biogas (methane) from animals' excrement
- ethanol, diesel or other liquid fuels made from processing plant material or waste oil

BIOMASS FUELLED SYSTEMS

Biomass, a renewable energy source, is material originally from living, or recently living organisms for example:

- wood, wood chippings and straw
- pellets or liquids made from wood

Biomass is a type of plant matter commonly known to produce heat energy. For example, dead trees, branches, sawdust, yard clippings and wood chippings and garbage may be used as biomass.

However, biomass can also include plants and animal matter used for the production of chemicals. It can also contain biodegradable wastes that could well be burnt as fuel. It does however exclude organic materials such as fossil fuels.

In terms of installation and running costs, biomass has probably the lowest capital cost of all renewal energy technologies. Wood fuel is also a carbon neutral resource and can make a significant contribution to meeting the commitment to reduce CO2 emissions.

COMBINED HEAT & POWER UNITS

Combined heat and power is the simultaneous generation of both usable Heat and Power in a single effective process. The process is a very effective and efficient way of utilising both fossil and renewable fuel which aids in sustainability in the long run in meeting goals and providing new means of a secure energy source.

A CHP system in its most common form consists of a gas turbine, an engine or a steam turbine to drive an alternator which produces electricity to be used either wholly or partially on site. This heat produced is recovered in what's most commonly known as a heat recovery boiler and steam can be raised for many other uses within the industrial sector to either provide water for space heating or with additional equipment cooling.

CHP systems can be large-scale, mini-CHP, or micro-CHP. The larger and mini systems, for industrial application and for use in small organisations such as hospitals, schools and community centres or grouped households, have proven track records (especially in parts of Europe). The micro-CHP systems, which would be applicable to domestic users in individual households still need further development and must be widely acceptable to the public.

CROSS CONTAMINATION & MISCONNECTIONS

Cross connections allowing contaminated or polluted water to flow back into the drinking water are the scourge of clean drinking water systems. The fact that water can backflow from a source of contamination/pollution has been known for more than a century, yet, cross connections are still very commonplace. In the US alone, over 10,000 incidents of backflow contamination are reported every year. Who knows how many incidents are not reported.

The risk to health caused by a cross connection is totally dependant on the level of pollution or contamination of the liquid flowing back into the drinking water source. This risk may be minor where the person experiences flu-like symptoms or it can be fatal.

The simplest and most effective way to provide protection against backflow is by an air gap between the source of the drinking water (the faucet, valve or tap) and the place where the water can collect (a sink, bucket or a depression in the ground). There are many backflow prevention devices available that can be installed to protect the drinking water supply.

As mentioned much earlier in this paper, there is a limited amount of water available for our consumption (drinking and cooking purposes) and it is our duty to protect that water as best we can.

In the developed countries, cross connection control programmes must be implemented to assure that the correct backflow prevention devices are installed properly, tested as required by the agencies having jurisdiction and maintained properly. There is still a considerable amount of education needed in all sectors of the plumbing industry, especially on the residential front, to eliminate cross connections.

In the developing countries, it is just as important to protect the drinking water supply from cross connections. All of the resources of time, effort and money that are spent to bring drinking water to a village or community can be wasted with a simple cross connection. It's as simple as installing a hose on a water spigot or tap, in some remote village, and having the hose be long enough to lie on the ground in a puddle below the spigot; if for some reason the water system is shut down and the spigot/tap is left open, the polluted/contaminated water can be siphoned from that puddle through the hose and into the drinking water system. When the pressure is restored, the first shot of water from the system will be that polluted/contaminated water to that spigot or tap. The simple remedy is that *air gap* mentioned earlier. Do not allow the hose to come in contact with the ground. This same scenario can and does happen repeatedly throughout the world in both developed and developing countries.

The answer to the problems with cross contamination and misconnections is **education.** We, as plumbing professionals, must do all that we can to educate the consumer to help us protect our limited supply of drinking water.

EDUCATION & CERTIFICATION

GREEN PLUMBING SYSTEMS

What makes a plumber or a plumbing system green?

"Plumbers have long held their mission to be protecting the health of the country," said Steve Lehtonen, spokesperson for *GreenPlumbers USA*. Because of climate change and global warming, our new mission is to protect the resources of the planet by training plumbers to be advocates and educators in environmental protection and conservation." [17]

GreenPlumbers USA is an accreditation programme that trains plumbers and enhances their skills and knowledge in water conservation, climate care issues and assists them in understanding their role in relation to environmental and public health concerns and issues. The training programmes also include instructions on how to provide the latest information on water and energy saving appliances and fixtures. It is intended to place the plumber in a better position to provide advice and information to consumers regarding these conservation measures.

This 32 hour program covers Climate Care, Caring for Our Water, Solar Hot Water, Water Efficiency Technology and Inspection Report Service.

Climate Care includes instruction on heating and cooling appliances, energy consumption and conservation and greenhouse gas emissions.

Caring for Our Water helps the plumber to understand the hydrologic-water cycle and covers the new technologies and behavior that result in water conservation. Some of the topics include water efficient fixtures, how to reduce household water consumption, storm water runoff pollution and prevention and an introduction to water audits.

The Solar Hot Water instruction includes the new technologies of solar water heating, rebate programmes, retrofit sizing and proper installation.

Water Efficient Technology covers recycled water; rainwater catchment; grey water systems; septic systems; wastewater treatment and the environmental, public health and safety regulations.

The Inspection Report Service is an introduction of residential and commercial auditing procedures, both water and energy including how to create a master plan for future improvements to the audited site.

GreenPlumbers USA is based upon the Australian model that has been in place since 2001. More than 5000 plumbers representing over 2100 businesses are certified to the program in Australia.

Including green plumbing systems in sustainable building design and increasing water efficiency provides economic, societal and environmental benefits. It can lower initial installation costs and reduce annual energy, water and sewage costs. It preserves our precious water resources for future generations and for use for agriculture and recreation while reducing the need to expand or build new potable water and wastewater treatment plants. Environmentally green plumbing systems lessen potable water use and the eventual waste water discharge thereby decreasing the strain on aquatic ecosystems and preserving water resources for wildlife and agriculture.

[17] "The Future of Plumbing is Green", Contractor magazine, February 2008

The green building systems discussed here can make very great inroads in the protection of our water resources. If these systems are employed we can reduce those 100 gallons of water used per person per day (USA) to a more manageable 25 gallons or less. However, if the infrastructure of our water supply system is not addressed this will virtually be only saving a drop in the bucket.

BASIC EDUCATION

Most developed nations have long established formal systems for the education and training of plumbers. These often include formal apprenticeships of around 4 years' duration involving comprehensive programmes of off-the-job and on-the-job learning leading to the achievement of nationally recognized plumbing qualifications. Post-qualification there are often regular updating training requirements and systems of Continuing Professional Development.

In some countries (such as the USA, Australia and New Zealand but notably not the UK). practising in the plumbing industry is regulated by law at either state or national level with various systems of licensing and registration.

In spite of this, there have been attempts in recent years to introduce short courses which purport to provide the new recruit with all the skills he or she requires to become a plumber. In the UK, for example, prompted in part by a recent shortage of appropriately qualified plumbing labour, there is currently a plethora of short courses (usually costing significant amounts of money). The shortest of these is 4 weeks!

Although it has to be accepted that technology, such as the use of plastic pipes and fittings, has to some extent reduced the skill requirements of the plumber, many plumbing organisations believe that the comprehensive set of skills required by today's plumbing professional (and more importantly the knowledge and understanding which underpins those practical skills) cannot be achieved in a few weeks or months. To some extent, politicians have contributed to these misconceptions about the plumbing industry.

If it is accepted that the plumber is a health professional, then a comparison can be drawn with the education and training requirements of other health professionals. Few would claim that a doctor or nurse can acquire all of their necessary skills and knowledge in a few weeks. Nor is that the case for the plumbing health professional.

Training programmes often prepare qualified individuals to meet local licensing, registration or certification requirements. Although licensing and registration is not applied in all developed countries, it is recommended as a means of ensuring that plumbing work is carried out professionally and in accordance with local legislative requirements. The appropriate licensing body can suspend or withdraw an individual's license to practise which acts as an important incentive for plumbers to do work in a competent and professional manner. It is suggested in "*Health Aspects of Plumbing*" that lack of regulation 'may contribute substantively to poor plumbing, especially in developing countries'. The resulting inference is that lack of regulation may mean that the real health benefits which plumbing can provide may not be experienced.

With the many emerging technologies that we, the plumbing community, are facing today and those that we will see into the future, we must be prepared to educate and train not only the plumbers (installers) but also the consumer or end users. Some of these systems are considerably more sophisticated than what we and the consumer is accustomed to seeing. The education of the consumer is most important to keep a system functioning properly. They must be instructed on the minor adjustments, when to change a filter or when and who to contact to ensure that everything is running properly. If the consumer doesn't understand how the device or system works, at the first sight of malfunction, they may remove the device or just condemn it as no good. At this point we would have lost all the good that the device or system was intended to accomplish, *i.e.* water efficiency or conservation. Education of the consumer can be a daunting and challenging task, but we must look at it as an opportunity to expand our own knowledge and experiences.

It really does not matter in what country a plumbing device or system is installed, if the technology is new to the consumer/end-user (whether it is a flow restricting device on a shower or faucet in a developed country or a simple spigot or sand filter in some remote village in a developing

country) we have a similar result if they do not understand how the device/system operates. Education is the key.

LEGISLATIVE & REGULATORY ISSUES

In the developed countries of the world, there are many local, state and national governmental agencies that control fresh water sources, treatment and delivery, and waste water management, treatment and disposal.

In the developing countries, clean water and sanitation are many times pushed aside when the time comes for policy-making, planning, budgeting or impletion. The correct political commitment is the first necessary ingredient.

Once the political commitment is made then the legislation and regulations must be implemented. "Creating the right types of legislation/regulations in support of extending sanitation and hygiene services and improving their quality is essential in the process of achieving targets and maintaining achievements. Legislation/regulations should create conditions that favour innovation (both in technology and in financing mechanisms); define cooperation between relevant stakeholders, including the private sector; allocate financial resources to capacity building and training, and to monitoring, implementation and maintenance. Consistent standards for sanitation and hygiene must be set across all other relevant sectors (for example, education, housing construction, workplace safety). Enforcement of enacted legislation/regulations is essential. Effective legislation/regulations will have both incentives for complying and sanctions for not complying with the requirements." [18]

[18] "Sanitation Challenge: Turning Commitment into Reality" World Health Organization at www.who.int/water_sanitation_health/hygiene/envsan/sanitchallenge/en/index.html

CONCLUSIONS

We are entering the most challenging and fascinating and rewarding period in the history of plumbing. We have the challenge of protecting the environment or, at the least, protecting the natural resources of the world's environment. What we do today and tomorrow as members of the plumbing community will influence the quality of life our children and grandchildren and their children will enjoy.

Some things that we must accomplish:

- Promote the recognition of PLUMBING as a core element in protecting the world's water supply through proper practices

- Take water efficiency and water conservation seriously and promote it everywhere starting at our own homes and businesses. The consequences are too costly to ignore any longer. We, as consumers also, must change those long entrenched habits of misuse of our clean and cheap water supply; and promote that message to all consumers.

- Realize, both as individuals and as a group, that providing clean water and proper sanitation will have a profound effect on human health and the elimination of poverty

- Join the "**GREEN WAVE**". Each of us can make a difference. Become knowledgeable regarding both water and energy conservation and then pass that knowledge on again and again.

- Learn how to do business differently – focus on which attributes to follow

- The KEY is Education and Training. We must educate the people in the developing countries to understand the very basic principles of keeping clean water clean; to understand the basic concepts of practical sanitation principles; to learn the basic maintenance skills to keep their clean water systems functional. We must educate the young people of the world that clean water and proper sanitation are basic to their survival and how they can attain sustainability.

- Embrace proven new technologies. Many can lead to sustainability. We must be able to sensibly discern those new technologies that save some water only to consume more energy, either in their construction or their use.

- We, as members of the plumbing community, must constantly exchange thoughts and ideas to continue to be the people that "**PROTECT THE HEALTH OF THE ENVIRONMENT".**

LIST of WRITTEN SUBMISSIONS

We wish to thank the following for providing their guidance and feedback during the research process. Some of the written submissions have been integrated into this paper in their entirety and others were excerpted into various sections of this paper.

The Role of the Plumbing Industry in Global Health by Robert D. Burgon, Chairman, World Plumbing Council

Green Plumbing Systems by Phillip J. Campbell, Training Specialist, United Association

Sections of the Executive Summary by Gary Evans, Technical Assistant, The Chartered Institute of Plumbing & Heating Engineering, UK

The Future of the Water Sector by All Part Parliament Water Group, submitted by Blane Judd, Chief Executive, The Chartered Institute of Plumbing & Heating Engineering, UK

Scoping Study to Investigate Measures for Improving the Water Efficiency of Buildings by Department of the Environment and Heritage, Australian Greenhouse Office submitted by John McBride, Director, Water and Energy Sustainability PTY Ltd., Melbourne, Australia *and* the WPC Liaison to the WPC/WHO Collaboration Project.

The sections on *Desalination, Storage of Harvested Water, Water Efficiency and Rainwater Harvesting* submitted from internet search by Stephen J. Movley, Institute Secretary, The Institute of Plumbing Australia Inc.

The sections on *Sanitation, Sewage Disposal. Lack of Waste Water Treatment & Waste Water Treatment* submitted from internet search by Jay Peters, Executive Director, Plumbing, Mechanical & Fuel Gas for the International Code Council

The balance of the paper quoted many articles, papers, publications and comments, all duly footnoted, along with much material gathered and paraphrased.

Appendix A

A Description of a Pro-Forma Report on Conditions in Your Country as a Case Study

- Choose a topic or topics from those listed below
- Describe the **current status** of the topic in your country. Give as much information and details as you can include: *i.e.* governmental issues, code issues, impact to the end-used (consumer), acceptance by the end-user, cost issues, etc. Describe any current initiatives or targets that are in place and the actual position of achieving that target.
- Add any changes **proposed over the next five years** that would impact the current status including any governmental targets or initiatives, legislative issues, code revisions, concerns from the manufacturers, etc.

For example:

In the UK the current water consumption is 150 litres per person per day and the current government target is 125l/p/d. *These facts along with any narrative concerning how the figures were determined would be included in the current status section of your report.*

The target to be reached by the year 2016 is 80l/p/d. There is no clear indication as yet how this figure will or can be achieved but there is an expectation that this will include grey water and rain water reuse. There is low penetration of these technologies within the UK market at the present time. *These facts along with any narrative would be included in the five year target.*

Topics:

Potable Water Treatment	Energy Efficient Boilers
Desalination	Solar Thermal Systems
Water Efficient Products	Heat Pump Technology
Infrastructure	Biomass Fuelled Systems
Rain Water Harvesting	Biofuel Utilisation
Grey Water Reuse	Combined Heat & Power Units
Sanitation	Cross Connections & Misconnections
Sewage Treatment	Education
Dry Drains	Licensing
Drainage	Legislative & Regulatory

Please include your Name, Organisation, Country and contact information. If you will be using direct quotations from other authors, please indicate with the appropriate footnote information. Submissions should be made to Richard Prospal: rjprospal@asse-plumbing.org