EXTENDING THE RESOURCE: INTEGRATING WATER QUALITY CONSIDERATIONS INTO WATER RESOURCES MANAGEMENT

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*"The wise use of water is quite possibly
the truest indicator of human intelligence,
measurable by what we are smart enough
to keep out of it. . . ."*
~ David Orr

INTRODUCTION

From its beginning, life on this planet has been fraught with danger, pain, death and threats to its continued existence. The eve of a new millennium, however, finds humanity imperiled by new, insidious menaces, arising largely from its own pursuits. Its population, aided by advances in medicine, agriculture, and numerous life supporting technologies, has grown so large, and is increasing so rapidly, that thoughtful persons are wondering how long it can go on providing itself adequately with food, water, fiber, shelter, and other basic needs. Trying to meet the needs and wishes of this enormous and growing number of people has resulted in the greatly expanded manufacture and use of chemicals. This mushrooming population also has brought increased urbanization, rapid and extensive encroachment into wilderness, and vastly expanded travel, all of which have contributed to the outbreak and movement of increasingly malignant outbreaks of new biotic threats. Water management challenges created by these two threats, chemical and biological, represent an entirely new genre, unprecedented in scope or magnitude.

These afflictions are compounded by three additional considerations. First, in the U.S., as in many other countries, population growth, urbanization, and increased water demands associated with higher standards of living, are causing water shortages in areas long considered "*water rich*." Second, the rapid growth of a *global economy* is increasing the demand for water in many places where water management, especially water quality management, has been largely missing. Finally, water management in the twenty-first century will be stressed even more by *climate change* and the accompanying disruption in global weather patterns. In the next millennium, these tribulations, if ignored or given inadequate attention, will produce spreading, perilous degradation of water quality everywhere, and in many locations, a continuously widening gap between water needs and the availability of useful water.

BACKGROUND

Historically, the first concern of water management has been quantity. Individually or collectively, people have always sought to assure themselves of enough of this miraculous substance to meet their requirements. To be sure, water quality has always been of some concern - even the unlearned have eyes, noses and palates - but thirsty people, and other animals, tend to make allowances. Similarly, water quality requirements for many agricultural and industrial purposes are not very rigorous, allowing for the use of poor quality waters, waters of excellent quality - and the entire range in between.

However, during the twentieth century, water quality considerations also became an important part of water management. In the U.S., unfortunately, maturing concerns about water quality began to result in an important dualism in the water management world. At the federal level, one set of policies, laws and institutions was created and given authority over developing and maintaining an adequate *quantitative* supply of water, while another set of policies, laws and institutions was generated and given responsibility for assuring that the *quality* of the nation's water was guarded. For the most part, this pattern was repeated at the state and local levels. Rather than growing together over time, as a result of their common interests in water management, these institutional entities, and the laws that sustain them, have continued to develop separately. One result of this has been that wastewater, stormwater runoff and other "dirty" waters have come to be regarded by those managing the quantitative aspects of water, as having little or no value as water supplies. Rather, they are looked on by most observers, including a large segment of the public, as of little positive, or even negative, value. Thus, they are seldom considered when a community is seeking to increase its water supply.

When faced with scarcities, water managers ancient and modern have most often attempted the traditional, and heretofore easy fix for such problems: bring in more water. Today, however, this response, is being met with increasing resistance as those "owning" more water than they are currently using begin to understand the value of their surplus. Furthermore, they don't trust people in the water short area either to use the imported water wisely, or to be more circumspect about allowing water demand to continue rising in the future. They worry about the "slippery slope" of future obligations they might incur if they let the water short area have some of their "surplus " water today. Thus, cross border disputes over water are becoming more common and more bellicose, whether they occur among urban communities, within a state, across state lines or across national borders.

Conservation of existing water also has been tried or proposed as a means of extending the useful resource. Conservation programs often involve limitations on certain water uses, educating homeowners and others to the benefits of water saving devices while offering inducements for their use, and requiring the reuse of water in targeted commercial or industrial enterprises. Some water conservation programs have been linked to changes in the price of water, changes designed to bring its price more into line with its cost. While certain portions of the water using public find such arrangements quite acceptable, the majority dislike any such restrictions, economic or otherwise, on what many have come to regard as a "free" good.

In some locations, when water supplies become extremely limited, its further use is based on determination of which user has the oldest "right" to it, or on a judgment about which uses have the highest "priority." Unfortunately, these rights and priorities were established long before population and other pressures on the resource were anywhere near as powerful as they are today - a time that is long past. Thus their application today in no way assures a fair, equitable, or even socially useful solution to the scarcity problem.

Another large part of the water supply problem, a critical part of it, is the continuing, spreading, and intensifying degradation of water quality at many locations. This adds to the problem of managing supply and demand, as it means that water available in a quantitative sense is not always available - not usable, not acceptable - to water users in a qualitative sense. In this age of information, water users are more sophisticated, more than ever aware of the potential impacts of polluted waters. They are aware, for instance, that the quality of surface waters, ground water and even sea water, almost everywhere, is highly suspect. They also recognize that current water and wastewater treatment standards and technologies are not protecting receiving waters or municipal water supplies from the chemical and biological dangers let loose on the world by a modern industrial society. Therefore, for the most part, they remain unwilling to consider reclamation and reuse of "dirty" water as an acceptable tool for solving some part of the water supply problem.

Thus, in the next century, people will find themselves needing more water, unwilling to negotiate the transfer of water across traditional political boundaries, opposed to restrictions on water use, saddled with an antiquated set of rules about priorities of use, and inimical to reclaiming and reusing stormwater runoff, domestic wastewater, or other supplies which they suspect are highly contaminated. In a word, they are stuck. They are stuck because they are trying to solve emerging and future water problems with thinking - policies, programs, and technologies - developed to serve the needs of a smaller, less industrial, less urban world, whose population used water in an entirely different way than do those of the present - or, than will those of the future (Hall, 1995).

Unless dealt with appropriately, the forces of population growth, urbanization, and increased water demands for home, industry and agriculture, coupled with an increasingly global economy and culture, will produce in the future spreading, perilous degradation of water quality everywhere, and a continuously widening gap between water needs and the availability of useful water in all too many locations. It seems clear that the first step in warding off these frightful occurrences must involve wide-ranging policy reforms. Especially needful will be the advent of new policies to achieve the integration of water management.

Such reforms need to include: (*i*) management across political boundaries, (*ii*) the collective management of atmospheric water, surface waters and ground water, and (*iii*) the combined management of water quantity and water quality. All three of these suggested reforms are important, and must be addressed in the world of the future. Reform in the first two arenas, however, will be a long time in coming. Their birth must be preceded by political solutions to such long festering issues as global governance, and in the U.S., questions related to aboriginal rights, states' rights vs. federal responsibilities, and by technical solutions to such problems as wringing liquid water from air, soil and rock, or storing water in the ground.

In the short term, then, the water problem of most importance in the U.S., and in many other places as well, is the combined management of water quantity and quality. It is also a problem which can be solved by application of existing technology, if the political will to do so, and the money, can be found.

WATER QUALITY CONCERNS OF THE FUTURE

In the next century the water quality issues experienced by water managers of the late 1900s will continue to be of considerable concern. These include unsightly, odorous, solids; oxygen demanding materials; common waterborne pathogens; plant nutrients; and salts of naturally occurring poisonous elements, such as mercury, lead, and arsenic. Over the past 50 years or so scientists and engineers have learned to control these common pollutants effectively and efficiently. Well operated modern treatment facilities can reduce their concentrations by 95 to 98 percent, for relatively modest costs. However, unless the way that modern societies use water changes, these contaminants will continue to be a problem in the future, *because they will have to be removed from ever increasing volumes of water*, as required by a burgeoning population. This will have two results: the overall cost of controlling water quality will continue to rise, and the total amounts of such substances released into the environment will continue to increase. This last means that the quality of streams and other waters receiving treated effluents will increasingly be degraded.

In addition to these continuing problems, however, additional, more complex, more menacing, water quality troubles will be encountered by the water managers of the future (Orr, 1994). Indeed, they are already being seen in the U.S. and elsewhere (Colborn, *et al*., 1996; Barker, 1997). Technical solutions for these difficulties, which are both chemical and biological in nature, do not exist, and little progress is being made toward their development. These new chemical and biological threats, now being discovered in waters all over the world, are the result of: (*i*) the abusively excessive use of water for irrigation, (*ii*) the thousands of synthetic chemicals and chemical residues being released into the environment by today's high technology cultures, and (*iii*) the breakdown of spatial and ecological barriers that have stood between these exotic waterborne microbial pathogens and humans for centuries.

Increasingly, irrigation is required to produce the crops needed by the world's people and animals. Increasingly, also, this irrigation water is applied to marginal agricultural lands. Poorer cropland requires more chemicals, and is more vulnerable to erosion. Irrigation of such land also requires the application of more water, which picks up and carries with it more chemicals and soil. Irrigation water used in this way often produces return flow, runoff, or percolate, that is severely contaminated with agricultural chemicals, naturally occurring salts, and silt. It is of little further use, without expensive treatment. Thus, the productivity of both the land, and the life-giving water, is greatly and steadily diminished. It also is an unfortunate truism that these occurrences take place most commonly in places where agricultural productivity, and clean water are in shortest supply (Brown, *et al*., 1997).

Humans live on this planet in a chemical "*soup*." It has ever been so. This soup helped to beget life, helped to sustain and modify it, and sometimes has ended it: for individuals and for species. In the twentieth century, however, the "soup" has become distinctly thicker, and decidedly more hazardous to living things. Today's life-styles, coupled with increased chemical pollution in all media, bring more and more people into direct, moment by moment, contact with dangerous chemicals. Human bodies, which have had no evolutionary time to develop ways of avoiding these recently constructed synthetic chemicals and their residues, or of mitigating their effects, are being routinely and constantly exposed to the thousands of them at large in the environment today. It is increasingly recognized that the health and reproductive success of numerous life forms, including human, are imperiled by these synthetic chemicals and chemical residues.

Similarly, humans have always been endangered by denizens of the microbial world. Today, however, people all over the globe are facing increasingly menacing outbreaks of new biotic threats, including those from microorganisms that have developed immunity to antibiotics, or which have jumped boundaries between their animal reservoirs and humans. Some of these are waterborne, and their appearance today among human populations appears to be directly related to long term, intensive water pollution. This threat also, is being attributed to today's human culture: urbanization, industrialization, encroachment into wilderness, extensive and direct transportation of goods and people to all parts of the world, and modern medicine's propensity to zap every infection with antibiotics. Thus far, success in dealing with the threats arising from human exposure to these ancient but long hidden microbial pathogens has been largely limited to avoiding contact with them, something that is increasingly difficult to do.

Famine. Poison. Pestilence. These are bad enough in and of themselves, but now are being compounded by changing climate and new, troubling global weather patterns. Storms of all types - tornadoes, hurricanes, cyclones, and typhoons - are seen with increasing frequency in places where they have been rare, and seem to have greater intensities in places where they have long occurred. These storms bring with them flood, drought, disordered water supply and wastewater management, homelessness, and a sometimes devastatingly degraded environment: all of which can aggravate the spread of pathogenic microbes and poisonous chemicals.

The U.S. since the early 1970s has experienced a growing control over the pollution of its waters by municipalities and industries, including agribusiness. In the years ahead, however, this trend will be reversed as it faces a new onslaught of the traditional water pollution control problems stemming from increased water use. It also will be confronted with an entirely new set of water quality threats. As demand for water continues to increase, as the demand grows to include consideration of other environmental values into all proposed solutions to water shortages, and as all such solutions are being powered by more costly energy, it will be increasingly clear that the water management policy of the twentieth century, and the technology supporting it, is not adequate to the task. It is backwards. It has placed the cart before the horse. Its application encourages the *once-through* use of water, and the treatment and/or discharge of wastewater containing contaminants added to it during this use. It was designed to permit the pollution of water, and treatment to make it "clean" again. The future will require a policy designed not just to clean up dirty water, but to keep it from getting dirty, to protect its quality rather than try to restore it.

A NEW BEGINNING

Integration of water quality considerations into water resources management requires a fresh approach. For several years, a number of observers have advocated that such an approach be based on information obtained from the observation of nature, particularly the hydrologic cycle and watershed ecosystems.

People in Western societies, including water managers, have been trained for centuries to have a linear view of things. Thus, they can only conceptualize certain kinds of solutions to problems: those involving linear thinking. Unfortunately, the world doesn't operate on a linear model. Thus, it can be argued that some of the blame for today's increasingly vexing water problems stems from the application of linear thinking to the problems of a cyclical world.

Consider the past. Throughout history, water management "systems," - policy, law, institutions, or hardware - for home, town, city, state, nation or continent have been developed in a linear fashion. Piece by piece, as the need arose, the components of such systems were put into place. As a result, each piece is largely independent of the others in function or control. Because of this piecemeal, straight ahead development, these "systems" have failed miserably in assuring efficient, sometimes even effective, water management. Furthermore, the linear thinking from which they result fails, for the most part, to allow cooperative planning endeavors among impacted parties for unified water resource management, for example, water pollution control and water quality maintenance. In fact, only by the sheerest stretch of the imagination can these combinations of assemblages be called systems. They were created at different times for different purposes. Their only connections are linear and unidirectional, and based on the rather trivial fact that they all handle some aspect of the fluid called water.

A new start is needed.

Events of the recent past have made clear the interrelationships between human activity and many aspects of the natural world, and the need to act with greater care regarding these interrelationships. Many now recognize the need for a more natural, cyclical, integrated approach to the management of all resources, including water, management that ". . . *mimics nature at every* step . . ." (Hawken, 1993). And so it happens that, after centuries of piecemeal water management, attempting to solve one problem without acknowledging its relationship to others, the idea of looking at water in a cyclical way, first expressed in Western Literature some three thousand years ago by the author of *Ecclesiastes* - *"The rivers run into the sea . . . , and the water returns again to the rivers, and flows again to the sea. . . ."* - is now being considered by some as a potential basis for public policy. And the hydrologic cycle observed by that writer, modified and fleshed out by generations of investigators, offers a worthy conceptual model for consideration of total, integrated water management.

This model, the *cyclical,* or natural hydrologic model, is a construction of many components, many of them the same ones contained in the linear model discussed earlier. The difference, between the two models is not one of parts, but of *interrelationships*. In the linear model, there is little, if any, feedback; relationships between components run in only one direction. By contrast, in the natural model, most or all the components are *interconnected*, joined together by feedback loops, as is all of nature. In this model, there is no "wastewater," *per se*. As is the case in all of nature, "waste" from one component becomes raw resource input to another component. Water is used in a particular place, for a particular purpose[2], until its quality (or, quantity) is altered sufficiently to make it unusable for that purpose. It is then either augmented with more and/or higher quality water, by (*i*) the input of freshwater, (*ii*) recycling, and/or (*iii*) reclamation, renovation and reuse.

If augmentation in-place is not feasible, the used water is passed along to become a useful input to another component; where the cycle may be repeated. When it must be passed along, it also may be renovated to a degree that it again becomes useful for the first purpose, or it may become input to a third component of the system whose water quality requirements are not as high as the earlier ones. And so on.

Among the advantages obtained from this approach are the greater potentials for utilization of "dirty" water, such as municipal wastewater, agricultural drainage, and stormwater runoff. It also can take greater advantage of natural purification and storage systems such as wetlands.

SOME REMEDIES OFFERED

Effectively integrating the management of water quality into the larger context of water resources management requires strong new policy in several areas. Chief among these are:

- a strong commitment to *Pollution Prevention*
- a requirement for the application of the *Best Available Technologies* in the treatment of all waters and waste waters
- a new definition of *Beneficial Use* addresses tomorrow's environmental, social, and economic conditions, and a restatement of water use *Priorities*
- a *Pricing* structure that reflects the full cost of making water available for a particular use or user, including the cost of restoring it to its original quality
- adherence to the ideals of "*Sustainable Development*,"[3] (WCED, 1987) with special emphasis on conservation, reuse, working with nature, and the health of aquatic ecosystems (Doppelt, *et al*., 1993)

Pollution Prevention

Those assuming the task of managing the quality of the nation's water will never be able to remove contaminants from it as fast as, or to the extent that, polluters can introduce them. Furthermore, achieving the removal of these pollutants will always be a costly undertaking, consuming financial resources that could be used in other, more productive ways. This attaches great importance to preventing this pollution. Pollution prevention should be exercised in the home, in business and industry, in agriculture, and in municipalities. It must include control of floods and erosion, as well as watershed protection for sources of domestic and municipal supply. It should apply as well in the cases of domestic and municipal water supplies, in stormwater runoff control, and in the management of irrigation return flows. Specifically, new policy in this area should include consideration of requirements to:

- minimize or eliminate runoff by increased use of small-scale storage and/or other means of keeping precipitation in place, such as natural or constructed wetlands, green spaces, terracing, no-till agriculture, and land/water banks
- compel developers to use on-site water retaining construction, landscaping and water conservative technologies in home building
- oblige farmers and ranchers to use water saving measures and water holding cultivation technology
- limit the amount and location of further urbanization, industrialization and/or agriculturization, in areas of critical concern

Pollution prevention is good physics and good economics, and is also good environmentalism, because there are as yet no technologies that can remove 100 percent of any pollutant 100 percent of the time.

Best Available Technologies

For all of its life, wastewater treatment has been a "stepchild" in the struggle to attract political favor and financial resources. This is true, in the U.S., for all levels of government. It matters not that the safe treatment of these wastes is absolutely essential to the public's health, those who parse a government's capital are never willing to spend a dime on the operation of, maintenance of, or improvements to treatment facilities until they are compelled to do so by a regulatory agency. The result is that such facilities are never "*state-of-the-art*," and never can be relied on to operate at design efficiencies. How can this situation be corrected? It can't be until water quality management is given its legitimate priority among the many competing claims on the community's human and fiscal resources. It will be obvious that this has been done, when laws against un permitted discharges begin to be fully enforced, with appropriately stiff fines being levied and collected, and recalcitrant officials arrested. Harsh? Perhaps. But how can a nation of laws survive if all are free to choose which ones to obey?

Additional points to be considered by policy makers trying to insure that the U.S. always has and makes use of cutting edge water pollution control technology include insuring:

- an emphasis on water reclamation, renovation and reuse
- that all involved with water quality management are equipped, with the education, training and technology to deal with change, whether climatic, socioeconomic, or environmental
- water management regulations that reflect future environmental and public health urgencies
- water quality control technologies that work with nature, use nonstructural approaches, and are linked to the management of related resources, such as air, soil, and biota
- conjunctive management of water quantity and water quality, as well as concurrent management of surface water and ground water
- integration of all water pollution control planning and operation into the national, regional, and state sustainable development plans

Beneficial Uses and Priorities

The traditions, laws, and regulations of water rights in the U.S. were largely in place by the beginning of the 1900s. They have served the nation and its people well. But the U.S. today is a far cry, in almost every respect from the one that existed one-hundred years ago, and a reexamination of this subject in light of today's needs is long overdue. For example, a large portion of the water rights in the western U.S. is still held and used by agriculture. Those rights often are based on crop water needs as they were understood a century ago. In addition, many of these existing rights, involving governmentally subsidized water originally granted as inducements to settle and cultivate the land, have now been acquired by large corporations, who despite their sometimes enormous assets, continue to enjoy this subsidy.

Those who live in the eastern part of the U.S. have a different set of problems with beneficial water uses and priorities. Riparian rights originally governed water use in these states. However, with the adoption of water use/withdrawal permit systems in most states, a huge increase in large scale water users, and immense return flows of water polluted with wastes from municipalities, industries and agriculture, little is left of the concept of ". . . undiminished in quantity or quality. . . "

If the nation is to make the best future use of its water, it must develop new policies concerning the uses to which its waters may be put, and the priorities for those uses. Included among those needs are:

- safeguarding water supplies, aquatic habitat, ground waters and surface waters from further despoliation
- preventing the use of water, and its concomitant pollution, for things[4] such as irrigation of low value crops, and the transport and dilution of industrial and agricultural wastes
- redefining beneficial use and priorities to assure that future distribution of the resource is made fairly and equitably among those who can make the best social, environmental and economic use of it
- defining the allowable amount of water that can be used for priority purposes, based on the best available conservation, reuse, and water needs technology

Pricing

Until the price of clean water reflects its cost, water will go on being misused, wasted, and polluted. Most municipalities subsidize the costs of treating wastewater, and many of them subsidize the cost of providing water to the user, especially large volume users who are also often large payers of payroll and property taxes. This sounds reasonable to many listeners. Low cost water and wastewater treatment encourages the development of industry, jobs and such good, wholesome family values as cleanliness.

However, these considerations are somewhat misleading. When the cost of water to the user is subsidized, there is a tendency to use more of it than is needed. This is bad enough, but there is a double negative at work in such cases. Not only is water wasted, more of it gets polluted in the process. If this water is returned as wastewater for treatment, an additional cost is incurred, and additional treated effluent is discharged - perhaps to an already polluted river. Making users pay the true cost of water and wastewater treatment is a necessary first step in the integration of water quality considerations into overall water resources.

CONCLUSIONS

For any community, at any time, there are always several futures. For example, one of these may be a place laid waste by flood, drought, water pollution, or other environmental disasters, with the survivors facing poverty, disease and despair. Another might be one in which the quality of life, for all, is no less than that experienced today by the U.S. middle-class. Still another might actually be a more abundant, fulfilling life for all. There is a choice.

The choice, however, is not between changing or not changing; the future will occur, and its occurrence will mean change. The question is about the kind of change that will come, and the results of that change in terms of life's quality for those who will live this future. Right choices, the fears of some notwithstanding, can mean not only continued economic prosperity but greater opportunity for development in all aspects of human life.

Can a high quality future be had in the U.S.? Probably. Can it be had without significant changes in the nation's water management practices? Perhaps not. The future is likely to add insult to injury in U.S. water resources management, unless thoughtful people seize the moment, make the right choice, and begin planning for it now.

And who will they be? For the past eighteen years, there has been no entity at the federal level with responsibility for leading the nation in the comprehensive management of its waters.

And what will they work with? The tools now in use for water resources management, quantitatively or qualitatively were created to handle the highly visible issues of a young, wildly growing nation: providing ports, harbors, and usable channels for water transport; supplying water and electricity for cities, industry, and agriculture; providing flood control for cities built hurriedly and in the wrong places; cleaning up visibly polluted rivers and lakes. These tools are the heavy equipment of water management, and they still serve us well when they are needed. In the U.S., however, most of these kinds of water management chores are finished. The heavy lifting has been done. The future will require skill and finesse, not brute force.

The water management problems of the past will continue to be seen in some places, occasionally. Future water concerns, however, will be far more obvious, compelling and complex.. Climate change, globalization, population pressures, new and fearsome chemical and biological threats promise new challenges to those who would assume the burden of providing the nation with adequate supplies of water, of sufficient quality to meet all foreseeable needs. Given today's political, educational, and cultural circumstance, it is a daunting task.

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[1] *This paper is dedicated to the memory of Richard S. Engelbrecht.*

[2] *For Example, filling water beds. About forty million Americans sleep in water beds; this represents one out of every five beds sold.*

[3] *The term, "*sustainable development;" *is a phrase with as many meanings, perhaps, as there are users. One that seems particularly useful here has been offered by the* *World Commission on environment and Development.* *It is "* development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

[4] *Who has not witnessed such irrational activities as watering lawns in the dessert - on that rare day when rain does occur!*