Chapter 2

2.2.1

Expanded definitions for and explanation of the MDGs:
http://www.un.org/millenniumgoals/ (Accessed 1/27/10)

1. Eradicate world hunger
   a. Halve, between 1990 and 2015, the proportion of people whose income is less than $1 per day.
   b. Achieve full and productive employment and decent work for all, including women and young people.
   c. Halve, between 1990 and 2015, the proportion of people who suffer from hunger.
2. Achieve Universal Primary Education
   a. Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.
3. Promote Gender Equality and Empower Women
   a. Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015.
4. Reduce Child Mortality
   a. Reduce by two thirds, between 1990 and 2015, the under-five mortality rate.
5. Improve maternal health
   a. Reduce by three quarters the maternal mortality ratio.
   b. Achieve universal access to reproductive health.
6. Combat HIV/AIDS, malaria and other diseases.
   a. Have halted by 2015 and begun to reverse the spread of HIV/AIDS.
   b. Achieve, by 2010 universal access to treatment for HIV/AIDS for all those who need it.
   c. Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.
7. Ensure environmental sustainability.
   a. Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources.
   b. Reduce biodiversity loss, achieving, by 2010 a significant reduction in the rate of loss.
   c. Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.
   d. By 2020 have achieved a significant improvement in the lives of at least 100 million slum dwellers.
8. Develop a global partnership for development
   a. Address the special needs of least developed countries, landlocked countries and small island developing states.
   b. Develop further an open, rule-based, predictable, non-discriminatory trading and financial system.
   c. Deal comprehensively with developing countries' debt.
   d. In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries.
   e. In cooperation with the private sector, make available benefits of new technologies, especially information and communications.

Below are two student responses to the question:

Millennium Development Goals:

The eight Millennium Development Goals are international targets to halve world poverty by 2015, agreed upon by all 189 United Nations member states at the UN Millennium Summit in 2000. Currently, almost 1 billion people do not have access to clean drinking water, and more than 2 billion lack adequate sanitation, which causes the unnecessary deaths of more than 4,000 people every day, mostly children under the age of five.

Access to clean water is desirable for several reasons: the improvement of health, the decrease of diseases, and the better taste of water. But there are a multitude of other reasons why access to clean water, and basic sanitation, is critical for a healthy global society.

Water, sanitation and hygiene education are crucial for poverty reduction and form the basis of a healthy, productive society. Without health and education, people will continue to remain poor and sick. Below is an outline of how the eight goals of the Millennium Development are related to water, directly or indirectly.

1/ Eradicate extreme poverty and hunger

First, water is necessary for the production of food, the personal consumption, and for sanitary reasons. It is impossible to eradicate poverty and hunger without providing enough water for the population. In fact, without water there are no crops. To reduce hunger, people must first have access to supplies of water in order to grow crops year round for food security.

Second, time-consuming water collection greatly contributes to poverty. The time people spend to look after the water could be used to work and earn money. Additionally, people who are forced to drink contaminated water suffer from diarrhoeal diseases that diminish the nutritional benefits of the food they actually eat. According to UNICEF, malnourishment affects a child's ability to learn and actively participate in school. Food deprivation provides a daily stress on children and stunts both their emotional and physical development.

Third, there are important side benefits from the availability of water thanks to wells and pumps. The excess water is often used for kitchen gardens which provide a sustainable source of vegetables to vary people's diets. The surplus crops can be sold at local markets thus decreasing poverty in the community as well.

2/ Achieve universal primary education

Women and young girls generally bear the responsibility of bringing water from distant wells and streams. When girls are forced to spend several hours each day hauling water, they don't have time to attend school or do their homework. Dropping out of school not only decreases their chances of getting a decent paying job, but it often contributes to an increase in the number of children they have. A lack of adequate sanitation facilities in schools also prevents girls from attending school. Convenient access to clean water and improved sanitation facilities in schools not only gives children time and an appropriate environment.

3/ Promote gender equality and empower women

In many cultures, water is a woman's responsibility. Usually, women have to spend their time and energy hauling water so they have little time for anything else such as furthering their education or getting training for a better job. Having a well closer to their home has an additional benefit to women. A closer distance is also safer for women who are very vulnerable. They risk to be raped every time they come back home in the dark. Women are also often the main actors in productive activities around the home that rely on water, like vegetable gardens, livestock, handicrafts, and services. Empowering women is critical to achieving more focused and effective water management.

Moreover, most of women know the locations of the wells, and are best placed to choose the right location of a new well. They could educate other women about hygiene and how to use best the water because they are able to talk to other women freely. Therefore, the third goal is related to water, and it would be very useful to incorporate women in important projects like water management.

4/ Reduce child mortality

Children are most vulnerable to the diseases that result from a lack of water, dirty water and poor sanitation. More children die from diarrhoea caused by drinking filthy, contaminated water than any other causes of death, including HIV/AIDS and the violence of war. According to UNICEF, about 4 billion cases of diarrhoea per year cause 1.8 million deaths, over 90% of them, or 1.6 million, among children under the age of five.
Thus, the access to clean water would reduce significantly the child mortality. Once again, water is very important to achieve this 4th goal.

5/ Improve maternal health

Water is very important to improve maternal health for two main reasons:
First, mothers who drink contaminated water are frequently malnourished and weak due to diarrhoea and parasitic diseases; women who have easy access to clean water are healthier, and are able to use improved hygiene methods that reduce the chances of post-natal infections.
Second, during pregnancy, women in developing countries still have to collect water and a lack of sanitation facilities means that basic hygiene practices cannot be carried out. After childbirth, women are often unable to wash themselves or the baby. Clean, accessible water and sanitation help women to minimise the chances of illness or even death to the baby or themselves.

6/ Combat HIV/AIDS, malaria,and other diseases

Although water-related diseases, associated with the lack of access to clean and safe water and sanitation have largely been eliminated in wealthier nations, they remain a major problem in many developing countries. There were on the order of 250 million cases of water-related diseases annually, excluding common diarrhoeal diseases.

For example, when the AIDS patients wash their pills with contaminated water, the anti-retroviral drugs are useless and nothing can help them. They will die of diarrhoea even with the best medication. Biological contaminants increase diarrhoea and diminish absorption of both the medication and the nutrients in the food they eat.
Access to clean water is also critical to preventing schistosomiasis, a chronic and debilitating waterborne disease common in Africa.
Furthermore, the risk of exposure to malaria-carrying mosquitoes is also increased when women and children have to get water from muddy, low-lying swamps.
Finally, some researches have revealed that clean water and sanitation assists HIV/AIDS sufferers. People contracting water-related illnesses are very likely to have compromised immune systems, which may cause them to succumb more quickly to the HIV virus and develop AIDS-related illnesses.

7/ Ensure environmental sustainability

One of the MDG target in goal number 7 is to halve the proportion of people without access to water and sanitation. This target will be focused in 17 countries in sub-Saharan Africa and South Asia which between them contain 30% of the world's population without safe water and 40% of the world's population without sanitation.
If people are forced to boil water to make it drinkable, they often have no choice but to cut down trees so that they can build a fire. As millions of trees get cut down every year to boil water the result is deforestation of the poorest regions of the world. Storm run-off from barren, deforested land is laden with bio-waste that ends up in the surface water in ponds and streams where people draw their water if they don't have a well. This increases the spread of waterborne diseases. If people had access to safe water, they wouldn't be forced to burn as many trees. The plantation of trees around wells would prevent people from cutting them down so that the groundwater would be replenished.
Therefore, water is again an essential component of the seventh goal. The environmental sustainability can't be achieved without a good water management.

8/ Develop a global partnership for development

For millions of years humans have settled near sources of fresh water: rivers, lakes, streams, or near plentiful aquifers. Without fresh water, the human race cannot exist. Pollution of freshwater resources is a problem not just in poor nations, but in all areas of the world.
In sub-Saharan Africa, rapid population growth, urbanization, industrialization, and the drive for food security are putting pressures on water resources, both in terms of quantity and quality. Domestic wastewater, industrial effluents, and agrochemicals are polluting both freshwater and coastal resources, causing health hazards, eutrophication, and stress on aquatic and marine ecosystems. Thus, a global partnership for development is more than necessary for water management.

To conclude, Millennium Development Goal 7 calls for halving the proportion of people without sustainable access to safe drinking water and basic sanitation. But water is linked not only to Millennium Development Goal 7. It also directly affects as we just saw that the achievement of all eight Millennium Development Goals, including, notably, the first goal, the eradication of extreme poverty and hunger.
Finally, properly managing water resources is an essential component of growth, social and economic development, poverty reduction and equity, all essential for achieving the Millennium Development Goals.

Student 2

The Millennium Development Goals (MDG) were established by the United Nations Development Program. The goal is to have all 8 MDG achieved by 2015. In order to accomplish that, there will need to be extensive reform in the water management sector since all 8 goals are related to and dependent on the ability of all nations to supply a reliable and safe source of water to its entire population.

The first goal of the MDG is to eradicate extreme poverty and hunger. The aim of this goal is to reduce the number of people surviving on one dollar a day to half its current value, offer full and productive employment to all people including women and young people, and reduce the number of people who suffer from hunger to half its past level. To reduce hunger, changes are needed in the agricultural industry to optimize the water used. With about 70% of the fresh water going to agricultural uses, improvements are needed here if the global food shortage problems are to be solved. Also, the diet of the upper and middle class are going to have to change and stop the trend towards higher meat intake and dairy products. The proportion of grain that goes into making meat causes a large stressor on the environment with large quantities of water required to grow the grain and to maintain the animals. To more evenly distribute the water requirements for food, developed nations need to decrease their food intake and change their diets to one that is less water intensive. Much of the world lives on rice and beans. There is no reason the US can't also.

The second goal is to achieve universal primary education. This means that all children must complete a full course of primary schooling and increase the literacy rates of 15-24 year-old men and women. Education can decrease the population of a country by educating the women about birth control and have them spend more time working outside the house. Education can also help the poor to help themselves by giving them the information needed to solve the problems of their own community. Both of these factors can increase the water management of a village by decreasing the demand on the available resources and by teaching the people to more effectively use what resources they have in a sustainable manner.

The third goal is to promote gender equality and empower women. This is to be done by eliminating gender disparity in primary and secondary school by 2005 and at all levels by 2015. As mentioned above, this will decrease the population as women will get married later in life decreasing the number of years in which they can reproduce. It will give them an incentive to have fewer children as they spend more time outside the house making money. This will produce a large cost associated with having a large family because their earning potential will be gone when they have to stay home with the children. By decreasing the population, there will be less strain on the water supply. Currently the northern section of Africa is growing at such a rate that they do not have sufficient fresh water to meet the growth. If women are educated the population will decrease.

The forth goal is the reduction of child mortality by 2/3 of the mortality rate among children under the age of 5. Child mortality rates and water quality and quantity are directly related. Many of the diseases that are prevalent in water are most dangerous against the old and young people in a population. Their bodies have not developed the strength to fight off many of the most common water born diseases. While cryptosporidium and geardia can make a grown adult sick, it can, and does, kill many children whose immune systems are additionally compromised by malnutrition. By eliminating the contact between waste water and fresh water, increasing education of hygiene, and providing the poor with safe drinking water, the infant mortality rate will decrease dramatically. Almost all human pathogens come from human and animal waste. By preventing their mixing, we can eliminate their infectious capabilities.

Goal five is similar to goal four in that both focus on protecting the weakest of society by protecting pregnant women through healthcare and education. Pregnancy is a very dangerous time for a woman especially in developing nations where the heath care is not always available. Improving the water supply could help the mothers by keeping themselves and their unborn babies healthy and preventing infection during labor due to low quality water. It would also decrease the birth rates by providing information of contraceptive and family planning which would decrease the strain on the natural resources and make the water supply more sustainable.

Goal six is to combat HIV/AIDS, malaria and other diseases. Malaria, and many of the other diseases, can be prevented by proper water/waste water management. Many diseases such as hepatitis A are transmitted through drinking water that is contaminated with human fecal matter. By protecting the fresh water from contamination, many of these diseases can be prevented. Malaria is transmitted from mosquitoes that breed in murky, stagnant water and is one of the leading causes of death in Africa. By protecting the surface water, the incidence of malaria should decrease. Another way water management is associated with this goal is that people infected with the HIV/AIDS virus have compromised immune systems that are more susceptible to water born diseases. This is not only bad for patients with AIDS in that they are more likely to die from seemingly mild diseases, but for others in that the microbes can more easily multiply in their systems and increase the contamination of the waste water.

Goal seven is to insure environmental sustainability by integrating the principles of sustainable development in a country's policies and programs, reversing loss of environmental resources, reducing biodiversity loss, reducing by half the proportion of people without access to sustainable safe drinking water and sanitation, and achieve significant improvement to at least 100 million slum dwellers. All these factors are related to and achieved by sustainable water and waste water management practices. Water is essential for anything to survive. Desertification is a result of the miss use of water. Salinity of soil is a direct result of placing too much water where is does not belong. Flooding is often caused by diversion of natural water flow or prevention of infiltration. Most of the people who live in the slums do not have access to safe drinking water or sanitation facilities. This cannot be achieved without improving the water situation for the poor.

Goal eight in the MDG is to develop a global partnership for development and looks at developing an open, rule-based, predictable, non-discriminatory trading and financial system, address needs of the least developed nations, address the needs of landlocked countries and island states, deal with debts of developing countries, provide affordable essential drugs to developing countries, and make the benefits of new technology available to more people such as phones and internet. It has come to the point where water issues are no longer a national issue but an international one. With the idea of virtual water, it is not only the country that uses the water that needs to make changes but also those that receive the goods produced. As has been shown with the current economic downturn, if one country suffers, they all suffer. This economic downturn is only money and real estate. When it turns to something like water which is essential to sustain life, it will be even worse. It is not only Africa that will suffer from its eminent water shortages but the whole world. This is what is being focused on in goal 8. When one nation suffers they all suffer so they all need to help minimize and/or prevent the problems from developing that far.

These goals seem admirable but impossible. There are too many factors at play with no real visible reward. Most Americans do not understand the real consequence of their actions. This comes back to the same idea mentioned throughout this paper about the need for education in order to sustain water. The developed nations, upper, and middle classes all need to be educated on the real consequences of their actions. Scare tactics should be avoided to prevent people from becoming numb to the real facts. Accurate, supported and proven facts need to be presented to all so that all will understand the consequences of doing nothing.

2.2.2

The National Water-Quality Assessment (NAWQA) Program has developed groundwater data-collection protocols and procedures for the selection, installation, and documentation of related data (Lapham et al.[59]) and also for the collection and documentation of water quality samples and related data (Koterba et al.[58]). Three types of studies are defined in the NAWQA program: (1) *study-unit (or subunit) surveys,* designed to obtain occurrence and distribution data on a variety of analytes; (2) *land-use studies;* and (3) *flowpath studies*, which assess spatial differences and possibly temporal variability in each of a selected number of analytes among wells located in different parts of a local groundwater flow system. Table 8.9.2 provides a summary of required, recommended, and optional water-quality constituents measured in the three studies.

Table 8.9.2 Summary of Current (1995) Required, Recommended, and Optional Water-Quality Constituents to Be Measured in the Three National Water-Quality Assessment Program Groundwater Components of the Occurrence and Distribution Assessment

Water-quality constituent or constituent class	Study-unit survey	Land-use studies	Flowpath studies[1]	Method[2]
Field measurements				
—Temperature	Req	Req	Req	Field
—Specific electrical conductance	Req	Req	Req	Field
—pH	Req	Req	Req	Field
—Dissolved oxygen	Req	Req	Req	Field
—Acid neutralizing capacity (ANC) (unfiltered sample)[3]	Rec	Rec	Rec	Field incremental
—Alkalinity (filtered sample)[3]	Req	Req	Req	Field incremental
—Turbidity[4]	Rec	Rec	Rec	Field
Major inorganics	Req	Req	Req	NWQL SC2750
Nutrients	Req	Req	Req	NWQL SC2752
Filtered organic carbon	Req	Req	Opt	NWQL SC2085
Pesticides	Req	Req	Opt	NWQL SC2001/2010 NWQL SC2050/2051
Volatile organic compounds (VOCs)	Req	Req or Opt[5]	Req or Opt[6]	NWQL SC 2090
Radon	Req	Req or Rec[7]	Req or Rec[6]	NWQL LC 1369
Trace elements[4]	Opt	Opt	Opt	NWQL SC 2703
Radium	Opt	Opt	Opt	NWQL-Opt
Uranium	Opt	Opt	Opt	NWQL-Opt
Tritium, tritium–helium, chlorofluorocarbons (CFCs)[8]	Rec	Rec	Rec	NWQL LC1565 (tritium)
Environmental isotopes[9]	Rec	Rec	Rec	NWQL-Opt

[Required water-quality constituents to be measured for the Occurrence and Distribution Assessment are determined partly by the water-quality topics of national interest selected for National Assessment. Topics selected for National Assessment (1994) are nutrients, pesticides, and volatile organic compounds. The topics selected can change over time. Quality-control samples also are required—types of quality control samples depend on study component. Req, Required; Rec, Recommended; Opt, Optional; NWQL, National Water-Quality Laboratory; SC, Schedule; LC, Laboratory Code]

[1]Selection of constituents for measurement in flowpath studies is determined by flowpath study objectives. During at least the first round of sampling, however, the broad range of constituents measured in study-unit surveys and land-use studies would be measured.

[2]Schedules and laboratory codes listed are required for study units that began their intensive phase in 1991 or 1994, and apply until changed by National Program directive. Schedules for radium and uranium can be selected by the study unit, but require NAWQA Quality-Assurance Specialist approval. A detailed discussion is found in Koterba et al.[58]

[3]ANC (formerly referred to as unfiltered alkalinity) is measured on an unfiltered sample. Alkalinity is measured on a filtered sample. Study unit could have collected ANC, alkalinity, or both to date.

[4]Turbidity measurements are required whenever trace-element samples are collected to evaluate potential colloidal contributions to measured concentrations of iron, manganese, and other elements.

[5]VOCs are required at all urban land-use study wells, but optional in agricultural land-use studies. If VOCs are chosen as part of an agricultural land-use study, then they should be measured in at least 20 of the land-use study wells.

(*continues*)

Table 8.9.2 (*continued*) Summary of Current (1995) Required, Recommended, and Optional Water-Quality Constituents to Be Measured in the Three National Water-Quality Assessment Program Groundwater Components of the Occurrence and Distribution Assessment

[6]VOCs are required at all urban flowpath wells for at least the first round of sampling. If VOCs are measured in an agricultural land-use study, then they should be measured at all flowpath-study wells within that land-use study for at least the first round of sampling.

[7]Radon is required at any land-use or flowpath study well if that well also is part of a study-unit survey; otherwise, radon collection is recommended for land-use or flowpath study wells located in likely source areas.

[8]Collection of tritium, tritium–helium, chlorofluorocarbons (CFCs), and/or other samples for dating groundwater is recommended, depending on hydrogeologic setting. For tritium methods, see NWQL catalog; for CFCs, see Office of Water Quality Technical Memorandum No. 95.02 (unpublished document located in the USGS Office of Water Quality, MS 412, Reston, VA 22092).

[9]For a general discussion of the use of environmental isotopes in groundwater studies, see Alley.[3]

2.2.3

World Water Assessment Program

Mission Statement

This UN-wide programme seeks to develop the tools and skills needed to achieve a better understanding of those basic processes, management practices and policies that will help improve the supply and quality of global freshwater resources.

Our goals are to:

- assess the state of the world's freshwater resources and ecosystems;
- identify critical issues and problems;
- develop indicators and measure progress towards achieving sustainable use of water resources;
- help countries develop their own assessment capacity;
- document lessons learned and publish a World Water Development Report (WWDR) at regular intervals.

Background

Acceptance of the need for a more people oriented and integrated approach to water management and development has gradually evolved as a result of a number of major conferences and fora. The Mar del Plata Action Plan of the 1977 UN Conference on Water, the Dublin Conference on Water and the Environment and the Rio Earth Summit, with its highly important Agenda 21 document, in 1992 and the World Water Vision exercises have successively reinforced the need for comprehensive assessment of the world's freshwater as the basis for more integrated water management. At the urging of the Commission on Sustainable Development and with the strong endorsement by the Ministerial Conference at The Hague in March 2000, UN Water has undertaken a collective UN system-wide continuing assessment process, the World Water Assessment Programme (WWAP).

WWAP's New Visual Identity

More about the main water conferences and decisions of the last thirty years, read the [Water Milestones 1972 - 2003 : from Stockholm to Kyoto]

Rationale for the programme

The growing global water crisis threatens the security, stability and environmental sustainability of developing nations. Millions die each year from water-borne diseases, while water pollution and ecosystem destruction grow, particularly in the developing world. In its Millennium Declaration, the UN called on the nations of the world "to halve by the year 2015 (...) the proportion of people who are unable to reach, or to afford, safe drinking water" and "to stop the unsustainable exploitation of water resources, by developing water management strategies at the regional, national and local levels, which promote both equitable access and adequate supply."

Over the past few decades there has been an increasing acceptance that the management of water resources must be undertaken with an integrated approach, that assessment of the resource is of fundamental importance as the basis for rational decision-making and that national capacities to undertake necessary assessments must be fully supported. Management decisions to alleviate poverty, to allow economic development, to ensure food security and the health of human populations as well as preserve vital ecosystems, must be based on our best possible understanding of all relevant systems.

Currently there is no global system in place to produce a systematic, continuing, integrated and comprehensive global picture of freshwater and its management.

The UN system, through the ACC/SCWR, has the mandate, credibility and capacity to take on the task of systematically marshalling global water knowledge and expertise to develop over time the necessary assessment of the global water situation, as the basis for

UN World Water Development Report

Third edition, 2009

Water in a Changing World

Previous Editions

Water: A Shared Responsibility,
Second edition, 2006
Water for People, Water for Life,
First edition, 2003

Currents, WWAP's newsletter

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action to resolve water crises.

Scope of the programme

The WWAP, building on the achievements of the many previous endeavours, focuses on assessing the developing situation as regards freshwater throughout the world. The primary output of the WWAP is the periodic World Water Development Report (WWDR). The Programme will evolve with the WWDR at its core. Thus there will be a need to include:

- data compilation (geo-referenced meta-databases);
- supporting information technologies;
- data interpretation;
- comparative trend analyses;
- data dissemination;
- methodology development and modelling.

The recommendations from the WWDR will include capacity building to improve country-level assessment, with emphasis on developing countries. This will include the building of capacity in education and training, in monitoring and database science and technology and in assessment-related institutional management. The Programme will identify situations of water crisis and will thus provide guidance for donor agencies and will provide the knowledge and understanding necessary as the basis for further capacity building.

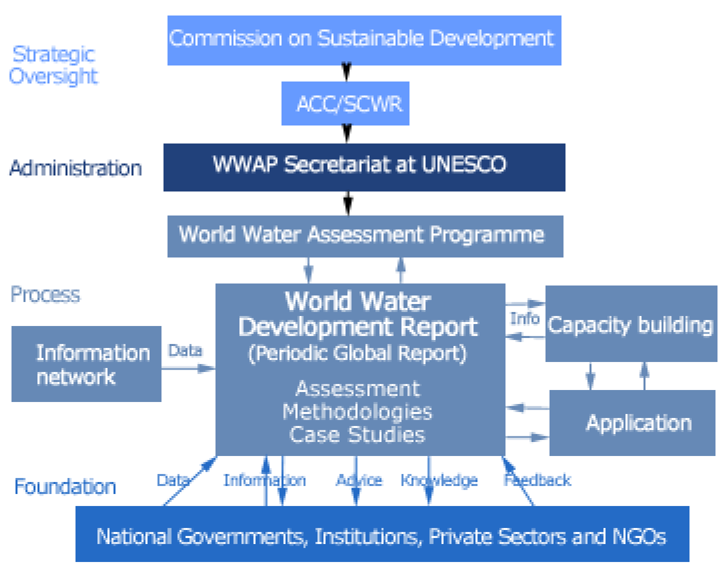
The Programme focuses on terrestrial freshwater, but will link with the marine near-shore environments and coastal zone regions as principal sinks for land-based sources of pollution and sedimentation and as areas where the threat of flooding and the potential impact of sea level rise on freshwater resources is particularly acute.

The Programme, including the new WWDR, is undertaken by the UN agencies concerned aided by a Trust Fund, donors providing support in cash and in kind either through specific agencies or through the Trust Fund. UNESCO currently hosts the WWAP Secretariat and manages the FUND at its Headquarters in Paris.

The Programme serves as an "umbrella" for coordination of existing UN initiatives within the freshwater assessment sphere. In this regard it will link strongly with the data and information systems of the UN agencies, for example GRID, GEMS-Water, the Global International Waters Assessment (GIWA) of UNEP, the Global Runoff Data Centre (GRDC) of WMO, AQUASTAT of FAO, the International Groundwater Resources Assessment Centre (IGRAC) being established by WMO and UNESCO, the water supply and sanitation databases of WHO and UNICEF and the databases of the World Bank system.

Programme components

The Programme consists of the following coordinated elements:



The WWDR component, involving the preparation of the periodic report and resultant advice, when

requested, to governments. The WWDR will include:
- a thematic component (in the first edition this will focus on developments in water management since the Rio Earth Summit and subsequent editions will include cross cutting themes such as "water and poverty", "water in cities" among other possible themes);
- a methodological component involving analyses and the production of indicators of water-related stress;
- a case study component, which will develop an integrated, cross-sectoral methodology and support its progressive dissemination in countries and river basins worldwide.

- A **Water Information Network** comprising:
  - global-scale meta-database;
  - knowledge management systems to facilitate the assessment and dissemination of information;
  - an online library, website and newsletter.

The network will allow communication with governments and water related non-government groups, facilitate capacity building and raise awareness about water.

- A **capacity-building component**, the prime purpose of which is to promote the ability of governments to conduct their own assessments through human resource development, education and training, provision of methodologies, institution and infrastructure development and development of data and information networks.

Specific programme objectives

- Provide an on-going global assessment of the state of the world's freshwater resources and their use.
- Identify and advocate methodologies which have been shown to work well.
- Identify and assess aspects of the state of

freshwater resources.

- Identify water management strategies and policies which work well and those which are unsatisfactory and analyzes the reasons for success and failure.
- Compile and synthesize data, information and knowledge on all aspects of water resource assessment.
- Develop mechanisms for the transfer of knowledge and expertise to national governments, decision makers at all levels from local to international, user organizations, academic institutions and the general public, especially in developing countries which are disadvantaged in terms of the availability and quality of data and information, in order to facilitate and improve freshwater assessment.
- Provide advice, on request, to Member States on water-related policies and technical issues at local, national, regional and international levels.
- Provide strong advocacy for changes needed to alleviate distress in disadvantaged regions of the world.
- Build the capacity for countries to make their own assessments through human resource development, education and training, institutional development and the development of appropriate legal and policy instruments.

Benefits of the programme

- Provide, for the first time, a comprehensive process of assessment, from monitoring at the country level, through global database and indicator development, to sectoral and watershed assessment, capacity development and global trend assessment, all leading to a progressively more comprehensive periodic report.

- Provide a framework for coordination and realignment of the existing programmes of ACC/SCWR members to take advantage of synergies, strengthen internal positioning of programmes and improve opportunities for external funding.
- Provide a framework and rationale for strategic investment by prospective donors, targeted to particular components of the WWAP, while emphasizing the magnitude of the task that must be funded.
- Recognize the importance of developing global geo-referenced databases, a comprehensive indicator system and harmonized data standards.
- Recognize the need to develop an effective methodology for such assessments based on river basins and aquifers.
- Address the essential role of countries in providing core national and watershed data for the assessment process.
- Address the critical, continuing need to build or strengthen the capacity in many developing countries to conduct their own assessments.
- Provide a mechanism to systematically address water issues that have been under-emphasized in the past, such as:
  - water quality;
  - aquatic ecosystem degradation;

- water management economics.

- Provide a prestigious, systematic institutional mechanism for interaction with non-UN partners and with developing-country water institutions in the assessment area;
- Provide a knowledge base that can be used to support other water management and capacity building programmes, within and external to the UN.

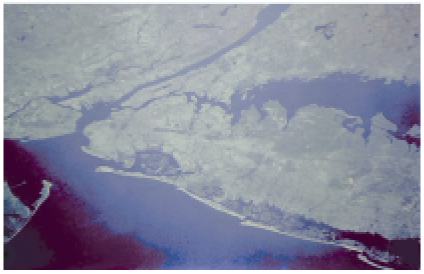
2.2.5

LONG ISLAND, NEW YORK

Ground water is the sole source of freshwater for the more than 3 million people who live on Long Island outside the metropolitan New York City boundary. (The Long Island ground-water system was discussed earlier in the sections on "Ground-Water Development, Sustainability, and Water Budgets" and "Effects of Ground-Water Development on Ground-Water Storage.") To help replenish the aquifer, as well as reduce urban flooding and control saltwater intrusion, more than 3,000 recharge basins dispose of storm runoff at an average rate of about 150 million gallons per day. Initially, many of these basins were abandoned gravel pits, but since 1936 urban developers are required to provide recharge basins with new developments. Practically all basins are unlined excavations in the upper glacial deposits and have areas from less than 0.1 to more than 30 acres.

Aerial photograph of development on Long Island showing recharge basin. (Photograph courtesy of Nassau County Department of Public Works.)

LONG ISLAND, NEW YORK



Long Island is bounded on the north by Long Island Sound, on the east and south by the Atlantic Ocean, and on the west by New York Bay and the East River. Long Island is divided into four counties—Kings, Queens, Nassau, and Suffolk. The two western counties, Kings and Queens, are part of New York City.

Precipitation that infiltrates and percolates to the water table is Long Island's only natural source of freshwater because the ground-water system is bounded on the bottom by relatively impermeable bedrock and on the sides by saline ground water or saline bays and the ocean (Figure 9). About one-half the precipitation becomes recharge to the ground-water system; the rest flows as surface runoff to streams or is lost through evapotranspiration (Cohen and others, 1968). Much of the precipitation that reaches the uppermost unconfined aquifer moves laterally and discharges to streams and surrounding saltwater bodies; the remainder seeps downward to recharge the deeper aquifers. Water enters these deeper aquifers very slowly in areas where confining units are present but enters freely in other areas where confining units are absent. Water in the deeper aquifers also moves seaward and eventually seeps into overlying aquifers. Predevelopment water budgets for most of Nassau and Suffolk Counties on Long Island are shown in Figure 9.

Over the past three centuries, the island's ground water has been developed through three distinct phases. In the first, which began with the arrival of European settlers in the mid-17th century, virtually every house had its own shallow well, which tapped the uppermost unconsolidated geologic deposits, and also had its own cesspool, which returned wastewater to these same deposits. Because population was sparse, this mode of operation had little effect on the quantity and quality of shallow ground water. During the next two centuries, the population increased steadily, and, by the end of the 19th century, the individual wells in some areas had been abandoned in favor of shallow public-supply wells.

The second phase began with the rapid population growth and urban development that occurred during the first half of the 20th century. The high permeability of Long Island's deposits encouraged the widespread use of domestic wastewater-disposal systems, and the contamination resulting from increased wastewater discharge led to the eventual abandonment of many domestic wells and shallow public-supply wells in favor of deeper, high-capacity wells. In general, pumping these deep wells had only a small effect on the quantity of shallow ground water and related surface-water systems because most of the water was returned to the ground-water reservoir through domestic wastewater-disposal systems.

OVERALL PREDEVELOPMENT WATER-BUDGET ANALYSIS

INFLOW TO LONG ISLAND HYDROLOGIC SYSTEM	CUBIC FEET PER SECOND
1. Precipitation	2,475
OUTFLOW FROM LONG ISLAND HYDROLOGIC SYSTEM	
2. Evapotranspiration of precipitation	1,175
3. Ground-water discharge to sea	725
4. Streamflow discharge to sea	525
5. Evapotranspiration of ground water	25
6. Spring flow	25
Total outflow	2,475

GROUND-WATER PREDEVELOPMENT WATER-BUDGET ANALYSIS

INFLOW TO LONG ISLAND GROUND-WATER SYSTEM	CUBIC FEET PER SECOND
7. Ground-water recharge	1,275
OUTFLOW FROM LONG ISLAND GROUND-WATER SYSTEM	
8. Ground-water discharge to streams	500
9. Ground-water discharge to sea	725
10. Evapotranspiration of ground water	25
11. Spring flow	25
Total outflow	1,275

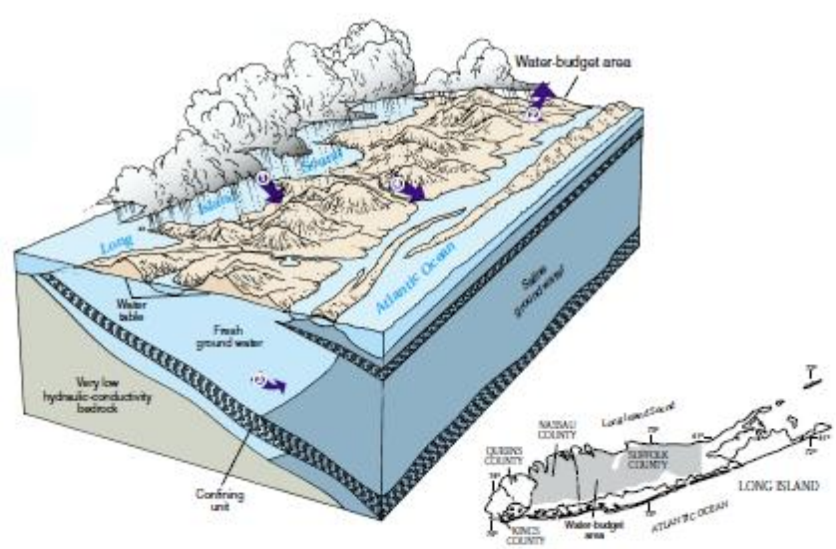


Figure 9. Ground-water budget for part of Nassau and Suffolk Counties, Long Island, New York. (Modified from Cohen and others, 1968.)

Block diagram of Long Island, New York, and tables listing the overall water budget and ground-water budget under predevelopment conditions. Both water budgets assume equilibrium conditions with little or no change in storage.

The third and present phase of ground-water development on Long Island began in the early 1950's with the introduction of large-scale sewer systems in the more heavily populated areas. The purpose of the sewers was to prevent domestic wastewater from entering the aquifer system because contaminants from this source were being detected in deep public-supply wells. Even though the sewers protect the aquifers from further contamination, they also prevent the replenishment (recharge) that the wastewater had provided to the ground-water reservoir through the domestic wastewater-disposal systems. The wastewater is now diverted to sewage-treatment plants, whose effluent is discharged to the bays and oceans. The decrease in recharge has caused the water table in the sewered areas to be substantially lowered, the base flow of streams to be reduced or eliminated, and the length of perennial streams to be decreased.

In Nassau and Suffolk Counties, about 200 cubic feet per second of wastewater (ground water that has been pumped and used) was discharged in 1985 by the three major sewer districts to the surrounding saltwater bodies (Spinello and Simmons, 1992). As previously noted, the only source of freshwater to the system is precipitation. Therefore, the water required to balance the loss from the ground-water system must come primarily from decreases in ground-water discharge to streams and to surrounding saltwater bodies. Capture of ground-water evapotranspiration, spring flow, and some surface runoff are also possible, but each of these sources is limited to a maximum of approximately 25 cubic feet per second (Figure 9). As the flow to the streams decreases, the headwaters of the streams dry up and the streams become shorter. As the discharge of ground water to surrounding saltwater bodies decreases, saline ground water moves landward as saltwater intrusion. Thus, this case is an example in which the determination of sustainable yields cannot be based solely on predevelopment water budgets. The specific response of the ground-water system to development must be taken into account in determining the appropriate limits to set on ground-water use.

2.2.6

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North America

- Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. *{WGII 14.4, SPM}*
- In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources. *{WGII 14.4, SPM}*
- Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. *{WGII 14.4, SPM}*
- Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution. *{WGII 14.4, SPM}*

2.2.7

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Europe

- Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise). *{WGII 12.4, SPM}*
- Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emissions scenarios by 2080). *{WGII 12.4, SPM}*
- In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. *{WGII 12.4, SPM}*
- Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires. *{WGII 12.4, SPM}*

2.2.8

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Africa

- By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. *{WGII 9.4, SPM}*
- By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. *{WGII 9.4, SPM}*
- Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of GDP. *{WGII 9.4, SPM}*
- By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios (*high confidence*). *{WGII Box TS.6, 9.4.4}*

2.2.9

The following definitions are from http://www.drought.unl.edu.whatis/concept.htm

Meteorological Drought
Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. Definitions of meteorological drought must be considered as region specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region. For example, some definitions of meteorological drought identify periods of drought on the basis of the number of days with precipitation less than some specified threshold. This measure is only appropriate for regions characterized by a year-round precipitation regime such as a tropical rainforest, humid subtropical climate, or humid mid-latitude climate. Locations such as Manaus, Brazil; New Orleans, Louisiana (U.S.A.); and London, England, are examples. Other climatic regimes are characterized by a seasonal rainfall pattern, such as the central United States, northeast Brazil, West Africa, and northern Australia. Extended periods without rainfall are common in Omaha, Nebraska (U.S.A.); Fortaleza, Ceará (Brazil); and Darwin, Northwest Territory (Australia), and a definition based on the number of days with precipitation less than some specified threshold is unrealistic in these cases. Other definitions may relate actual precipitation departures to average amounts on monthly, seasonal, or annual time scales.

Agricultural Drought
Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, reduced ground water or reservoir levels, and so forth. Plant water demand depends on prevailing weather conditions, biological characteristics of

the specific plant, its stage of growth, and the physical and biological properties of the soil. A good definition of agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of final yield. However, if topsoil moisture is sufficient for early growth requirements, deficiencies in subsoil moisture at this early stage may not affect final yield if subsoil moisture is replenished as the growing season progresses or if rainfall meets plant water needs.

Hydrological Drought

Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that is almost immediately discernible to agriculturalists, but the impact of this deficiency on reservoir levels may not affect hydroelectric power production or recreational uses for many months. Also, water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes (e.g., flood control, irrigation, recreation, navigation, hydropower, wildlife habitat), further complicating the sequence and quantification of impacts. Competition for water in these storage systems escalates during drought and conflicts between water users increase significantly.

2.4.2

Following excerpt is from McPhee and Yeh, Multiobjective analysis for sustainability – conjunctive use planning of groundwater and surface water, Chapter 6, Water Resources Sustainability, ed. by L.W. Mays, page 120, McGraw-Hill, 2007.

As population in urban centers around the world increases and economic development raises standards of living, domestic and industrial water demands grow steadily. Mounting pressure on existing water supply sources is compounded by uncertainty regarding the future reliability of water supply due to the not-yet quantified effects of global climate change. Conjunctive use of groundwater and surface water can counter these effects and enhance the reliability of water supply systems by taking full advantage of the almost unlimited storage capacity of groundwater systems. By controlling the total water resources of a region, conjunctive use planning of groundwater and surface water can increase the efficiency, reliability, and cost-effectiveness of water use, particularly in river basins with spatial or temporal imbalances in water demands and natural supplies. Rarely do regions and times of high rainfall and runoff coincide with regions and times of extensive water development and demand. Rather, periods of lowest stream flow and groundwater recharge usually coincide with the largest demand, or vice versa. Integrated management of surface water and groundwater can reduce these deficiencies by using groundwater to supplement scarce surface water supplies during the drier seasons. During the periods of medium or high runoff, surface water can then be used to satisfy the water demands and to recharge the aquifers using spreading basins, abandoned stream channels, and wells.

Conjunctive use of surface water and groundwater requires knowledge about past and current availability of water sources from a hydrologic point of view; the potential for recharging aquifers with a suitable amount of water; and the behavior of water under the ground surface and associated risks of contamination, together with the potential for natural treatment of reclaimed water. Most importantly, relevant questions applicable to conjunctive use involve how to operate such systems, that is, when to recharge, when and how much to extract from the aquifer, and how to value the benefits associated with capacity expansion (Philbrick and Kitanidis, 1998).

It follows that conjunctive use requires accurate knowledge about the physical systems as well as decision-making tools for adequately managing recharge and pumping operations. Knowledge about physical systems can be achieved with adequately planned field data collection campaigns, as well as with numerical modeling. On the other hand, optimization or system analysis techniques can provide invaluable help in identifying good solutions to problems that generally are complex, multidimensional, and unstructured in nature.

The following is from

Holway, J., Adaptive Water Quantity Management: Designing for Sustainability and Resiliency in Water Scarce Regions, The Water Environment of Cities, ed. by L. Baker, Springer, 2009.

Conjunctive management entails managing all types of water as a common resource in ways that allow us to maximize the utilization of each supply. It recognizes the unique characteristics of the availability and qualities of different sources of groundwater, surface water, and effluent and builds in flexibility to adjust to changing hydrologic conditions as well as institutional constraints. For example, Arizona's Salt River Project (SRP) provides an excellent example of conjunctive management of Salt and Verde River water, groundwater, and CAP water. Historically, SRP has delivered surface water when available, but switched to groundwater to preserve scarce surface water supplies during drought. More recently SRP has utilized excess CAP water to avoid draining the limited surface water in the reservoirs in the SRP system. SRP has also recently joined other Arizona interests in developing groundwater recharge projects, which can store significant quantities of surplus CAP or surface water for later use.

Conjunctive management is a key strategy for dealing with five increasingly important aspects of western water management (adapted from Bloomquist et al. 2004):

- as supplies become tight it is increasingly important to efficiently utilize all available sources of water including effluent,
- the seasonal patterns of peak demand differ from those of supply availability,
- as the region becomes increasingly urban, water supply reliability is becoming just as important as availability,
- water demands in the west will not be met without extensive storage (which can include underground aquifers) and distribution facilities,
- each of these management challenges increases the need to cooperate regionally and overcome institutional and legal constraints that limit water supply reliability, efficiency and resiliency.

Characteristics that facilitate conjunctive management include:

- clear specification of water rights
- consistent rules for all sources of water
- ability to conserve water without loosing rights
- ability to transfer water supplies and rights
- infrastructure to move water (in particular surplus surface water)
- large aquifers with storage space
- clear standards for permitting or allowing recharge projects
- health and environmental quality regulations that facilitate effluent reuse and recharge
- clear rights to recover stored water and protect those supplies from other users
- protection of recharge zones and well sites
- ability to cooperate on financing and assessing fees, and
- regulatory incentives for conjunctive management.

2.5.1

The solution to this is specific to the region inwhich you live.

2.5.2

	Demand	Supply		
		CAP Water	Effluent	Groundwater
Municipal Sector	210	0	9.5	200.5
Agricultural Sector	120.9	0	2.22	118.7
Industrial Sector	74.3	0	0.99	73.3
Loss Due to Evaporation	4.56	0	0	4.6
Totals	**410**	**0.00**	**12.7**	**397.1**
Groundwater Use				397.1
(Less) Net Natural Recharge				-75
(Let) Incidental Recharge				-101.5
Groundwater Overdraft				220.6

2.5.3

	Demand	Supply		
		CAP Water	Effluent	Groundwater
Municipal Sector	191.8	0.12	9.5	182.2
Agricultural Sector	60	0	2.22	57.8
Industrial Sector	74.3	0	0.99	73.3
Loss Due to Evaporation	4.56	0	0	4.6
Totals	**331**	**0.12**	**12.7**	**317.8**
Groundwater Use				317.8
(Less) Net Natural Recharge				-75
(Let) Incidental Recharge				-101.5
Groundwater Overdraft				**141.3**

2.5.4

$S_c = 0$, and $D_a = 0$ then solving for D_m

$$D_m = \frac{A - S_{gs} + (1 - I_e)E + (1 - I_i)D_i}{R + I_m - 1}$$

$$D_m = \frac{A - S_{gs} + (1 - 0.9)E + (1 - 0.12)D_i}{R + I_m - 1}$$

$$D_m = \frac{A - S_{gs} + 0.1E + 0.88D_i}{R + I_m - 1}$$