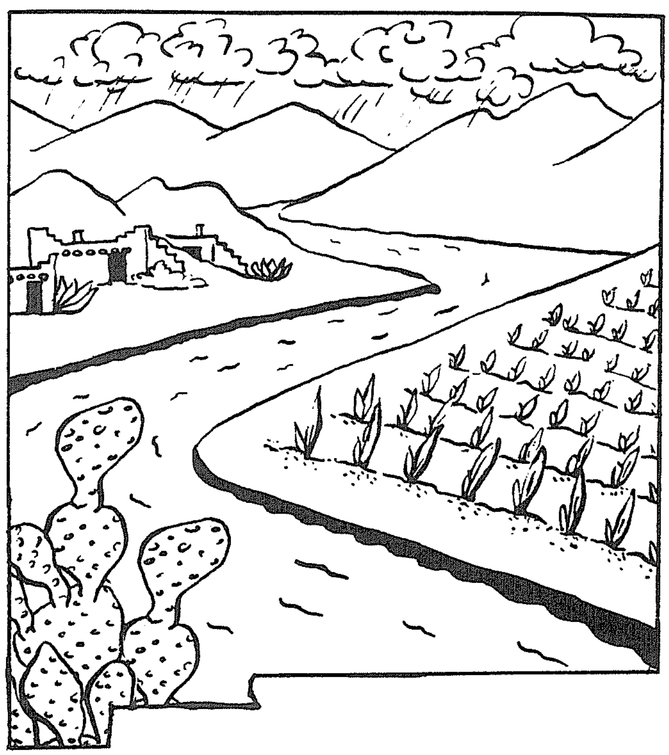
MAY 1991

WRRI Report No. 257

# PROCEEDINGS

# 35TH ANNUAL
# NEW MEXICO WATER CONFERENCE

*Toward a Common Goal:*
*Forging Water Quality Partnerships*



November 15-16, 1990
Holiday Inn Pyramid • Albuquerque

New Mexico Water Resources Research Institute
New Mexico State University • Box 30001, Dept. 3167 • Las Cruces, New Mexico 88003-0001

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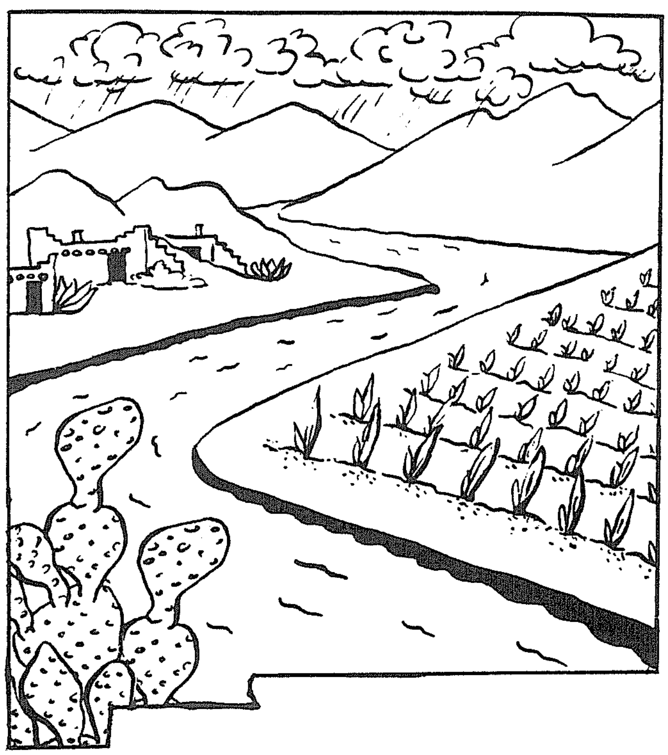

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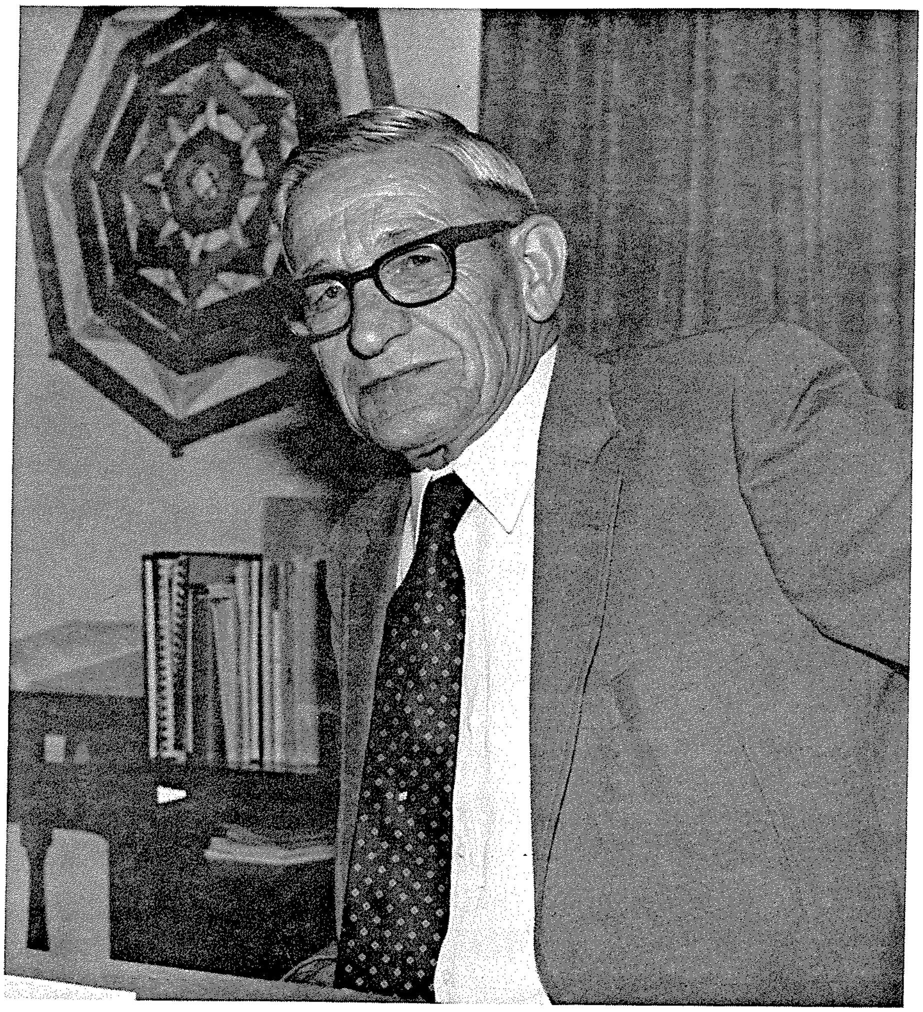
IN MEMORY OF
STEVE REYNOLDS
1916 - 1990



NEW MEXICO STATE ENGINEER
1955-1990

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# PREFACE

At last year's water conference, then Governor Garrey Carruthers predicted that water quality would be the issue of the 1990s. Immediately following that conference, the Water Conference Advisory Committee met to begin planning the 1990 conference. As in the past, they were most helpful in suggesting the topic, format, speakers and site for the 35th Annual New Mexico Water Conference.

This year's conference focused on water quality and the interrelationships of those charged with protecting the quality of New Mexico's water and those who are regulated. Those who regulate, with their abundance of laws and regulations, met with those who are regulated, armed with their particular water needs and practical considerations. The two groups, along with interested citizens, met in an informal setting to discuss openly their water quality concerns.

Several recognized experts presented overviews of federal water law, state surface water legislation, tribal water quality regulation, and federal and state groundwater protection laws. Other knowledgeable speakers provided the background to current water quality issues and conflicts. These talks provided the framework for the lively exchange during panel discussions in which all interested parties presented their perspectives. The audience had an opportunity to ask questions and join in the discussions.

In February 1990, the advisory committee met to finalize plans for the conference. Steve Reynolds, an active member of the advisory committee, was present, and, as always, contributed enthusiastically to the planning. His wisdom, advice, and friendship will be sorely missed in the years to come. In honor of Steve's commitment to our state's water resources, we dedicate this conference to his memory.

Tom Bahr

Tom Bahr
Director

# 35TH ANNUAL NEW MEXICO WATER CONFERENCE

**Toward a Common Goal:**
**Forging Water-Quality Partnerships**

Holiday Inn Pyramid
Albuquerque, New Mexico

THURSDAY, NOVEMBER 15

**Session I: Surface-Water Quality**

| | |
|---|---|
| Moderator: | **Bob Creel, Water Resources Research Institute** |
| 8:30 a.m. | Overview of Federal Water Quality Laws and Regulations<br>**Joe Moore, BCM Engineers, Dallas** |
| 9:00 a.m. | Surface Water Legislation and Regulation in New Mexico<br>**Ruth Kovnat, University of New Mexico Law School** |
| 9:30 a.m. | Tribal Water Quality Regulation<br>**Kevin Gover, Gover, Stetson & Williams, P.C.** |
| 10:00 a.m. | Break |
| 10:30 a.m. | Introduction to Surface Water Issues and Conflicts<br>**Gary Daves, City of Albuquerque** |
| 11:00 a.m. | Panel Discussion<br><br>Moderator: **Al Utton, University of New Mexico Law School**<br><br>Panel Members:<br>**Daniel Sanchez, All Indian Pueblo Council**<br>**Cecilia Castillo, Silver City attorney**<br>**Steve Hernandez, Elephant Butte Irrigation District attorney**<br>**Bob Hogrefe, City of Albuquerque**<br>**Ken Kirkpatrick, EPA Region 6 Office**<br>**Bill Miller, State Engineer Office**<br>**Jim Piatt, Environmental Improvement Division**<br>**Nicasio Romero, New Mexico Acequia Association**<br>**Jean Manger, US Army Corps of Engineers** |
| Noon | Lunch |

**Session II: Groundwater Quality**

| | |
|---|---|
| Moderator: | **Lynn Brandvold, New Mexico Bureau of Mines and Mineral Resources** |
| 1:30 p.m. | An Overview of State and Federal Legislation Designed to Protect Groundwater from Contamination<br>**John Hernandez, New Mexico State University** |
| 2:00 p.m. | What is Groundwater and How Does it Behave?<br>**Robert Bowman, New Mexico Tech** |
| 2:30 p.m. | USGS Water Quality Assessment Program<br>**Russell Livingston, U.S. Geological Survey** |
| 3:00 p.m. | Break |
| 3:15 p.m. | Drinking Water Protection Strategies<br>**Bruce Thomson, University of New Mexico** |
| 3:45 p.m. | Groundwater Issues and Conflicts: The Decade Ahead<br>**George William Sherk, Will & Muys, P.C.** |
| 4:15 p.m. | Panel Discussion<br><br>Moderator: **George William Sherk, Will and Muys, Wash. D.C.**<br><br>Panel Members:<br>**Cynthia Ardito, Hydrogeologist**<br>**Dave Boyer, Oil Conservation Division, NM Energy, Minerals and Natural Resources**<br>**Stuart Castle, Environmental Improvement Division**<br>**Dan Stephens, Daniel B. Stephens & Associates, Albuquerque**<br>**Greg Odegarde, El Paso Natural Gas** |

## FRIDAY, NOVEMBER 16

### Session III: The Human Element in Water Pollution Control

| | |
|---|---|
| Moderator: | **Maxine Goad, Environmental Improvement Division** |
| 8:30 a.m. | Risk Assessment: How Safe is Safe?<br>**Stephen Shelton, University of New Mexico** |
| 9:00 a.m. | The Squawfish that Ate Farmington<br>**Charles DuMars, University of New Mexico Law School** |
| 9:30 a.m. | Aquatic Habitat and Critters in a Dry State<br>**Richard Cole, New Mexico State University** |
| 10:00 a.m. | Break |
| 10:15 a.m. | Costs and Benefits: What is Sensible and Reasonable in the Realm of the Possible?<br>**William Humphries, State Land Office** |
| 10:45 a.m. | Panel Discussion<br><br>Moderator: **John Hernandez, New Mexico State University**<br><br>Panel Members:<br>**John Dendahl, Economic Development and Tourism Dept.**<br>**Fred Gross, New Mexico Wildlife Federation**<br>**David Henderson, Audubon Society**<br>**Richard Mitzelfelt, Environmental Improvement Division**<br>**Dick McCleskey, New Mexico Game & Fish Dept.**<br>**Bob Porter, New Mexico Farm & Livestock Bureau**<br>**William Humphries, State Land Office** |

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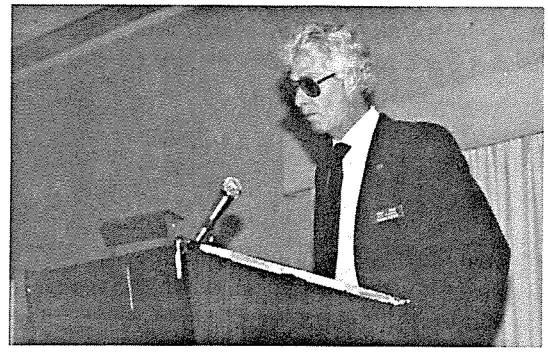
**Bob Creel** is the assistant director of the New Mexico Water Resources Research Institute. He served as WRRI's acting director from 1987-1989. Dr. Creel's experience in resource economics includes more than 25 projects including work on the $6 million High Plains Ogallala Aquifer Study. He holds a doctorate in resource economics from the University of New Mexico and bachelor's and master's degrees in agricultural economics from New Mexico State University. Dr. Creel is a native New Mexican who grew up on a ranch near Ruidoso.



**Albert E. Utton** is chairman of the New Mexico Interstate Stream Commission. He also serves as director of the International Transboundary Resources Center and as professor of international law at the University of New Mexico. He teaches international law, natural resources law, and water law. Mr. Utton has written and edited numerous books and articles on the law of natural resources, including *Pueblo Indian Water Rights*, *International Groundwater Law*, and *Transboundary Resources Law*.

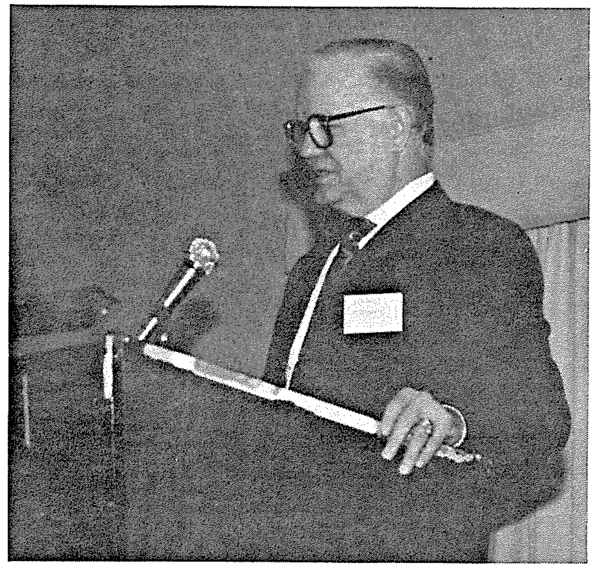
**Lynn Brandvold** is a senior chemist at the New Mexico Bureau of Mines and Mineral Resources and an adjunct professor at New Mexico Tech. Ms. Brandvold has been with the Bureau of Mines since 1965. She is the most senior member of the Water Quality Control Commission, having served on the WQCC since 1972. Ms. Brandvold received a B.S. and an M.S. from North Dakota State University.

**George William Sherk** is an attorney with the Washington, D.C. firm, Will and Muys. He served as a trial attorney with the U.S. Department of Justice, Land and Natural Resources Division for six years, specializing in water law. Prior to his Justice Department position, Mr. Sherk was a special assistant in the Office of Water Policy and was a staff associate with the National Conference of State Legislatures where he worked with 24 states regarding state legislation affecting water and alternative energy development. He holds bachelor's and master's degrees in political science from Colorado State University. He received his J.D. from the University of Denver College of Law.

**Maxine S. Goad**, water resource specialist, has been working in water pollution control for the New Mexico Environmental Improvement Division since 1974. She was principal draftsperson and one of the principal developers of the New Mexico Water Quality Control Commission regulations to protect groundwater quality. Present and recent duties include working on coordination of programs to protect groundwater quality and on New Mexico's Wellhead Protection Program. Ms. Goad received B.S. and M.S. degrees in physics from Stanford University.

**John Hernandez**, is a professor in the Civil, Agricultural, and Geological Engineering Department at New Mexico State University. He is the former Dean of Engineering at NMSU, and has served as an associate engineer with the New Mexico Department of Health where he was responsible for the water-pollution control program and has worked for the New Mexico State Engineer Office twice. Also, Dr. Hernandez was Deputy Administrator at the U.S. Environmental Protection Agency from 1981-1983. He received a B.S. in civil engineering from the University of New Mexico, master's degrees from Purdue and Harvard universities as well as a doctorate in water resources from Harvard.

*Joe Moore, Jr. is a senior technical consultant with BCM Engineers in Dallas. Moore was program head for the graduate program in Environmental Sciences at the University of Texas at Dallas from 1976-1979, and was a professor in the program from 1979-1989. For four of those years he commuted from Dallas to Detroit, Michigan, where he was assistant administrator of wastewater operations. He has served as special master in a soil cleanup and remedial program involving the state of Texas, the city of Dallas, and a lead smelter. Mr. Moore also served as program director for the National Commission on Water Quality from 1973-1976 and as commissioner in the Federal Water Pollution Control Administration under Stewart Udall. Mr. Moore holds bachelor's and master's degrees from the University of Texas at Austin, and has completed 80 hours of law courses in their law school.*



# OVERVIEW OF FEDERAL WATER QUALITY LAWS AND REGULATIONS

*Joe G. Moore, Jr.*
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*14651 Dallas Parkway*
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## HISTORY

Today I'll begin by providing a bit about the history of water quality law to put into perspective what I will later say about current laws and regulations. Federal water pollution control began with a 1956 statute calling for a Publicly Owned Treatment Works (POTW) Construction Grant Program. This water pollution control program predates programs on which the media has focused when discussing environmental legislation. The 1965 Water Quality Act set in motion the development of state and federal water quality standards. The act was based on a constitutional provision that relates to interstate commerce. Therefore, the original Water Quality Act was applicable to interstate waters only. The law's focus had to be interstate commerce because it was that part of the U.S. Constitution upon which the federal action was founded.

Water quality standards are comprised of three parts. The first concerns criteria relating to various water uses without regard to specific locations. Those criteria led to the so-called green book, blue book, red book, and gold book—the water quality criteria books issued by federal agencies. The criteria apply to municipal use for human consumption, industrial use, agricultural use, cooling water, navigation and so on. Secondly, each state is required to classify its surface waters as to intended uses, whether they are for municipal water supply, industry, irrigation, navigation, hydropower, fisheries or so on. Thirdly, an implementation plan is developed in which states propose how they will achieve the required water quality standards for various uses. Implementation plans were subject to approval by the Federal Water Pollution Control Administration, which subsequently passed them to the Secretary of the Interior for approval.

It is not often remembered that federal water pollution control was initially housed in the old Department of Health, Education, and Welfare. It was moved to the Department of Interior and remained there until the creation of the Environmental Protection Agency (EPA).

One of the important issues in the 1960s regarding water quality was non-degradation. The original policy statement on non-degradation was issued by Stewart Udall largely at the urging of the National Wildlife Federation. (In those days we called environmentalists the "fin and feathers people"—those interested in fishing or hunting.) The non-degradation statement was a major federal/state controversy in the late 1960s and referred to water that was above the quality specified in the water quality standards. For water below the quality intended to be achieved under the water quality standards, there was wasteland allocation. All who deal with water quality today know that those two concepts still exist in the administration of water quality standards.

Congress became disenchanted with the progress being made under the Water Quality Act of 1965. As is usually the case with legislators, they think they solve problems by passing laws. They passed the act in 1965; in 1967 they amended it slightly, and by 1969 they were wondering why water quality had not yet improved. It had taken 100 years to degrade our water to that point, but Congress wanted to solve the problem in two to four years, which is about their attention span since they run for office every two years. So Congress became dissatisfied and felt water quality standards were not working. Senator Muskie helped lead the charge in the Senate to change the law. After two years of hearings, the 1972 amendments to the Federal Water Pollution Control Act were passed.

The Senate bill that passed was largely the one that emerged as the 1972 amendments. The amendments shifted the constitutional basis for the Federal Water Pollution Control Act from the interstate commerce clause to the general welfare clause. This has led to the confusion we now have over United States waters.

## CURRENT FEDERAL WATER QUALITY REGULATION

The current Clean Water Act contains what I call a circular definition—waters of the United States are navigable but nobody has ever been able to define navigable waters for the entire nation accurately and legally. Each state has its own definition. In Texas, navigable waters are those waters and streams that may have flowed at least one inch deep from cut bank to cut bank with a width of at least 30 feet. Thus most of West Texas' dry arroyos are navigable waters. But navigable waters do not mean that much. For all intents and purposes, the federal government has jurisdiction over all surface waters for water quality purposes.

The law has shifted to technology-based effluent standards or effluent limitations applied uniformly to every industrial and agricultural business discharge without regard to water quality. Dischargers must employ the technology to achieve the effluent limitations whether or not it is needed for water quality purposes. Even irrigation return flows that were covered by the original statute were not removed until the 1977 amendments. The law also mandated universal national secondary treatment by publicly owned treatment works be achieved by 1977. Congress made the cities sit still for that by bribing them with 75 percent matching federal grants for publicly owned treatment works construction. This program lasted until the 1981 amendments to the construction grant section of the Clean Water Act.

There were two primary goals in the 1972 statute. One was introduced by California Senator Tunney. He managed to set the interim goal of attaining a level of water quality by 1983 wherever attainable that would allow recreation in and on the water and protect fish, shellfish and wildlife. The law has been applied nearly everywhere without regard to the words "wherever attainable."

A goal instituted at the insistence of Senator Muskie called for the elimination of pollutant discharges by 1985. Originally Muskie had written into the Senate bill a provision mandating a 1985 deadline for the elimination of all discharged pollutants into surface waters. The House had a different view, and the disagreement turned into the longest controversy on any piece of legislation in the United States Congress up until that time. The House wanted to retain water quality standards in the law. For that reason, we have a peculiar statute that is bifurcated with a series of provisions that relate to technology-based effluent limits and another series of provisions that relate to water quality standards. Those of you who were around then will remember that early administrators of EPA ignored almost completely the water quality standards provisions. Given the law, the EPA had the responsibility for somehow making sense of these two different sets of provisions.

Another provision of the 1972 act created the National Commission on Water Quality and called for developing a 1977 mid-course correction for the Clean Water Act in the event the impact of the 1972 amendments was so severe that the law needed amending. What the National Commission on Water Quality really created was a forum in which the unresolved issues of the 1972 act could be resolved by an ad hoc committee serving for about three years. The commission was comprised of five senators, five members of the House, and five presidential appointees. That meant you had three Democrats from the Senate, three Democrats from the House, two Republicans from the Senate, two Republicans from the House, and since Nixon was president then, there were five Republican presidential appointees. If you can add up the arithmetic, that makes nine Republicans and six Democrats. The general assumption was that because the Republicans had a majority, they would drive the commission. Don't you believe it. If you challenge either congressional house, you will find that the Republicans and the Democrats stick together like glue when the prerogatives of Congress are threatened. When these five presidential appointees tried to push a particular point of view that appeared to be critical of Congress, all ten congressional members lined up together and said, "No, we won't vote that way." Eventually I went to one of the Republican presidential appointees and said, "Dr. Gee, you don't understand how this system works." Everything you say to congressional members sets their teeth on edge. You need to find a way to couch what you are saying. I tutored him on how to handle the politics of a body like this. We ultimately managed to develop a commission report with some recommendations.

Another aspect that complicated the commission's work was the fact that we had four potential presidential contenders on the commission: two Democrats and two Republicans. None wanted to see anyone else get an advantage from the commission's actions. And of course, we had that thoroughly non-political person, Vice President Nelson Rockefeller as chairman, along with Senators Muskie and Baker on the executive committee. Texas Senator Bentsen, who was beginning his early run for the democratic nomination for the Presidency, also served. It was an interesting body that had an impact on the current law.

It is important to remember that the Clean Water Act is not designed to protect human health. It is not designed, like other statutes that have since been passed, with a human health perspective. The law's water quality provisions and the administration of the effluent limitations are designed to protect fish, shell fish, and wildlife. There is only a passing mention of municipal water use and no definition of what water quality is appropriate for municipal use. There is certainly nothing like what has evolved in the Safe Drinking Water Act for protecting water for human consumption. Groundwater was incidentally mentioned, and Congress has never figured out quite how to get its foot in the door on groundwater. Congress will continue to try, although western states generally have managed to keep groundwater out of the Federal Water Pollution Control statutes.

An amendment to the 1981 Clean Water Act substantially revised the POTW Construction Grant Program. Several other statutes concerned with water quality have been passed since the original Federal Water Pollution Control Act, now known primarily as the Clean Water Act. First, the 1974 Safe Drinking Water Act established maximum contaminant levels (MCLs) and goals (MCLGs) for drinking water quality. Amendments to the act have further restricted water quality levels. In many instances the EPA regards MCL or MCLGs as the driving numbers for groundwater remediation under the Resource Conservation and Recovery Act (RCRA). RCRA started as a statute relating to garbage collection but was converted into a hazardous waste disposal act as amendments were added. So now we have a cradle-to-the-grave program for regulating the disposal of hazardous waste. The requirements regulate the design and construction of treatment, storage and disposal hazardous waste facilities. The program also calls for the elimination of open dumps and governs landfills.

An enormous number of National Priority List (NPL) sites must be remediated under the Superfund program (Comprehensive Environmental Response, Compensation and Liability Act). The EPA has largely consolidated its regulations on water quality for groundwater into the process for remediation of Superfund sites. There are also Superfund amendments, the 1984 re-authorization, and Title III: the Community Right to Know Statute that pose problems in some areas regarding water quality.

## THE GOVERNMENTAL PROCESS

I would like to make some pronouncements, which is what one can do when one gets to my age—one can afford to make them. I love to make predictions for at least 25 years in the future because I won't be around when someone wants to come up to me and say I was wrong. Before making those pronouncements I am going to provide a little bit about the reality of the governmental process. Here are a few of my observations.

- No president has had significant impact on major environmental bills whether Democrat or Republican. No president has had a real impact. Executive influence is more often negative rather than positive, preventing or delaying action rather than initiating it. For example, three presidents have vetoed the major water pollution control statutes—Eisenhower in 1956, Nixon in 1972, and Bush in 1986. Thus, presidents generally have not supported the statutes.
- Administrative agency regulations issued pursuant to, or under the authority of a statute, are equal, in legal effect, to the law from which they are derived. A properly promulgated regulation does not have less stature than a law. Regulations are not second-class statutes. They are as binding as the law itself.
- No regulation prepared by an executive agency including EPA can be published in the Federal Register unless it is approved by someone in the Office of Management and Budget (OMB), a part of the White House staff. Don't ever let anyone tell you that an EPA regulation doesn't represent the president's view. It can't get out unless it represents the president's view. Someone from OMB may not be speaking entirely for the president, but he or she presumes to speak for the president. The practical effect is that OMB does speak for the president.
- EPA staff who write environmental regulations have less knowledge and understanding of, and experience in, the activities for which they write regulations than do those in the regulated group or community. Often competent EPA staff are hired away by the regulated groups so that they do not have to put up with their being effective regulators.
- If the EPA administrator does not issue regulations as rapidly as Congress believes he or she should, Congress imposes schedules for issuance of regulations that have come to be known as "hammer" provisions. The new Clean Air Act was signed by the President just today. Those of you who may have some involvement in the Clean Air Act are going to be up to your eyeballs in air toxics within a matter of 18 months to two years. The hammer provisions say that if the EPA doesn't do something by such and such a date, dire consequences will ensue.
- If the EPA administrator issues regulations with which Congress disagrees or the courts reach opinions which Congress believes are incorrect, Congress changes the regulations or the laws to make them consistent with congressional opinions.
- There is a widespread belief in both federal and state governments that demanding laws and regulations are "technology forcing" whereby state and federal governments adopt requirements that cannot be met with any known technology. In other words, regulations can be imposed for which there is no technology to achieve compliance. The statute's mere existence will guarantee the development of the technology. It's as though Alexander Graham Bell were under a congressionally mandated deadline to produce the

telephone. There are those, like Senator Muskie's assistant, Leon Billings who are firm believers in this result. When I see Leon occasionally today he tells me, "See, I told you we'd develop the technology." In some instances, of course, we have.

Several publications are worth reading on this subject. "Environmental Russian Roulette" appeared in the August 19, 1990, issue of *Water and Environment Technology*, a new publication of the Water Pollution Control Federation. The article describes the difficult regulations being proposed by the EPA through the 1976 Resource Conservation Recovery Act and the impossibility of fixing limits at or below the detection level. "Technologies Risk List Assessment Distortions" was written by Dr. J.H. Lehr, an active member of the National Waterwell Driller's Association and a prime mover in the development and passage of the Safe Drinking Water Act. Dr. Lehr makes the point that regulators have gone overboard with controlling toxics, particularly under the Safe Water Drinking Act in the development of which he was influential.

Recently, on October 9, 1990, the EPA proposed a final agency lead strategy directed toward the elimination of lead uses in the United States that may have adverse environmental consequences. This strategy includes testing drinking water at the tap for lead. A statute restricting lead in drinking water at the tap did not pass both houses of Congress but it did pass the Senate Committee on Environment and Public Works. The reason I call attention to these documents is that there is a continuing trend to achieve the impossible in water quality matters and particularly in water quality regulations.

**PREDICTIONS FOR THE FUTURE**

I believe some principles, trends or consequences can be perceived from the past twenty years of environmental laws and regulations that will be applicable in the foreseeable future.

- Environmental regulations will continue to become more restrictive and more specific. Numerical limits on permissible discharges of pollutants will become lower and cover more pollutants. Public demand and congressional response will mandate the changes.
- Public fears rather than scientific certainty will dominate new areas of regulation and generate legislation and regulations that will narrow the discretion of governmental administrators and the range of compliance choices available to the regulated groups.
- Those in the regulated groups who desire voluntarily to comply with environmental regulations will be increasingly frustrated with the number, length and complexity of new regulations and will succumb ultimately more and more to what I call the "Income Tax Syndrome"—I'll just do the best I can and see if they ever catch me!

With specific reference to those statutes and regulations for water, the 1990s will, I believe, see the following:

- Expansion of the number of effluent limits on discharges from POTWs to include any chemical or substance of concern for the protection of fish, shellfish and wildlife that may reach an individual treatment plant from household wastewater, industrial discharges subject to pretreatment effluent limits, and stormwater infiltration or runoff. At a minimum, POTW limits will be prescribed for all "priority pollutants" and "toxics in toxic amounts" even below the detection limit. I am associated with the city of Detroit where I have been working for eleven years with the city's Wastewater Treatment Plant. The state of Michigan has proposed a permit for Detroit that would require limits on mercury and cadmium ten orders of magnitude below the detection limit by any known methodology. There will be a provision that indicates if the detection limit is reached in the effluent from the POTW, it is an automatic violation and the city should mail a $25,000 per day check to the Michigan Department of Natural Resources. The reason the permit is now in Federal District Court is because there are 18 other pollutants the state wishes the city to monitor during the five-year permit with the obvious intent to add numerical limits in the next permit.

- Technology-based effluent limits will be prescribed for smaller and smaller groups in the standard industrial classification (SIC) system of the Department of Commerce; these limits will cover every chemical or substance of concern for the protection of fish, shellfish and wildlife and "toxics in toxic amounts"; pretreatment effluent limits will be as strict as those for direct discharge, that is, "best available technology economically achievable" (BAT), wherever applicable.
- Use of calculated effluent limits derived from state adopted water quality standards, including those derived from state compliance with the EPA published strategy for stormwater control and treatment, will expand significantly. Such an approach avoids the procedural due process required for "best practicable control technology currently available" (BPT), "best conventional pollutant control technology" (BPCT), and BAT prescribed in the Clean Water Act, and no "economic achievable" determination is necessary.
- Municipal and industrial treated wastewater dischargers will be required to provide state and federal regulators "Pollutant Mass Balance Reports," recording the volume of every pollutant required to be identified in the treatment plant influent and documenting its ultimate proportionate alternation, disposition in the wastewater discharge, emission to the air, and disposal in the sludge or ash. Influent pollutant volumes will be required to balance, as nearly as possible, volumes disposed into the air, water, or ground.
- Congressional efforts to fashion a groundwater pollution control statute will continue and will ultimately succeed. The most likely first successful step will be some scheme for a comprehensive groundwater quality inventory, followed with attempts to establish groundwater quality standards. The number of "sole source aquifers" designated under the Safe Drinking Water Act will continue to increase.
- Control of water pollution will lead ultimately to schemes for water quantity allocation where supplies of good quality water for desired uses are short. Surface water quantity will be controlled separately from, and before, groundwater use.
- Non-point source pollution controls for agricultural and urban stormwater runoff will become more precise and specific, probably emphasizing pollution prevention more than treatment after contamination.
- Treatment for all municipal water supplies will become more sophisticated and expensive; MCLs under the Safe Drinking Water Act will become more numerous and more restrictive. Disposal of water supply treatment plant sludge will become more difficult and more expensive.
- Municipal and industrial water reuse will expand because of the cost of higher levels of treatment of wastewaters; if concentrations of sodium chloride can be controlled adequately, human reuse of human wastewater will become a viable alternative in water-short areas and where treated wastewater is of higher quality than the receiving water.
- Superfund sites on the NPL will continue to contaminate groundwater (and maybe surface water, also) far into the 21st century because of the large number of sites (nearly 1200), the procedures being followed to select the remediation method, and the substantial per site costs being incurred.
- Because of groundwater contamination fears, landfilling of hazardous waste will be terminated. Incineration at sites remote from population centers or in floating incinerators at some distance offshore are the most likely substitutions for landfilling.
- Waste reduction, recycling and reuse are the most likely methods to reduce the volume of non-hazardous waste going to landfills, thus avoiding any substantial contamination of groundwater likely to occur from solid waste disposal.

Thank you for the opportunity to participate in this significant conference.

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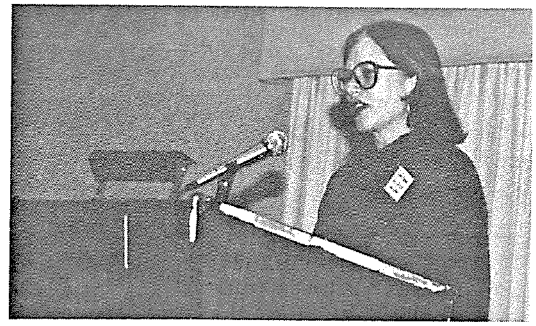

# SURFACE WATER LEGISLATION AND REGULATION IN NEW MEXICO

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## SUMMARY

The Water Quality Act, N.M. Stat. Ann. 74-6-4, empowers the Water Quality Control Commission (WQCC) to adopt a comprehensive water quality program and to adopt water quality standards as a guide to water pollution control. The commission is further empowered to adopt regulations to prevent or abate water pollution. In making its regulations, the commission is required to give the weight it deems to be appropriate to all facts and circumstances, including, but not limited to:

- gravity of injury to or interference with health, welfare and property;
- the public interest, including social and economic value of the water contaminant sources;
- technical practicability and economic reasonableness of reducing or eliminating water contaminants from the sources affected;
- successive uses;
- feasibility of pre-treating before a subsequent use; and
- property rights and accustomed uses.

Section 303(c)(1) and 303(c)(2)(B) of the Federal Clean Water Act require the Water Quality Control Commission to review "Water Quality Standards for Interstate and Intrastate Streams in New Mexico" triennially. Adoption of both regulations under the Water Quality Act and water quality standards under the Federal Clean Water Act must be preceded by a public hearing following at least 30 days notice (N.M. Stat. Ann. 74-6-6).

WQCC regulations and standards adopted as rules are appealable to the New Mexico Court of Appeals (N.M. Stat. Ann. 74-6-7; see Bokum Resources Corp. v. N.M. WQCC, 93 N.M. 546, 1979). However, the requirement that the commission consider the factors identified in section 74-6-4 D. appears to be limited to the adoption of regulations as distinguished from the adoption of water quality standards (N.M. Stat. Ann. 74-6-4 C). In any event, in the context of adopting standards for organic compounds in groundwater, the New Mexico Court of Appeals held that subsection D does not require the record before the commission to contain the commission's consideration of every part of every one of the six statutory factors for each compound, recognizing considerable commission discretion in its consideration of the factors and the weight it gives to each (Tenneco Oil Co. v. New Mexico Water Quality Control Commission, 107 N.M. 469, Ct. App. 1988).

Section 74-6-12 F of the Water Quality Act provides that reasonable degradation of water quality resulting from beneficial use shall be allowed in the adoption of both regulations and water quality standards. However, Part 1 of the WQCC Water Quality Standards for Interstate and Intrastate Streams sets forth an antidegradation policy which provides that degradation of waters the quality of which is better than the stream standards established by the WQCC is not reasonable degradation and is subject to abatement, unless it is justifiable as a result of necessary economic and social development. In addition, it requires protection and maintenance of existing instream water uses, WQCC Water Quality Standards 1-101.

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# TRIBAL WATER QUALITY REGULATION

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Federal environmental regulatory laws generally require the Environmental Protection Agency (EPA), to establish standards for various sources of pollution, enforce standards through a permitting system, and, where a state so requests, delegate primary enforcement authority to the state. In general, no person or activity is beyond the reach of federal environmental statutes or outside the jurisdiction of the state in which the person conducts his activity. However, special rules apply when the regulated person is an Indian or Indian tribe or the regulated activity takes place within Indian country. This paper will discuss the applicability of federal water quality laws to Indians and Indian country and the scope of tribal and state authority to enforce water quality laws within Indian country.

## Applicability of Federal Environmental Laws to Indians and Indian Lands

Indian tribes have been characterized as "domestic dependent nations"[2] that possess all powers of government that have not been explicitly removed by the United States or held inconsistent with a tribe's status as a domestic dependent nation.[3] Based on this unique political status, Congress has full plenary power to legislate with respect to Indians and Indian tribes.[4] Thus, the initial inquiry is whether federal water quality statutes apply to Indians, Indian tribes, and Indian lands.

Congressional power to include Indians and tribes within the scope of federal statutes is unquestionable.[5] However, whether a specific federal statute applies to Indians and tribes depends on the intent of Congress.[6] General federal laws apply within Indian country and are enforceable against Indians and Indian tribes where the statute expressly mentions Indians and tribes.[7] In most instances interpretative questions arise when federal laws do not specifically refer to Indians and tribes, but instead appear to apply across the board to all persons or property.[8] In resolving these questions, the United States Supreme Court generally requires that Congress' intent to invade tribal rights and authority be clearly expressed in the legislative history, or the surrounding circumstances, or by the existence of a statutory scheme requiring national or uniform application.[9] Special considerations are triggered when the subject of the enactment involves treaty rights and areas traditionally left to tribal self-government.[10]

Federal environmental regulatory laws require uniform application to be effective. Both the Clean Air Act[11] and the Resource Conservation and Recovery Act (RCRA)[12] have been held to apply to Indian lands. No case in which a tribe has successfully challenged the application of federal environmental laws to its lands has been reported.

The federal courts have consistently held that the RCRA applies to Indian lands and may be enforced against Indian tribes.[13] In *Blue Legs v. United States Environmental Protection Agency*,[14] the Oglala Sioux Tribe operated several solid waste disposal sites on lands owned by the Tribe within the Pine Ridge Reservation. Each of the sites was operated as an "open dump," despite the prohibition on such dumps in the RCRA.[15] The court noted that the citizen suit provision[16] could be invoked for proceedings against "persons engaged in the act of open dumping." The term "person" is defined by the RCRA as including a "municipality,"[17] which in turn is defined to include "an Indian tribe."[18] The court concluded that these provisions and definitions indicate that Congress intended to include Indian tribes as regulated entities under the RCRA.[19] The Court ruled that federal jurisdiction existed to enforce the prohibition of open dumps against the tribe. Additionally, the court held that the tribe has the responsibility, stemming from its inherent sovereignty, to regulate, operate, and maintain solid waste facilities on the Reservation.[20]

The same result would be expected under federal water quality laws. The enforcement provisions of the Clean Water Act apply to "persons."[21] "Person" is defined to include "municipalities."[22] "Municipality" is defined to include "an Indian tribe."[23] The reasoning of the *Blue Legs*[24] and *Washington Department of Ecology*[25] cases yields the conclusion that the Act applies to Indian tribes.[26] Similarly, under the Safe Drinking Water Act, national primary drinking water regulations apply to all "public water systems."[27] A "supplier of water" is "any person who owns or operates a public water system."[28] "Person" is defined to include a "municipality,"[29] and "municipality" is defined to include an "Indian tribe."[30] Again, *Blue Legs*[31] and *Washington Department of Ecology*[32] would indicate that tribes are subject to the Act.

**Tribal Authority to Enforce Environmental Laws**

The likely result of litigation concerning the applicability of federal water quality laws to Indians, Indian tribes, and Indian lands is that the laws will be held to apply. Moreover, virtually no question exists that Congress can expressly require the application of such laws to Indians and Indian lands.[33]

Given that federal environmental laws either do apply to Indian lands, or can be made to apply, the issue becomes one of determining which government—federal, tribal or state—should enforce those laws within Indian country. Before that issue may be resolved and policy established, the scope of tribal jurisdiction must be determined. No doubt exists as to the power of tribes to enforce tribal laws against members. The key inquiry is whether tribes may enforce their laws against nonmembers.

Tribes retain sovereign authority to regulate activities within their territory, and this power extends to non-Indian activities on fee lands within reservations when those activities affect or threaten important tribal interests. In *United States v. Mazurie*,[34] the United States Supreme Court addressed the question of whether Congress may properly delegate its regulatory authority to tribes. The Court relied on the Indian Commerce Clause[35] and the "recognized relation of tribal Indians to the federal government" in upholding

Congress' power to do so.[36] The Tenth Circuit had characterized the tribal government as a"private, voluntary organization, which is obviously not a governmental agency," but the Supreme Court disagreed:

> [Previous decisions of the Court] surely establish that Indian tribes within "Indian country" are a good deal more than "private, voluntary organizations," and they thus undermine the rationale of the Court of Appeals' decision. These same cases, in addition, make clear that when Congress delegated its authority to control the introduction of alcoholic beverages into Indian country, it did so to entities which possess a certain degree of independent authority over matters that affect the internal and social relations of tribal life.[37] (Citations omitted.)

The seminal case of *Montana v. United States*,[38] sets forth principles which guide courts in determining the extent of tribal civil regulatory authority over non-Indians within reservation boundaries. In 1974, the Crow Tribe enacted an ordinance prohibiting hunting and fishing within the Crow Reservation by non-members of the Tribe. The United States Supreme Court held that neither the Crow treaties nor inherent tribal sovereignty empowered the Crows to regulate non-Indian hunting and fishing on fee-patented land within the Reservation. In rejecting the Crows' argument, the Court distinguished between tribal authority over Indians and tribal authority over non-Indians. Relying on *United States v. Wheeler*,[39] the Court held that:

> [E]xercise of tribal power beyond what is necessary to protect tribal self-government or to control internal relations is consistent with the dependent status of the tribes, and so cannot survive without express congressional delegation. Since regulation of hunting and fishing by non-members of a tribe on lands no longer owned by the tribe bears no clear relationship to tribal self-government or internal relations, the general principles of retained inherent sovereignty did not authorize the Crow Tribe to adopt [the ordinance prohibiting non-Indian hunting and fishing]."[40](Citations omitted.)

Despite the sweeping nature of the foregoing proposition, the Court then used equally broad language to describe the scope of jurisdiction over non-Indians retained by the tribes:

> To be sure, Indian tribes retain inherent sovereign power to exercise some forms of civil jurisdiction over non-Indians on their reservations, even on non-Indian fee lands. A tribe may regulate, through taxation, licensing, or other means, the activities of non-members who enter consensual relationships with the tribe or its members, through commercial dealings, contracts, leases, or other arrangements. A tribe may also retain inherent power to exercise civil authority over the conduct of non-Indians on fee lands within its reservation when that conduct threatens or has some direct effect on the political integrity, the economic security, or the health or welfare of the tribe.[41] (Citations omitted.)

Several subsequent cases interpreting *Montana*, have upheld tribal civil regulatory jurisdiction on fee lands over non-Indians in the context of tribal health and safety regulations[42] and land use zoning.[43]

Last year, the United States Supreme Court rendered its decision in *Brendale v. Confederated Tribes and Bands of Yakima Indian Nation*,[44] striking down tribal authority to zone fee lands owned by non-members within one portion of the reservation, and upholding tribal zoning authority over all land located within another portion of the reservation. The Justices wrote three opinions, with no majority agreeing on the rationale for either holding. The effect of *Brendale* on tribal civil regulatory jurisdiction remains uncertain.

The courts have not yet resolved definitively the scope of tribal authority to enforce federal environmental statutes. Because, however, tribes may lawfully be delegated federal authority, the tribes and the EPA have developed a variety of schemes by which tribal interests are protected through federal regulation.

In *Nance v. Environmental Protection Agency*,[45] the Ninth Circuit affirmed the EPA's approval of the Northern Cheyenne Tribe's redesignation of its reservation and held that the action of the EPA was not arbitrary or capricious.[46] Several petitioners argued that the delegation of redesignation authority to tribes violated the Clean Air Act on the theory that Section 107(a) delegated the responsibility to the states "for assuring air quality within the entire geographic area comprising the state."[47] The court rejected that argument and concluded that:

> [W]ithin the present context of reciprocal impact of air quality standards on land use, the states and Indian tribes occupying federal reservations stand on substantially equal footing. The effect of the regulations was to grant the Indian tribes the same degree of autonomy to determine the quality of their air as was granted to the states. We cannot find compelling indications that the EPA's interpretation of the Clean Air Act was wrong. Nor can we say that the Clean Air Act constitutes a clear expression of Congressional intent to subordinate the tribes to state decision making.[48]

The petitioners also charged that the delegation of redesignation authority to the Tribe was unconstitutional. The petitioners attempted to distinguish *Mazurie*[49] on the grounds that here tribal authority to redesignate could result in effects off the reservation. Addressing this argument, the court stated:

> Certainly the exercise of sovereignty by the Northern Cheyenne Tribe will have extraterritorial effect. But another element must be considered, namely the effect of the land use outside the reservation on the reservation itself. This case involves the "dumping" of pollutants from land outside the reservation onto the reservation. Just as a tribe has the authority to prevent the entrance of nonmembers onto the reservation, a tribe may exercise control, in conjunction with the EPA, over the entrance of pollutants onto the reservation.[50] (Citations omitted.)

**State Authority to Enforce Environmental Laws in Indian Country**

As noted above, primary enforcement responsibility may be delegated to states under most federal environmental regulatory statutes. In developing these statutory schemes, Congress failed to consider the regulatory authority of tribal governments and the limited nature of state authority on Indian reservations. Before a state may assume primary enforcement responsibilities for federal environmental laws on reservations, the state must demonstrate to EPA's satisfaction that the state has jurisdiction.

Recognition of tribal sovereignty does not serve as a complete barrier to the assertion of state authority in Indian country. Recent cases indicate that courts are increasing their reliance on preemption as a method for resolving jurisdictional questions involving tribes and states. Under principles of preemption, state regulatory laws cannot be applied to Indian reservations if their application will interfere with the achievement of the policy goals underlying federal laws relating to Indians. Where tribal and federal interests are adequately protected and the state has a strong regulatory interest, state laws can be applied to Indian reservations, at least as to non-Indian activities on fee lands.

The United State Supreme Court recently articulated the preemption analysis in *California v. Cabazon Band of Mission Indians*,[51] to decide the issue of state regulatory jurisdiction within reservation boundaries. The Court held that "[s]tate regulation would impermissibly infringe on tribal government. . . ."[52]

The tribes urged that, in the absence of express congressional consent, states cannot apply their regulatory laws to Indians on Indian reservations. The Court disagreed and set forth the following preemption analysis:

> Our cases, however, have not established an inflexible *per se* rule precluding state jurisdiction over tribes and tribal members in the absence of express congressional consent. . . .
>
> Decision in this case turns on whether state authority is pre-empted by the operation of federal law; and "[s]tate jurisdiction is pre-empted . . . if it interferes or is incompatible with federal and tribal interests reflected in federal law, unless the state interests at stake are sufficient to justify the assertion of state authority." The inquiry is to proceed in light of traditional notions of Indian sovereignty and the congressional goal of Indian self-government, including its "overriding goal" of encouraging tribal self-sufficiency and economic development.[53] (Citations omitted.)

In identifying the federal and tribal interests involved, the Court found that the federal government had pursued a policy of promoting tribal bingo enterprises through loans and other financial assistance and through federal regulation of tribal bingo management contracts. The Court noted that the bingo games were the only sources of revenue for the two tribal governments, and that the tribes therefore possessed a substantial interest in the bingo activities.[54] California asserted the need to prevent the infiltration of organized crime in the tribal games as its sole interest in regulating the bingo enterprises. However, because California presented no evidence of such infiltration, the Court ruled that this concern was insufficient to "escape the pre-emptive force of federal and tribal interests."[55]

The courts also thus far have prohibited the application of state environmental laws to Indian reservations. *State of Washington Department of Ecology v. United States Environmental Protection Agency*,[56] addresses the issue of whether a federal environmental statute conveys authority to a state over tribal lands. Section 3006 of the RCRA[57] authorizes states to establish hazardous waste management programs "in lieu of" the federal program administered by the EPA that otherwise would apply. The State of Washington submitted an application to the EPA to assume primary enforcement responsibility for the RCRA, including enforcement on Indian lands within the state. The EPA approved Washington's primacy application "except as to Indian lands,"[58] and retained to itself jurisdiction to operate the program "on Indian lands in the State of Washington."[59] Washington petitioned the Ninth Circuit Court of Appeals for review of the decision, and the Ninth Circuit held that the Regional Administrator of the EPA properly refused to approve the State program as applied to Indian lands.

The court examined the statutory language and legislative history of the RCRA, and found the RCRA ambiguous as to whether states could regulate hazardous wastes on Indian reservations. Although tribes were defined as being among those "persons" to whom the enforcement provisions of the RCRA applied, the statute was silent as to the authority of states to enforce their hazardous waste regulations against Indian tribes or individuals on Indian land.[60] Additionally, the court found nothing in the legislative history on the issue of state regulatory jurisdiction on reservations. The court ruled that the EPA reasonably interpreted the RCRA as not granting "state jurisdiction over the activities of Indians in Indian country."[61]

The court stated that "[s]tates are generally precluded from exercising jurisdiction over Indians in Indian country unless Congress has clearly expressed an intention to permit it."[62] Additionally, the court noted that federal retention of authority over Indian lands is consistent with the United State's trust responsibility to tribes.[63] The court stated:

> The federal government has a policy of encouraging tribal self-government in environmental matters. That policy has been reflected in several environmental statutes that give Indian tribes a measure of control over policy making or program administration or both. . . . The policies and practices of EPA also reflect the federal commitment to tribal self-regulation in environmental matters.[64]

**United States Environmental Protection Agency Indian Policy**

The jurisdictional rules applicable to Indian country leave the EPA unable to pursue its usual practice of delegating primary enforcement responsibility to states where Indian reservations are concerned. Moreover, until recently, none of the major federal regulatory statutes provided for delegation to tribal governments. In short, the EPA was forced to develop special rules and practices concerning environmental regulation on Indian reservations. To address these special circumstances, in November 1984, the EPA issued the EPA Policy for the Administration of Environmental Programs on Indian Reservations (The "Indian Policy").[65] The stated purpose of the Indian Policy is "to consolidate and expand on existing EPA Indian Policy statements in a manner consistent with the overall Federal position in support of Tribal self-government' and government-to-government' relations between Federal and Tribal Governments" and to improve the "environmental quality on reservation lands."[66]

The Indian Policy clearly assumes that tribal governments should be the primary decision-makers on environmental matters arising on Indian Reservations:

> The keynote of this effort [to protect human health and the environment] will be to give special consideration to Tribal interests in making Agency policy, and to insure the close involvement of Tribal Governments in making decisions and managing environmental programs affecting reservations lands.[67]

The Indian Policy appears to contemplate that unitary regulatory systems governing both Indians and non-Indians are to be developed, as indicated by the constant references to "Indian reservations" rather than "Indian lands." To the extent it reflects official congressional policy toward tribal governments, the Indian Policy may have the effect of preempting state regulatory authority as to the matters to which the policy is directed.

The EPA's prior policy of working with tribal governments, even in the absence of explicit statutory authority, was specifically approved by the Ninth Circuit in *Nance*[68] and *Washington Department of Ecology*.[69] In line with this prior practice, the Indian Policy states that the EPA will assist interested tribes in developing programs and in assuming regulatory environmental management over reservations. This assistance will include making grants to tribes similar to those currently available to state governments.

Finally, with respect to jurisdictional issues, the Indian Policy states that, until tribes assume full responsibility for delegable programs, the EPA will retain responsibility for reservations unless the state has received an express grant of jurisdiction from Congress. The Indian Policy also makes clear the EPA's view that all federal environmental regulatory statutes apply to Indian reservations and are enforceable against Indians and even Indian tribes. The Indian Policy acknowledges that impediments to tribal assumption of delegable programs exist in the language of present procedures, regulations, and statutes and states that EPA will work to remove such impediments.

**The Indian Amendments to Federal Water Quality Laws**

As described above, federal environmental regulatory statutes as initially conceived did not provide for the delegation of primary enforcement responsibility to Indian tribes. In 1985, representatives of tribal governments began working with Congress to develop amendments to the Safe Drinking Water Act and Federal Water Pollution Control Act to specifically authorize such delegations.

The Safe Drinking Water Act was amended in 1986 to allow tribes to be treated as states for its programs. 42 U.S.C. Section 300j-11 now provides that tribes may obtain primary enforcement responsibility for public water systems and for underground injection control if:

- the tribe is federally recognized and has a governing body carrying out substantial governmental duties and powers;
- the functions to be exercised by the tribe are within its jurisdiction; and

- the tribe is reasonably expected to be capable of carrying out the functions to be exercised in a manner consistent with all the terms and purposes of the Act and all applicable regulations.

Proposed regulations for tribal enforcement of National Primary Drinking Water and Underground Injection Control Standards were published on July 27, 1987;[70] final rules were published in the Federal Register on September 26, 1988.[71] These regulations establish a three-step process by which tribes may assume primary responsibility for enforcement of the Public Water System and Underground Injection Control programs, requiring that they:

- obtain designation for "treatment as a State;"
- apply for a grant to develop a program; and
- receive primacy.

Following the amendment to the Safe Drinking Water Act, the Clean Water Act[72] was amended to allow tribes to be treated as states for certain purposes, provided that:

- the Indian tribe has a governing body carrying out substantial governmental duties and powers;
- the functions to be exercised by the Indian tribe pertain to the management and protection of water resources which are held by an Indian tribe, held by the United States in trust for Indians, held by a member of an Indian tribe if such property interest is subject to a trust restriction on alienation, or is otherwise within the borders of an Indian reservation; and
- the Indian tribe is reasonably expected to be capable, in the Administrator's judgment, of carrying out the functions to be exercised in a manner consistent with the terms and purposes of this chapter and of all applicable regulations.[73]

Under the amendments, tribes may be treated as states for purposes of, *inter alia*, the following:

- grants for pollution control programs under Section 1256;
- grants for construction of treatment works under Section 1281-1299;
- water quality standards and implementation plans under Section 1313;
- enforcement of standards under Section 1319;
- clean lake programs under Section 1324;
- certification of National Pollutant Discharge Elimination System ("NPDES") permits under Section 1341;
- issuance of NPDES permits under Section 1342; and
- issuance of permits for dredged or fill material under Section 1344.

The proposed regulations on the development and implementation of water quality standards under the Clean Water Act were published on September 22, 1989.[74] Several important issues remain regarding the details of the state-tribal dispute mechanism, the arbitrary acceptance of state water quality standards on reservations in the absence of tribal standards, and the burdensome and vague application process for tribes. The proposed rule for treatment of tribes as states for the Dredge and Fill Permit Program was published on November 29, 1989.[75]

**The Nature and Scope of Tribal Environmental Programs**

While the passage of the "Indian Amendments" to the federal water quality laws permits and encourages tribal governments to become involved in the development, operation, and control of tribal water quality programs, not all of the twenty-two tribal governments in New Mexico can be expected to initiate such programs. However, the tribal environmental regulatory programs that do develop in the 1990s will present a mixed bag of blessings and curses. Tribal laws are, after all, just more laws, providing both the desired certainty and loathed restrictions characteristic of all laws. And tribal enforcement requires learning yet another set of procedures to follow in yet another new, and somewhat idiosyncratic, jurisdiction.

Each tribe—like each state—will approach the development and management of its environmental program in an individual way, intended to meet the concerns and address the realities of its reservation resources and the needs of its residents and those doing business on the reservation. Persons who have experienced the development and implementation of several tribal tax programs may recognize the process and will understand that a large, wealthy tribe will be more likely to have a relatively sophisticated existing administrative infrastructure while a small, poor tribe may have to adopt a more basic approach.

One of the difficulties of dealing with tribal water quality programs is that they are likely to represent quite a spectrum of procedures, personalities, policies, and predictability, thus placing new learning requirements on persons under tribal jurisdiction, for while the tribes, like the states, follow the federal mandate, the implementation strategies are as diverse as the governments themselves, and the myriad of jurisdictional differences should keep things lively for the remainder of the century.

Becoming familiar with the programs themselves is just the beginning. Often appeals from administrative decisions are made to the tribal council or are in tribal court, thus requiring the regulated community to become familiar with strange new local customs and practices, from admission through final appeal. For example, every tribal court system has its own rules regarding who can practice before it, and under what circumstances; yet the number of attorneys who overlook the necessity and courtesy of checking into such rules is greater than one might hope. Though the councils and courts are themselves changing to accommodate the increasing contact with and challenges of non-Indians, careless attorneys may very well find themselves dealing with rules, decisions, attitudes, and customs for which they are unprepared. Most of these peculiarities are similar to those an attorney reasonably could expect in any unfamiliar jurisdiction, but some will be specific to tribes in general. For example, though state water codes often establish separate divisions to manage ground and surface water, tribal water codes are more likely specifically to recognize and accommodate the interrelation not only of ground and surface water, but also of water, the land, and the air.

Such differences in positions have the potential to frustrate industry's attempts to negotiate and participate within a tribal framework. Anyone within a tribe's jurisdiction should develop at least a passing knowledge of and respect for the various tribal positions on environmental issues that affect the reservation land, air, water, and wildlife. A tribal position may often be grounded in religion, oblivious to—or at least unswayed by—the financial concerns motivating many. Users and developers of natural resources may heartily disagree with traditional resource-based environmentalists who seek to ensure that resources are used wisely and with an eye to the future, but both approaches are themselves contrasted with the concept of deep ecology that does not recognize the earth, its habitats, its minerals and forests, as "resources" of any kind, only to be used, however wisely. The philosophy of deep ecology, similar to many tribal traditions that honor and respect nature and the earth, requires learning to "think like a mountain." As educator Robert Aitken Roshi says "[w]hen one thinks like a mountain, one also thinks like the black bear, so that honey dribbles down your fur as you catch the bus to work."[76] Thinking like a mountain can be expected to contrast with thinking like a coal miner or an oil man, and it will be easier to clash over the nature and scope of tribal water quality regulation and enforcement if these profound differences in perspective are not recognized and reconciled. While "green" thinking or "mountain" thinking may be a part of the future of off-reservation development, it is likely to be an integral part of the present for on-reservation development.

Another difficulty in dealing with tribal programs may very well be the imposition of heavy costs or impact fees on the business interests. When state governments were launching their environmental programs in the 1970s, federal funding was plentiful. Today, tribes face the ordeal of starting up tribal programs under Gramm-Rudman restrictions; they must compete with dozens of other tribes and with the states for the limited funds; and the tribal resources themselves are often scant. As a result, many tribes must start their demanding environmental programs with inadequate start-up funding.

Tribes were not originally eligible for the billions of dollars distributed to the states over the past twenty years to develop their regulatory programs. Now, while state programs have matured and require only maintenance funding, tribal programs are in their vulnerable embryonic stages, sadly handicapped by the lack of funding. Although all the major federal environmental laws are expected soon to authorize tribes to assume primacy, much remains to be done in the development and implementation of federal policies and regulations if the tribal programs are to be useful and effective. New incentives are needed to take into account the fact that tribal environmental concerns have been largely ignored throughout the history of EPA. This failure to recognize and meet the needs of fledgling tribal programs threatens the promise of the EPA Indian policy and the tribal amendments to the statutes. Prior to the emergence of tribal environmental programs, EPA claimed sole responsibility to enforce federal environmental laws on the reservations. The experience of many tribes, however, is that EPA failed to meet that responsibility. The EPA now is asking the tribes to address the legacy of its neglect of reservation environments but refuses to make available resources adequate to the task.

Tribes faced with the desire to regulate the use of their water and land, but without the requisite dollars, may seek to fund their environmental programs with tax revenues obtained from on-reservation businesses such as minerals production, particularly if the business activities are those requiring regulation. Tribes may also seek to fund their programs with permitting fees obtained, for example, from a company desiring an exclusive right to landfill on the reservation. And they may seek to fund their programs by requiring interested developers to pay the costs of setting up the infrastructure and procedures under which the developers propose to proceed. Because natural resource and land developers ultimately must go where the natural resources and land are, and because the developers have found it cost effective to pay for the opportunity to use tribal resources, the tribes have been relatively successful in pursuing these rather creative but obligatory financing schemes.

Despite the difficulties in adjustment and the start-up costs, the specter of functioning under tribal water quality programs is not thoroughly dismal, and the advantages may far outweigh the disadvantages. Tribal programs are smaller, and being smaller, are more flexible and responsive than cumbersome state programs could ever hope to be. The tribal procedures, from permitting to appealing, are generally faster, more efficient, and substantially simpler than the analogous state or federal procedures. And because tribal programs are in their genesis, they are often relatively unformed and receptive to outside suggestions and change. Opportunities exist for the non-Indian public to have a significant impact not only on the substance of the laws but also on their subsequent interpretation and application.

Normally, a tribe wishing to exercise increased control over particular aspects of its tribal environment will create a tribal environmental quality and protection agency under the aegis of its general governmental powers. The powers of such a tribal agency may be broad enough to encompass various interrelated areas, or may be tailored to address the specific environmental concern sought to be controlled. In the latter case, the agency may be run by one person with contract access to experts and consultants. Larger environmental quality agencies may be made up of several individual environmental departments, each with its own experts and consultants.

### Conclusion: The Need for Tribal-State Cooperation

Although federal environmental laws, as originally enacted, failed to address the regulatory authority of tribal governments and the limited nature of state authority in Indian country, the current view of Congress, the courts, and the EPA is that states do not have jurisdiction to enforce environmental laws on reservations. With respect to the recently amended statutes that allow tribes to assume responsibility for delegable programs, state authority over Indian country is effectively foreclosed. In accordance with the objectives set forth in the EPA Indian Policy,[77] presumably other federal environmental laws will be amended to expressly provide for the delegation of primary enforcement responsibility to Indian tribes. Disputes between states and tribes are bound to erupt as the tribes develop their programs.

One possible solution to such controversies between tribes and states over jurisdiction issues is to resolve them by negotiation. Certainly this is the preferred method for a variety of reasons, not the least of which are the costs and uncertainty of litigation. Moreover, the tribes and state are fitting partners in environmental regulation. Pollution does not respect political boundaries, and neither tribes nor states can regulate environmental quality on a regional basis without the cooperation of the other.

The likely parameters of such agreements are fairly obvious. First, jurisdiction is simply non-negotiable. No tribe or state is going to concede that it lacks jurisdiction or that the other has jurisdiction; it makes little sense to negotiate on an issue as to which agreement will never be reached. Further, it is extremely doubtful that either tribes or states have the power to confer jurisdiction over Indian country on the other. No one doubts, however, that a person conducting activities on a reservation requiring environmental regulation is subject to the jurisdiction of one or the other; and it should not matter much whether a joint tribal-state regulatory program is exercising state power or tribal power at any given moment.

A second advantage to tribal-state agreements is that they acknowledge that the states have something the tribes don't, which is to say the resources, experience, and expertise acquired in regulating environmental quality to date. Through an agreement, a tribe might simply retain a state environmental agency to serve as its "consultant" in technical matters arising in the enforcement of tribal environmental laws. Particularly given the limited resources of most tribes, the ability to call upon state resources and expertise would be a valuable asset to any tribal regulatory program.

A third advantage to tribal-state agreements is that they acknowledge that the tribes have something that the states do not: jurisdiction over Indian lands. As noted above, an environmental regulatory program cannot be effective if it cannot be applied on a regional basis. A state with an exemplary program could fail in its efforts to protect the environment if it cannot control pollution originating on Indian lands. Indeed, the states should be anxious to see strong and effective tribal regulatory programs develop, since such programs can guarantee that state environmental quality goals are met.

**Endnotes**

1. Gover, Stetson & Williams, P.C. is an Indian-owned law firm that represents Indian tribes and tribal agencies. The attorneys contributing to this article are Kevin Gover, Catherine Baker Stetson, and Jana L. Walker.
2. *Cherokee Nation v. Georgia*, 30 U.S. 1, 17 (1831).
3. *See generally, F.S. Cohen, Handbook of Federal Indian Law*, 231 (1982 ed.); *see also, United States v. Wheeler*, 435 U.S. 313 (1978); *Oliphant v. Suquamish Indian Tribe*, 435 U.S. 191 (1978).
4. *Lone Wolf v. Hitchcock*, 187 U.S. 533 (1903). This power is not absolute, but is subject to guardianship and constitutional limits. *United States v. Sioux Nation*, 448 U.S. 371, 415 (1980).
5. *See supra* note 4.
6. F.S. Cohen, *Handbook of Federal Indian Law*, 282 (1982 ed.).
7. "The intended coverage of statutes specifically pertaining to Indians is generally clear; by their terms these laws are either territorially confined to Indian country or are topically applicable only to Indians, tribes, the Indian Service, or Indian property." F.S. Cohen, *Handbook of Federal Indian Law*, 282 (1982 ed.).
8. Examples of such general federal laws include federal tax laws, environmental laws, civil rights laws, laws regulating business activities and labor relations regulations. F.S. Cohen, *Handbook of Federal Indian Law*, 282 (1982 ed.).
9. *See, e.g.*, F.S. Cohen, *Handbook of Federal Indian Law*, 283 (1982 ed.); *Santa Clara Pueblo v. Martinez*, 436 U.S. 49 (1978); *Bryan v. Itasca County*, 426 U.S. 373 (1976).
10. *See, e.g., United States v. Dion*, 476 U.S. 734 (1986).
11. Clean Air Act, 42 U.S.C. Section 7401-7642 (1982).
12. Resource Conservation and Recovery Act, 42 U.S.C. Sections 6901-6991i (1982).
13. *Washington Department of Ecology v. United States Environmental Protection Agency*, 752 F.2d 1465 (9th Cir. 1985); *Blue Legs v. United States Environmental Protection Agency*, 668 F.Supp. 1329 (D.S. Dak. 1987) aff'd sub nom. *Blue Legs v. Bureau of Indian Affairs*, 867 F.2d 1094 (8th Cir. 1989).

14. *Blue Legs v. United States Environmental Protection Agency*, 668 F.Supp. 1329 (D.S.Dak. 1987).
15. *See* 42 U.S.C. Section 6945.
16. The citizens suit provision of the RCRA at 42 U.S.C. Section 6972, combined with the open dumping prohibition of the RCRA, creates a federal cause of action that allows citizens and states to seek judicial relief from federal courts. *Blue Legs*, 668 F.Supp. at 1336.
17. 42 U.S.C. Section 6903 (15).
18. 42 U.S.C. Section 6903 (13).
19. *Blue Legs*, 668 F.Supp. 1337. The court also relied heavily on the decision in *State of Washington Department of Ecology v. United States Environmental Protection Agency*, 752 F.2d 1465 (9th Cir. 1985), which established that Indian tribes are regulated entities under the RCRA. The court reasoned that as such, tribes should also be subject to the citizen suit provision of the RCRA. *Id.* at 1338.
20. *Id.* at 1337.
21. *See, e.g.*, 33 U.S.C. Section 1311(a).
22. 33 U.S.C. Section 1362(5).
23. 33 U.S.C. Section 1362(4).
24. *Blue Legs v. United States Environmental Protection Agency*, 668 F.Supp. 1329 (D.S.Dak. 1987).
25. *State of Washington Department of Ecology v. United States Environmental Protection Agency*, 752 F.2d 1465 (9th Cir. 1985).
26. Safe Drinking Water Act, 42 U.S.C. Sections 300f-300j (1982).
27. *See* 42 U.S.C. Section 300g.
28. 42 U.S.C. Section 300f(5).
29. 42 U.S.C. Section 300f(12).
30. 42 U.S.C. Section 300f(10).
31. *Blue Legs v. United States Environmental Protection Agency*, 668 F.Supp. 1329 (D.S.Dak. 1987).
32. *State of Washington Department of Ecology v. United States Environmental Protection Agency*, 752 F.2d 1465 (9th Cir. 1985).
33. *See supra* note 4.
34. *United States v. Mazurie*, 419 U.S. 544 (1975).
35. U.S. Const. art. I, Section 8.
36. *Mazurie*, 419 U.S. at 553-57.
37. *Id.* at 556-57
38. *Montana v. United States*, 450 U.S. 544 (1981).
39. *United States v. Wheeler*, 435 U.S. 313 (1978).
40. *Montana*, 450 U.S. at 564.
41. *Id.* at 565-66.
42. *See Cardin v. De La Cruz*, 671 F.2d 363 (9th Cir. 1981). In *Cardin*, the Ninth Circuit upheld the Quinalt Nation's application of tribal health and safety regulations to a non-Indian operating a grocery store on fee lands. The court observed that the store owner engaged in voluntary commercial dealings with the Tribe, and that the store owner's conduct threatened the health and welfare of the Tribe.
43. In *Knight v. Shoshone and Arapahoe Tribes*, 670 F.2d 900 (10th Cir. 1981), the Tribes enacted a zoning ordinance and applied the ordinance to prohibit a non-Indian from subdividing and selling fee land for a residential development. The court held that the absence of land use control within the reservation, coupled with the tribal interest in protecting their homeland from exploitation, justified the zoning code. Additionally, the court ruled that "[t]he fact that the code applies and affects non-Indians who cannot participate in tribal government is immaterial" because the developers' activities "directly affect Tribal and allotted lands." 670 F.2d at 903.
44. _ U.S. _, 109 S.Ct. 2994 (1989).
45. *Nance v. Environmental Protection Agency*, 645 F.2d 701 (9th Cir. 1981), *cert. denied sub nom*, *Crow Tribe of Indians, Montana v. Environmental Protection Agency*, 454 U.S. 1081 (1981).
46. *Nance*, 645 F.2d at 704.
47. *Id.* at 713.
48. *Id.* at 714.
49. *United States v. Mazurie*, 419 U.S. 544 (1975).
50. *Nance*, 645 F.2d at 715.
51. *California v. Cabazon Band of Mission Indians*, 107 S.Ct. 1083 (1987).
52. *Id.* at 1095.
53. *Id.* at 1091-92.
54. *Id.* at 1092-1094.
55. *Id.* at 1094.
56. *State of Washington Department of Ecology v. United States Environmental Protection Agency*, 752 F.2d 1495 (9th Cir. 1985).
57. Resource Conservation and Recovery Act, 42 U.S.C. Section 6926.
58. *See* 48 Fed. Reg. 34954 (1983).
59. *Id.* at 34957.
60. *Id.* at 1469.
61. *Id.* at 1469.
62. *Id.* at 1469-1470.

63. *Id.* at 1470.
64. *Id.* at 1471.
65. *EPA Policy for the Administration of Environmental Programs on Indian Reservations*, Nov. 8, 1984.
66. *Id.* at 1.
67. *Id.*
68. *Nance v. Environmental Protection Agency*, 645 F.2d 701 (9th Cir. 1981).
69. *State of Washington Department of Ecology v. United States Department of Ecology*, 752 F.2d 1465 (9th Cir. 1985).
70. 52 Fed. Reg. 28112 (1987).
71. 53 Fed. Reg. 37396 (1988).
72. Clean Water Act, 33 U.S.C. Sections 1251-1387 (1982) (previously known as the Federal Water Pollution Control Act).
73. 33 U.S.C. Section 1377.
74. 54 Fed Reg. 39098 (1989).
75. 54 Fed. Reg. 49180 (1989).
76. Robert Aitken Roshi, "Gandhi, Dogen, & Deep Ecology," *The Mind of Clover* (San Francisco, Calif: North Point Press, 1984).
77. *EPA Policy for the Administration of Environmental Programs on Indian Reservations*, Nov. 8, 1984.

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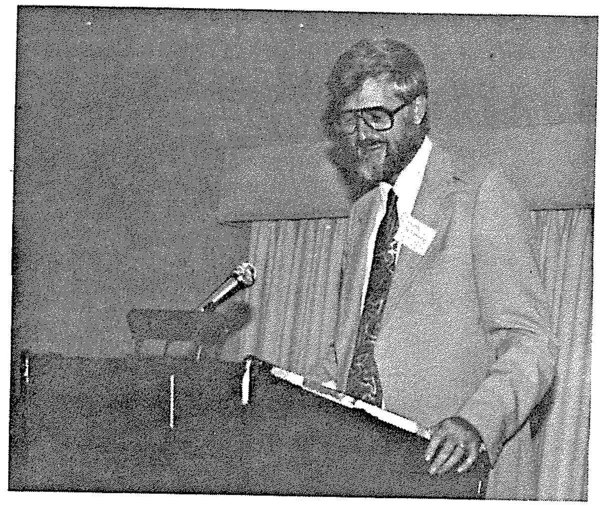

# INTRODUCTION TO SURFACE WATER ISSUES AND CONFLICTS

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This paper sets forth my views on problems existing in the environmental regulatory milieu as they apply to New Mexico's surface water. The focus of this discussion will be surface water quality issues that are conflicts with common sense and rational decision making to an extent that the real issues are masked. Surface water issues addressed concern:

- application of water quality standards to highly regulated streams that can have no to very low flow and dry arroyos;
- water quality standards themselves with ammonia as an example;
- conflicts between water quality standards and irrigation use of surface water; and
- water quality standards and water rights.

Among environmental regulators and enforcers, a **tight bomb pattern syndrome** prevails. The term "tight bomb pattern" comes from a popular book of my college generation called *Catch 22* by Joseph Heller. Let us consider some snippets from this book that give its flavor and illustrate the tight bomb pattern syndrome concept.

The first obscure reference is on page 193:

> The chaplain hesitated, feeling himself on unfamiliar ground again. "Yes, sir," he replied finally. "I think it's conceivable that such an action could interfere with your chances of having the prayers for a tighter bomb pattern answered."
> "I wasn't even thinking about that!" cried the colonel, with his eyes blinking and splashing like puddles. "You mean that

God might even decide to punish me by giving us a looser bomb pattern?"

An aside on parades (page 317) before it's explained:

General Peckem began to wonder with genuine concern just what sort of (expletive deleted, English version of his German name) the Pentagon had foisted on him. "What do you know about?" he asked acidly.
"Parades," answered Colonel Scheisskopf eagerly. "Will I be able to send out memos about parades?"
"As long as you don't schedule any." General Peckem returned to his chair still wearing a frown.
"Can I schedule parades and then call them off?"
General Peckem brightened instantly. "Why, that's a wonderful idea! But just send out weekly announcements postponing the parades. Don't even bother to schedule them."

Then to page 318:

"Don't let it worry you, Scheisskopf," said General Peckem, congratulating himself on how adeptly he had fit Colonel Scheisskopf into his standard method of operation. Already his two colonels were barely on speaking terms. "Colonel Cargill envies you because of the splendid job you're doing on parades. He's afraid I'm going to put you in charge of bomb patterns."
Colonel Scheisskopf was all ears. "What are bomb patterns?"
"Bomb patterns?" General Peckem repeated, twinkling with self-satisfied good humor. "A bomb pattern is a term I dreamed up just several weeks ago. It means nothing, but you'd be surprised at how rapidly it's caught on. Why, I've got all sorts of people convinced I think it's important for the bombs to explode close together and make a neat aerial photograph. There's one colonel in Pianosa who's hardly concerned any more with whether he hits the target or not."

And more on page 321:

Colonel Korn gave Major Danby's shoulder a friendly squeeze without changing his unfriendly expression. "Carry on with the briefing, Danby. And make sure they understand the importance of a tight bomb pattern."
"Oh, no Colonel," Major Danby blurted out, blinking upward. "Not for this target. . . ."
. . . "We don't care about the roadblock," Colonel Korn informed him. "Colonel Cathcart wants to come out of this mission with a good clean aerial photograph he won't be ashamed to send through channels. Don't forget that General Peckem will be here for the full briefing, and you know how he feels about bomb patterns."

Page 323:

"Go on out there and bomb—for me, for your country, for God, and for that great American, General P.P. Peckem. And let's see you put all those bombs on a dime!"

The book's hero on page 324:

Yossarian no longer gave a damn where his bombs fell . . .

Too many of our environmental solutions are tight bomb patterns. Somewhere in the process we have lost sight of the target in the substantive sense. Let's give a damn where our environmental bombs fall.

I don't view the syndrome as applied to environmental solutions with the malicious glee that pervades *Catch 22* but rather as a descriptive term of an inevitable phase in the environmental movement which needs to mature into a new era, an era of harder targets and fewer bombs.

Let me characterize some antidotes to the tight bomb pattern syndrome as I've found them expressed in the September 1990 Environmental

Protection Agency (EPA) report entitled, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*. Key words and phrases from this report are:

- Reasoned use of discretion
- Prioritization
- Public perception vs. scientific understanding
- Bias against new approaches
- Temporal/Spatial extent of risk from pollution

Discretion - The overriding disturbing element of environmental law to me is the limits on discretion it imposes in successive layers as it trickles down from Congress. It's as if only the big guys upstream can be trusted to set the rules. Yet, discretion does and should exist, and **must** be used by those who have it in a way they think it makes sense. New Mexico should not lockstep with General EPA Dallas to put its nitrification/denitrification bombs on Albuquerque's Wastewater Plant unless it makes sense. If not, let's find another target.

The EPA-commissioned report expressed it this way:

> "EPA should reflect risk-based priorities in its budget process. Although EPA's budget priorities are determined to a large extent by the different environmental laws that the Agency implements, **it should use whatever discretion it has to focus budget resources at those environmental problems that pose the most serious risks.**" (page 6)

So should the Environmental Improvement Division (EID). And to the extent EID or the Water Quality Control Commission can focus (by regulation or persuasion) others' budgets toward "environmental problems that pose the most serious risks," they should do so.

Prioritization - This is the report's overriding theme and an essential element in the rational use of discretion. The report states:

> "Seen in its historical context, the ad hoc development of U.S. national environmental policy is understandable. Yet 20 years of experience in developing and implementing environmental policy has demonstrated that not all environmental problems are equally serious and not all remediation efforts are equally urgent. The nation cannot do everything at once. In national efforts to protect the environment, the most obvious steps have been taken to reduce the most obvious risks. Now environmental priorities must be set." (page 6)
> "These priorities should be based on an explicit comparison of the relative risk posed by different environmental problems, and, more specifically, on the opportunities for cost-effective risk reduction." (Appendix C, page 4)

The state should heed this advice.

Public Perception vs. Scientific Understanding -

> "Public opinion polls taken over the past several years confirm that people are more worried about environmental problems now than they were 20 years ago when the first wave of environmental concern led to major changes in national policy. But the remaining and emerging environmental risks considered most serious by the general public today are different from those considered most serious by the technical professionals charged with reducing environmental risk." (page 12)

And:

> "EPA's budgetary and programmatic priorities are established largely by Congress, which in turn responds to the interests expressed by the electorate. The public's attitude about an environmental problem is often heavily influenced by qualitative aspects of the risks it presents—whether the risks are voluntary or involuntary; whether there is an identifiable 'villain' responsible for the problem; whether the risks are familiar and predictable or unusual and dreaded. By contrast, scientists and other technical experts are trained to judge the serious-

ness of an environmental problem in much more quantitative terms, asking, for example, about the number and severity of adverse effects likely to be caused by the problem. As a result, the environmental problems that they consider most important often do not match the priorities set by Congress." (Appendix C., pages 13, 14)

For environmental decision makers to rely solely on public perceptions—to the exclusion of their own views of reality—is poor policy and an injustice to the public served.

Bias Against New Approaches -

"EPA needs to overcome its bias against new approaches. Today, when new approaches are examined, they tend to be held to a higher level of performance than existing approaches. There are long lists of known implementation problems with existing approaches but the status quo continues partly because thorough evaluations of the effectiveness and cost of existing programs are not routinely performed. EPA needs to allocate resources to non-conventional approaches and to give these types of measures serious consideration in agency decision making." (Appendix C, page 5)

One can substitute EID and the state for EPA.

Temporal/Spatial Extent and Intensity of Exposure from Pollution -

"... Other aspects of potential environmental problems (i.e., their temporal and spatial dimensions) also must be given considerable weight in any analysis of relative environmental risk. Consideration of time and space can help guide judgments about relative risks in the absence of complete data."

"The time and space dimensions of environmental problems should weigh heavily in any comparison of relative environmental risks. For example, if long-lived pollutants like DDT and PCBs can become concentrated in the food chain and pose a threat to future as well as present human and ecological health, those future risks should be taken into account when relative risks are compared. Similarly, if global climate change or stratospheric ozone depletion has the potential to affect the health and/or economic well-being of virtually everyone on earth, now and in the future, the extent and duration of the risk should suggest a relatively high-risk ranking." (page 10)

The report set out the following considerations for ranking environmental concerns:

- the spatial extent of the area subjected to the stress;
- the importance of the ecosystem that is actually affected within the stressed area;
- the potential for the problem to cause ecological effects and the ecological response;
- the intensity of exposure; and
- the temporal dimension of both effects and the potential ecological recovery. (Appendix A, page 12)

Let's not lump toxics together without distinction. DDT accumulates as it goes up the food chain. Ammonia dissipates as it goes down the river.

To sum up, the tight bomb pattern syndrome can be avoided by "elbows-out," reasoned use of discretion to seek environmental goals consistent with the New Mexico water environment and priorities with due regard to New Mexico water environmental problems. Legislation and regulations should provide for administratively and judicially reviewable discretion to fit environmental goals to site-specific realities. Bureaucrats need to think.

All should agree that costs and benefits are essential ingredients of environmental prioritization. Money spent for environmental reasons with no or minimal benefit is not available for other things including environmental programs of real, substantial and comparatively greater benefit. Environmental progress should relate to dollars spent but can't be measured by dollars spent. On a related point, perceptions should not blur differences that might warrant differentiation nor, on the other hand, make distinctions of emotional or semantic import but that shouldn't make a difference. All of these are alive and well in the water quality regulatory business.

**New Mexico Water Quality Standards**

A brief summary discussion of the New Mexico Surface Water Quality Standards regulations provides a backdrop to the water quality issues that will be discussed.

In concept, the standards protect, maintain, and in some cases improve water quality in New Mexico's surface waters, for the protection, maintenance and attainment of desirable uses of the surface waters. As set out in the standards:

> "The purpose of these standards is to designate the uses for which the surface waters of the State of New Mexico shall be protected and to prescribe the water quality standards necessary to sustain the designated uses."

Within the standards, uses are variously labelled as "designated," "attainable" and "existing." Stream reaches, ponds and lakes are assigned designated uses that are either "existing" or "attainable." "Existing" uses are presumably those that in fact exist in a given surface water, whereas "attainable" uses are those that a given surface water could achieve with implementation of the standards for that water.

Surface water uses include:

- Five subcategories of fishery: high quality cold water, cold water, marginal cold water, warm water, and limited warm water;
- Primary (swimming) or secondary (boating, bank fishing) contact recreation;
- Domestic water supply;
- Livestock and wildlife watering and
- Irrigation.

Protection standards are either numerical or narrative, and relate to water chemistry (dissolved oxygen, heavy metals, ammonia, chlorine, pesticides, organics, etc.), turbidity and temperature. Water quality parameters, to which no standards currently attach but nevertheless affect attainable or existing uses, are such things as stream flow or water body level variability, water depths, and stream or water body bottom constituency.

The standards apply to discharges into waters by placing waste-load limits to the pollutant concentration in the discharge to prevent the standards from being exceeded in the receiving waters beyond a mixing zone. The standards also contain purely regulatory elements such as determination of flow levels to which they apply for setting waste--load limits and defining their applicability to certain activities such as irrigation and flood operations.

Proposed changes to the standards for which a public hearing was held in June 1990 are pending. Proposed changes include amendments to text, definitions, changes to and additional numerical standards, etc. The proposed amendments have been initiated by the state EID for adoption by the New Mexico Water Quality Control Commission (WQCC).

Under the Water Quality Act, the WQCC "shall adopt water quality standards as a guide to water pollution control" (Section 74-6-4C, NMSA) and "shall adopt .... regulation to prevent or abate water pollution ...." (Section 74-6-4D). "Under the Act, 'water pollution' means introducing or permitting the introduction into water, either directly or indirectly, of one or more water contaminants in **such quantity and of such duration** as may with reasonable probability injure human health, animal or plant life or property, or to unreasonably interfere with the public welfare or the use of property." Section 74-6-2, NMSA. (Emphasis added). Accordingly, introduction of a contaminant into water is not water pollution unless it hurts someone or something.

The Water Quality Standards for Interstate and Intrastate Streams in New Mexico are clearly both the "guide" of subparagraph C. and the "regulations" of subparagraph D., despite informal statements by EID personnel that the standards are not regulations. This construction is important, because as regulations their promulgation requires the WQCC to "give weight it deems appropriate to all facts and circumstances, including but not limited to:

- character and degree of injury to or interference with health, welfare and property;

- the public interest, including social and economic value of the sources of water contaminants;
- technical practicability and economic reasonableness of reducing or eliminating water contaminants from the sources involved and previous experience with equipment and methods available to control the water contaminants involved;
- successive uses, including but not limited to, domestic, commercial, industrial, pastoral, agricultural, wildlife and recreational uses;
- feasibility of a user or a subsequent user treating the water before a subsequent use; and
- property rights and accustomed uses."

(Section 74-6-4-D)

**Standards-Making Process**

The standards-making process has two significant shortcomings. First, the process does not allow consideration of site-specific factors that often affect the validity and value of a particular standard as applied to a particular situation. In fact, the trend in the proposed changes is for the standards to be more and more generally applied across different designated uses and to all waters. Opportunity for site-specific analysis should allow the possibility of a specifically tailored standard or, more likely, allow conditions for meeting a standard that are less stringent.

On the other hand, to the extent that a site-specific analysis supports the standard and its routine application to a given location, credibility and support for the standards and the discharge permits they drive would be enhanced. Allowing site-specific determinations within otherwise generally applied numerical standards should protect designated uses. It would have the added benefit of creating and expanding New Mexico-specific technical knowledge applicable toward standards-setting and create and quantify true benefits gained from money and effort expended to implement the standards. To do otherwise satisfies only those content with the crisp photograph of the tight bomb pattern.

Second, standards-setting is exclusively technically based and driven. This results in setting very consequential policies in isolation from critical policy considerations. The WQCC has inadequate knowledge of the "facts and circumstances" it must weigh in standards-setting. The EID now makes no meaningful effort to develop this necessary record. Ad hoc responses to ad hoc comments generated by the public hearing **after** the formal proposal do not suffice.

These considerations should be sought out and reviewed in an organized way before the formal proposal stage to create a record to be used by EID to recommend standards whose impacts would be much more clearly defined. This process would answer questions such as: What, in terms that rise above concepts and are west of Dallas, are the water quality benefits to be derived from a standard? Is the cost of applying the standard justified over other competing demands, including other environmental needs?

These considerations must be part of the standards-setting process. It would allow the state and its communities to use what was described in the June public hearing as its "wriggling room" within federal mandates and policies; not to wriggle out of them, but to set rational, priority-based New Mexico policies, tailored to New Mexico needs.

**Issues Relating to Stream Flow Variability**

Most New Mexico streams have high flow variability resulting from several factors: seasonal changes, weather, drought-wet cycles, and human regulation through dams and diversions. Controlling discharges to maintain standards and to protect stream uses is much more difficult and should call much more for use of discretion and the application of policy judgments than systems with relatively limited variations in flow and levels. A policy question would be, for example, should standards for a discharge be designed—and at what cost—to protect uses in a stream that would be lost from normal and expected cessation of stream flows but for the continuance of the discharge? This question was answered in the affirmative by a quiet standards-making in 1987, with, so far as I know, no analysis of the cost side of the equation and nothing more than the abstract notion that the change would help water quality on the other.

**Seasonal Variations and Dechlorination**

Because of stream flow variability, waste-load limits for contaminants in discharge permits are set to allow the standards for the contaminants to be maintained down to a determined critical low flow condition (CLFC). The rationale for the low flow limit is that, at lower flows, the flow conditions alone prevent attainment of standards and designated uses.

The other side of the coin is that, if discharge limits pegged to low flow conditions are enforced year-round, the total assimilative capacity of a stream is not utilized at higher flows and their application "during seasons of abundant receiving water flow may be both costly and unnecessary to preserve stream quality and designated uses." (Quoting from a 1981 EID document entitled *Critical Low Flow Conditions for New Mexico Streams*). Accordingly, the standards have provided that discharge limits can be based on "critical low-flow numeric values ... determined on an annual, a seasonal or a monthly basis, as appropriate, after due consideration of site specific conditions."

While it is encouraging to find this kind of common sense flexibility in the regulations, seasonal variations in discharge limits are for the most part impractical because most wastewater treatment processes can't be turned on or off. However, by limiting the seasonal variations to "non-toxics," the EID now proposes to remove the flexibility for the one parameter I am aware of that appears would allow its use; that is, dechlorination of chlorinated effluent. The 1981 EID document, by the way, does not make a toxic/non-toxic distinction.

First, limiting the use of seasonal variations to non-toxics is the use of a distinction that doesn't make a difference. Lack of dissolved oxygen can be as toxic as chlorine in excess. But, this semantical issue is mooted by the fact that taking advantage of the stream's assimilative capacity at higher flows to allow a higher wasteloading of a contaminant, whether "toxic" or "non-toxic" will maintain stream standards and preclude any toxic effects. Remember, the goal is to remove toxics in toxic amounts.

What would allowing a wastewater plant to turn off the toxic sulfur dioxide gas (used to dechlorinate when stream flows are sufficient to insure standards will not be violated and that there will be no toxicity) accomplish? It would save the sulfur dioxide, save the energy used to produce and transport it, and lessen the dangers associated with production, transportation and use. These are surely all unimpeachable environmental goals.

For those who want the removal of toxics, and in this case chlorine, completely or to the extent practical, without regard to toxic effects or to countervailing considerations, I have these thoughts. To the extent that it is a moral imperative, it is an imperative riding on the back of a tight bomb pattern to the detriment of its own cause. Further, chlorine and its toxicity is a situation of a distinction that in some cases should make a difference regarding its treatment as compared to other toxics. It is not the Cl of chlorine (i.e., the element Cl itself) that is toxic, but rather its highly reactive (corrosive, oxidative) state, which for that reason doesn't last for long. Thus, chlorine in its reactive forms does not build up or bioaccumulate, rather, it dissipates to its non-reactive and relatively non-toxic state, chloride. The standard for chlorine in the Albuquerque reach of the Rio Grande is 0.008 milligrams/liter (mg/L), whereas the standard for chloride is 250 mg/L, a difference in magnitude of more than 30,000 times. The fact that chlorine has limited toxic life in the environment should be weighed in consideration of its actual effects in receiving waters and with how it should be dealt. That is not to say there should be no chlorine standard. Presumably the one that exists is reasonably justified. It is to say that the spatial-durational effects of chlorine wasteloading are different from those of a stable toxic and, therefore, differing treatments can be warranted.

**Dry Arroyos and Silver City**

A related element is the application of surface water standards to dry arroyos receiving treatment plant discharges. It is not enough for water quality regulations designed to protect "designated," "attainable" and/or "existing" uses to be applied to such discharges solely on the mechanical notion that dry arroyos are "waters of the United States." Are there uses that can exist in the dry arroyo depending upon the standards that are applied? Should it be the discharger's obligation to create them—whatever the cost? To me these questions are not cut and dried issues of environmental progress but rather questions that turn on considerations of common sense and judgment.

The 1988 changes in the water quality standards regulations apply surface water quality standards to ephemeral streams and dry arroyos when they would be dry but for the regulated discharge. This was discussed at the December 10, 1987 hearing on the proposed changes. An EID witness stated that the effect of the then-proposed changes in the language regarding "Applicability of General Standards," Section 1-102, and addition of a definition of "attainable use," was to make the standards applicable to "ephemeral water courses"—defined to be "a stream or reach of a stream that flows briefly only in direct response to precipitation or snowmelt in the immediate locality." The mechanical effect of this was that a dry arroyo receiving a discharge that could create a use (any subcategory of fishery, subcategory of recreation, domestic water supply, livestock and wildlife watering, or irrigation) would be held to standards to attain the use. The logical consequence of this extension is that the end-of-pipe quality of a discharge had to be sufficient to sustain the uses without the benefit of dilution in receiving water.

Applying standards to those "waters of the U.S." in New Mexico that are dry arroyos with no aquatic life or water uses but for a discharge demands site-specific considerations. Silver City remains the classic case as it discharges its effluent into a dry arroyo some months of the year—the non-irrigation season presumably—and delivers the water for irrigation use during the irrigation season. This requires a discharge permit for its cold weather discharge into Silver City's "waters of the U.S." During the discharge period, I assume there is a surface flow of some several hundred yards. The leap—from if "waters of the U.S.," then standards apply—was in this case made with eyes shut.

Following EID's interpretation of the standards, EPA decided Silver City should dechlorinate its effluent when putting it into the arroyo because the general standards applied to all waters when **any** use for the water exists. And there was a use.

EID determined that the seasonal dry arroyo discharge created a livestock/wildlife watering use —at least when there was water. Therefore, the reasoning went, all general standards applied regardless of the use a particular standard protected. So Silver City's permit required dechlorination designed to protect a fishery use, which of course does not exist in the seasonally dry arroyo, with or without dechlorination. This is not just a tight bomb pattern, this is a transcendent Catch-22 that even Joseph Heller would hold in awe.

But, it's not quite that simple. EID created a "penumbra" protection for aquatic life use just as the Supreme Court created the right to privacy from the "penumbra" of the Bill of Rights—a valid sort of reasoning by the way. EID reasoned that chlorine was toxic to desirable aquatic life not constituting a formally recognizable use that might exist at a lower threshold than a fishery. So, it decided, this hypothetical sub-use was what was being protected. I have no disagreement with this conceptually. But I do have two problems.

First, it was apparently an after-the-fact rationalization of the Catch-22 absurdity.* Second, and more importantly, there is no inkling of whether and how the seasonal aquatic life that dechlorination would allow at the Silver City waters would differ from the status quo and whether any differences would be worth fifty cents environmentally.

The process must lay concepts on a site-specific reality. The moss on a stone under a dripping faucet is aquatic life. Let's dechlorinate tap water. Absurd, yes. And so might be the requirement to dechlorinate the Silver City discharge. For me to judge, I would like to know: In the Silver City situation, what aquatic life exists now? What would exist with dechlorination? Would the difference be consequential with regard to aquatic life value? What effect does the seasonality of the flow have on the aquatic life value? Is the surface flow of sufficient length that there is water downstream from which the chlorine toxicity is attenuated? How much? And, I would want to know the cost of dechlorination.

The point is that standards should not be applied mindlessly to such U.S. waters with no idea

*The proposed standards remove the absurdity of applying a general standard designed to protect a specific use (i.e., fishery) to waters not being able to attain that use for other reasons. That is being done by adding a sentence to the Hazardous Substances paragraph which will read: "This general standard shall be applied to attainable or designated uses in consistence (sic) with the purpose of standards set in Section 1-100 A." (1-102 F.) Section 1-100 A reads: The purpose of these standards is to designate the uses for which the surface waters shall be protected and to prescribe the water quality standards **necessary to sustain the designated uses.** (Emphasis added). Speaking directly, if dechlorination is not needed, and it isn't, to maintain the livestock/wildlife watering use then it wouldn't be required by the general standards. But Silver City is not off the dechlorination hook. Silver City's permit requires dechlorination, and the definition of wildlife watering has been expanded to include foraging as well as drinking. Of what? The aquatic life that conceptually will exist with dechlorination? This fix comports with the philosophy of cutting red tape—lengthwise.

of the water quality benefit, if any, and the relation between the benefit and the cost. The money Silver City spends to vindicate a concept that, as applied, has no value is not available for other bombs.

The ethics of this country and state support water quality standards to discharges into dry arroyos. This has particular value in an arid state like New Mexico. Certainly for example, if Albuquerque were to discharge its fairly constant 70 cfs or so into a dry bed, a significant stream would result that could support uses including a fishery. Further, some contaminants in discharges pose a potential threat to groundwater quality or the surface environment generally without regard to surface water values. Heavy metals come to mind. After weighing the costs, appropriate standards should be applied to such discharges.

A practical solution to address the problem was suggested to me. Rather than a mechanical application of standards in a dry arroyo discharge informally determined by EID staff, each discharge to a dry arroyo should go through a formal designation of uses by the WQCC. This has been done for particular stream reaches and lakes in Part 2 of the standards. This would allow the interests, values, benefits and costs involved to be determined on a case by case site-specific basis through public hearings with presentations by both EID and the discharger. Silver City would be allowed to make known things like the seasonality of discharge, and put some burden on both EID and the discharger to go beyond concepts into site-specific effects, values, and benefits. It would allow policy to be made with due input from those affected by the policies. Equally importantly, it would insure that the real policy considerations not be hidden under tight bomb pattern pieties.

I call attention to an ironic anomaly of the application of the standards to perennial streams as compared to dry arroyos. As discussed above, wasteloading limits in permits for discharge into perennial streams are based on a low flow factor below which the standards are considered nonachievable. Such wasteloading limits are thus based upon dilution available at the low flow. By necessity, application of standards to dry arroyos requires end-of-pipe compliance. Perennial streams administration based on low flow factors ignores the uses the discharge itself might sustain, which is in fact the practical basis for applying standards to dry arroyos. This difference might be good policy but it is not consistent policy nor was it, so far as I know, consciously derived.

**Ammonia Standards**

Ammonia toxicity, ammonia standards and wasteload allocations for ammonia provide a multifaceted set of issues relevant to this discussion. Effluent from wastewater treatment plants such as Albuquerque's, not having tertiary nitrification/denitrification treatment, can contain ammonia in amounts toxic to aquatic life. It is a good possibility that if the proposed ammonia standards are adopted, Albuquerque will need to remove ammonia under its next discharge permit. Tertiary treatment of effluent to remove ammonia by nitrification/denitrification is practical, well-established technology.

Albuquerque has estimated that nitrification/denitrification of its effluent would initially cost $60 to $100 million in capital outlays and several million dollars in operating costs each year thereafter.

The above provides a conceptually compelling justification for Albuquerque to move with all due speed to spend that $60 to $100 million for nitrification/denitrification facilities to further the environmental goal of removing toxics in toxic amounts from our waters. In the vernacular of *Catch-22*, this action could be a nice neat tight bomb pattern, the "photo" of which would please those directing policy from upstream.

Let's go beyond the concepts to see their application to reality and ask some questions relating to priorities and benefits. There are numerous overlapping elements to take into consideration to see whether this bomb pattern fits this target.

For the benefit of city professionals who are skeptical as to whether the benefits approach the costs, and the rate-payers who would bear the costs, it would be nice to have discreet knowledge of the aquatic life improvements that ammonia removal from city effluent would allow. Surely a study—even costing some hundreds of thousands of dollars—is warranted if its results would justify even postponement of this large expense. On the other hand, a site-specific study that showed real and substantive aquatic life benefits would go a long way toward justifying the cost to utility professionals, elected officials and the rate-paying public.

These are thoughts I think should be considered. The ammonia wasteload limits would be determined based on a low flow event of one week in two years which could otherwise be higher given assimilative capacity from dilution provided by higher flows. To put it more directly, the ammonia removal process might only be needed on average one week every two years with dilution precluding toxicity the rest of the time. But ammonia removal is not like dechlorination, which requires limited capital investment, and can be turned on and off in response to seasonal flow variations.

Ammonia is like chlorine in having a transient toxicity. Un-ionized ammonia is toxic, but also volatile and reactive, tending toward oxidation to non-toxic states. Thus, in the low flow event with ammonia toxicity, how far down the river before it attenuates to non-toxicity?

Assuming the toxicity in the low flow event (that week in two years) creates a toxic barrier isolating aquatic life downstream from upstream, what is the significance, if on average it is only one week in two years? On this point, another site-specific reality ought to be considered. The low flow event in the Albuquerque reach of the Rio Grande occurs most probably in August or September when there invariably are irrigation diversions upstream of the city discharge point. These diversions would be in the range of 400 cubic feet per second. Arguably, this bypass flow could maintain aquatic life throughout the Albuquerque reach during the low flow event that would render a week-long city-created ammonia toxicity barrier inconsequential.

Finally, in terms of a barrier, in fact, during the time there are very low flows in the Albuquerque reach, there is invariably **no** flow in the river from the Isleta diversion, just south of Albuquerque for some 17 miles to where bypassed water rejoins the river. This break in aquatic life and uses in the Rio Grande floodway would seem to overwhelm the impact of a one-week limited-ammonia toxicity in the Albuquerque floodway reach. The proposed ammonia standard might be valid, but must be overlaid with these kinds of considerations before ammonia wasteload limits for Albuquerque discharge are determined.

In addition to meeting the simple burden of the value to be gained from Albuquerque's removal of ammonia by nitrification-denitrification (at a cost of $60 to $100 million in capital investments and several million dollars in Operations and Maintenance), the value gained needs to be placed alongside other environmental priorities.

The 1990 EID report, *Water Quality and Water Pollution Control in New Mexico* states: "This report has the.....purpose of being a source of basic information on ground and surface water quality and water pollution control programs in New Mexico . . ." The report is instructive, but unfortunately ambiguous and incomplete. What does it suggest regarding ammonia toxicity compared to other water quality problems?

> "Ninety-eight percent of all water quality impairment in New Mexico's surface waters is due to non-point source water pollution. Of primary concern is the effect of non-point source pollution in toxic concentrations in New Mexico's surface waters. With the exception of waters impaired by chlorine and un-ionized ammonia, essentially all known toxic pollutant impairment of surface waters is due to non-point source pollution."

Thus ammonia pollution presumably is at least primarily due to point sources such as wastewater discharges. Let's see how the report further characterizes the ammonia problem generally and for the Albuquerque reach particularly.

Table 9 of the report lists 563.2 miles of rivers not fully supporting designated or attainable uses that is due at least in part to "moderate/minor" impacts from un-ionized ammonia. **Zero** miles had "major" impacts from ammonia. In contradiction to the idea that essentially all ammonia pollution is from point sources, Table 5 states that only 86.1 miles of rivers with non-attained uses was due to point sources: municipal and domestic wastewater. Despite this inconsistency, surely a reasonable conclusion is that any ammonia impact is no more than "moderate."

Let's look at the report regarding ammonia problems in the Albuquerque reach classified by the Water Quality Standards as a limited warm water fishery (lwwf) that might be caused by Albuquerque effluent. Table 2 indicates that 11.9 miles of river designated lwwf have "partially impaired designated uses" due to point source pollution. Table 5 indicates 86.1 miles of New Mexico rivers are not attaining designated uses due to municipal and domestic wastewater discharges among which the 11.9 miles of affected limited warm water fishing would be subsumed.

Subsequently, Table 10 lists municipal sources as being responsible for 54.7 miles of "major" and 288.5 miles of "moderate/minor" impact causing rivers to "... not fully support designated uses . . ." However, since Table 9 indicates no major impacts from ammonia, any major municipal source impacts would not be from ammonia. These general tables do not amount to a very persuasive case for a $60 to $100 million ammonia problem.

The report goes on to break down specific river reaches corresponding to reaches as designated in the standards. This focuses data from the other tables to the specific reach. The Albuquerque reach is shown as having uses not fully supported for reasons including un-ionized ammonia, but **fails** to list municipal wastewater as the source for any non-attainment of uses in the reach. "Urban runoff/storm sewers, spills and other" are listed as the probable sources. So after winnowing through the tables to investigate the possibility that the ammonia content of Albuquerque wastewater could be the problem source for the Albuquerque reach, this is the result. I would say this failure must be an oversight and that, in fact, EID staff sort of assumes that ammonia is a problem. But Albuquerque is the largest city in New Mexico with the largest wastewater discharge. For the report as a "source of basic information on ground and surface water quality and water pollution control programs in New Mexico" to persuade us that Albuquerque should spend $60 to $100 million for ammonia removal, it must make a better case than this!

Let's look at other problems set out in the report that might take priority over this ammonia problem. Under a heading of "Areas of Special Concern" regarding groundwater, the report states as its first of six listings: "The Albuquerque South Valley, located in the shallow water table zone along the Rio Grande, has problems with groundwater contamination from a variety of causes including septic tanks and a variety of industrial sources." Regarding the same area, the report noted the problem of widespread anoxic conditions and noted:

> "Even if remaining areas were sewered immediately, it might take decades for natural purification processes to eliminate the contamination caused thus far. In the Barcelona area .... septic tanks are responsible for doubling and tripling nitrate levels since 1977 and for contaminating two public wells and 29 private wells with dangerous nitrate levels and excessive total dissolved solids."

Further on the report lists "present and emerging concerns" for prevention and abatement of groundwater pollution. Of relevance here is "the threat to extremely effective programs to prevent groundwater pollution in time of **tight budgets**, which could lead to expensive pollution problems in a few years." (Emphasis added). A relevant "emerging concern" listed for surface waters is "an ongoing problem regarding the discharge of raw sewage from sewer collection lines that break or overflow due to poor maintenance or location." This latter point was likely generated by the two major breaks in the Albuquerque system in the last five years. The result of both these breaks was emergency chlorination downstream of the breaks for disinfection of the raw sewage that most likely retained chlorine toxicity to aquatic life as it hit the river.

Where should Albuquerque's environmental priorities lie? Let's compare the problems:

- un-ionized ammonia in Albuquerque wastewater discharge;
- the continuation of extensive septic pollution in Albuquerque's South Valley; and
- inadequate maintenance of sewer lines.

What are the "temporal/spatial" implications that the EPA report urges using as a basis for setting priorities? The first, ammonia toxicity, is only conceptual, with not even close to compelling documentation. And, once fixed, there will be no residual problems for time and the environment to abate. South Valley septic pollution is beyond concepts—nitrate concentrations doubling and tripling in groundwater in several widely separated areas that even with immediate removal of the pollution sources will possibly take decades to remediate. Failure to maintain adequately and replace major sewer lines will insure continued toxic episodes on the river.

What will happen to the state and city's "tight budget" with a $60 to $100 million dollar outlay to remove ammonia to protect the river from that low flow event? What effect might it have on the "extremely effective programs" of sewering critical portions of the South Valley to abate and prevent groundwater pollution? And to what extent will this heavy investment to remove ammonia for that low flow event lessen the likelihood of timely maintenance and replacement of sewer collection lines to minimize breaks and discharge of raw sewage?

The 1990 Water Quality Report states that legally, it must include, "an estimate of the environmental, social, and economic impact of restoring and maintaining the chemical, physical and biological integrity of waters within the state." However, it gives no hint as to the costs of something like removing ammonia through nitrification/denitrification of effluent for the City of Albuquerque or anywhere else. City staff has estimated that this would cost from $60 to $100 million. The report does contain a history and projections of wastewater facility construction expenditures in New Mexico. The projections indicate an expected total expenditure in local, state and federal dollars of $74 million for the six years ending 1995. Does it make sense that all this available money be spent for nitrification/denitrification of Albuquerque effluent to prevent ammonia toxicity for the low flow event?

**Irrigation**

In comments for the record on the proposed standards changes, the Elephant Butte Irrigation District (EBID) staked out its legal position. Its position was that all the water in the system, at least from Elephant Butte Reservoir down, was dedicated exclusively to irrigation, with only incidental and "subservient" recreational uses and no other. EBID cited as preemptive authority, federal legislation creating the Rio Grande Project in 1905, the Rio Grande Compact, and the Mexican Treaty of 1906, which requires annual delivery water to Mexico from Elephant Butte.

> ". . . Thus EBID takes the position that there are no designated uses which require a standard to be set which would impair the irrigation function in the name of recreation or maintenance of a fishery."

EBID's position could probably be considered a proxy for other irrigators.

How do the proposed standards affect irrigation use of water? Irrigators have concerns about some ambiguities in the standards language that push the door ajar—a door most irrigators probably would prefer to keep closed. The standards applicability to irrigation is found in Part 1-102, General Standards, which as would be amended states:

> The occurrence of a water contaminant or a deficiency of dissolved oxygen attributable to .... the reasonable **routine** operation and maintenance of irrigation .... facilities is not subject to these **general** standards.

The emphasized words, "routine" and "general" are proposed to be added to the sentence as it presently exists. Both have raised questions.

Regarding "routine," the question was how it would apply to "reasonable" not necessarily regular irrigation practices that might impact levels of contaminants or dissolved oxygen such as flushing or otherwise removing deposited material from irrigation facilities. The Bureau of Reclamation addressed this concern in comments and recommended clarifying language:

> "Routine operation and maintenance" means those operation and maintenance procedures or activities necessary to continue the functional performance of the facilities but does not include the major reconstruction of diversion dams or storage dams.

Addition of the word "general" raised the question in Bureau of Reclamation comments of whether the intent or effect was to exclude parts 2 and 3 numeric standards from the "reasonable routine" irrigation exemption found in the general standards. Or stated affirmatively, should "routine reasonable" irrigation activities be subject to parts 2 and 3 numeric standards? This would seem to be so even without the addition of the word "general," but certainly so with it included. Under ordinary construction of meaning, the word "these" in "these general standards" denotes only the general standards, so the word "general" might be considered a clarifying redundancy.

However, an ambiguity lies with inclusion of an exemption to dissolved oxygen standards because there is no "general standard" for dissolved oxygen, whose numerical standards are instead found in Part 2.

Assuming that parts 2 and 3 standards can be used as a basis for regulating irrigation practices, this could be used for requiring rather than urging voluntary implementation of "best management practices" for the abatement of non-point source pollutants such as fertilizers (ammonia, nitrates, phosphates) and insecticides.

The ambiguities should be resolved. The extent to which irrigation activities can be regulated under authority of the standards must be clarified. Any change must also be forthrightly and openly initiated allowing early participation of those affected. Farmers, as others, don't take kindly to being ambushed.

As an interesting sidebar, the well known *Sleeper* case on the law of water rights transfers could have become a precedent with significant adverse effect on attempts to control non-point source pollution. The State District Court enjoined a State Engineer Office ruling allowing purchasers of water rights in Nutritas Creek, historically used for irrigation, to change the use and point of diversion of the water to new uses associated with a ski resort development. The case has been hailed for using "public interest" criteria as a grounds for deciding the case. The court found that allowing the change would result in "the imposition of a resort-oriented economy (that) would erode and likely destroy a distinct local culture ..." and thus be "contrary to the public interest."

In an equally perspicacious ruling in the case, the court also created a short-lived "right to silt" doctrine for New Mexico water law which would, had it survived, been quickly echoed in its corollary: a "duty to erode." Specifically, the court found, as an alternative ground for reversing the State Engineer Office approval, that the protestors (other irrigators) were injured with the transfer because "... water users would be deprived of their first watering ... which benefits the land ... by fertilizing the soil by providing rich silt carried by the waters of the Nutritas Creek."

On appeal, the state's Court of Appeals reversed the lower court, leaving the "public interest" issues as related to water to be resolved in later cases. But the reversing court specifically found that silt was not an element of a water right, pointing out that "to hold otherwise could prevent all upstream users from controlling erosion on their lands for fear that silt would be reduced downstream." *Ensenada Land & Water Assoc. et al. v. Sleeper*, 107N.M.494 (1988).

While the New Mexico District Court in effect imposed a silt requirement on the Nutritas, Section 2-116 of the Water Quality Standards designates that reach as a high quality cold water fishery, a use antithetical to silt deliveries for fertilizer. The law and regulations in their search for the public interest can be like ships in the night.

**Water Quality Standards and Water Rights**

I will touch briefly on one issue related to possible water rights implications of the Water Quality Standards. The 1988 rulemaking added a definition of "flow" that included the language, ". . . but natural flow cannot be created artificially by point-source discharges of wastewater." The 1990 amendments propose deletion of the definition of "flow." The inference to be drawn from the proposed deletion is not clear but this along with other proposed changes has excited Santa Fe concerns that there might be an attempt to limit Santa Fe's right to stop its discharge in favor of another use of its effluent such as for aquifer recharge.

Santa Fe effluent discharges into an ephemeral portion of the Santa Fe River. The proposed changes redefine the reach of the Santa Fe River with specific designated uses, which include marginal cold water fishery and warm water fishery. The change moves the upper end of the reach from State Highway 22 to the outfall of the Santa Fe wastewater treatment facility. This added reach is a fishery only if adequately treated water flows continuously from this discharge point.

Santa Fe's question is: "Will this mean Santa Fe cannot cut off this discharge if it wants to, because stopping the discharge would make the uses non-affordable?

## CONCLUSION

Much of this presentation is polemical in style (a wanton random bombing a la Yossarian) that should not be taken as pretensions of great wisdom or truth. As I stated in my conference talk, my views on this topic are filled with existential doubt, anguish and despair, which doubt... I wish more folks shared. In this discussion I've continuously griped about concepts and perceptions being applied mechanically with little or no attention to their validity in a particular situation. I hope and trust the concepts and perceptions scattered among the polemics have some validity. I think they deserve consideration. Like others, they need testing against reality. Let's remember the goal is not feel-good pretty bomb patterns, but results even if messy and imperfect.

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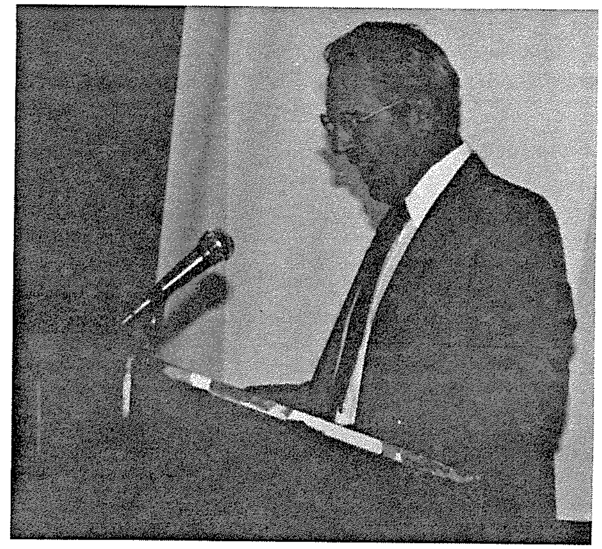

# AN OVERVIEW OF STATE AND FEDERAL LEGISLATION DESIGNED TO PROTECT GROUNDWATER FROM CONTAMINATION

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## NATURE OF THE PROBLEM

Most of us in the water resources field have no difficulty in thinking of good examples of groundwater pollution in New Mexico. A better way of stating the problem is that none of us would have any real difficulty thinking of some bad examples of groundwater pollution in the state. The latest count of known instances is on the order of 1500 separate sites according to the March 1990 New Mexico Water Quality Control Commission report entitled, *Water Quality and Water Pollution in New Mexico*. The sources and nature of the contaminants are quite diverse as is the affected aquifer's hydrogeology. The pollution has been the result of:

- casing failures in oil wells
- oil-field produced salt-water discharged into ponds
- seepage from tailings ponds used to store mill-waters from the mineral industry
- tailings spills accidentally discharged into dry arroyos
- metal cleaning operations at federal installations
- improper disposal of liquid wastes in landfills
- over-pumping of aquifers used for irrigated agriculture
- seepage from manure ponds at dairies
- leakage from underground storage tanks
- tens of thousands of septic tanks in the state
- almost every other imaginable cause and source

New Mexico is probably not much different than most states. When asked to rank their principal sources of groundwater contamination, 33 states listed underground storage tanks, 25 gave municipal landfills as a major source, 22 cited agricultural activities, and 20 states identified septic tanks as a prime source (USEPA 1988, State Section 305(b) CWA reports).

A pattern of groundwater contamination prevails throughout America: one-sixth of the public water supplies in the U.S. show contamination from volatile organics, pesticide residues, and/or nitrates from septic tanks or agricultural activities. While most of the contaminants are at levels far below those of serious public health concern, the susceptibility of fresh-water aquifers to pollution has been demonstrated across the country. For example, based on a 1981 Environmental Protection Agency (EPA) survey reported in *Ground Water Supply Survey*, about 10 percent of the community water supply wells contain pollution from one or more of the dozen or so volatile organic compounds that are in common commercial and industrial use (USEPA 1983).

A recent study of agriculture-related groundwater pollution from nitrates and pesticides showed a similar, but less severe pattern. Nitrate concentrations greater than 10 mg/L (nitrates as nitrogen) were found in 1.2 percent of community wells and residues of at least one pesticide were found in 10 percent of these wells (AWWA 1990).

If the levels of these contaminants are typically quite low (below safe drinking water levels), why the concern? For two reasons: over 90 percent of New Mexico's population takes its drinking water from a groundwater source, and aquifer restoration is a costly and almost impossible task. For these, and a host of other reasons, the U.S. Congress and the New Mexico Legislature have each enacted a series of measures over the past fifteen years designed to provide a comprehensive state and national program to limit and control groundwater pollution.

Others might take a different view and say that there is no single comprehensive piece of federal legislation dedicated to groundwater-source protection and that what we have is a complex patchwork of state and federal laws. While not being "one law," taken in its totality in so far as New Mexico is concerned, the system of laws and rules that are in effect are comprehensive in their coverage of potential sources of aquifer pollution. The result is an interlocking program founded on four basic elements:

- state supremacy in the management, planning, and allocation of its groundwater resources;
- delegation of federal programs and powers related to groundwater protection to the states;
- a system of state and federal regulations that establish permits for the siting, construction, operation, and/or termination of operation of potential sources of pollution; and
- monitoring of public water supply sources and potential pollution sources, notification of accidental releases of pollutants, and notification of the contamination of a public water supply.

## FEDERAL LEGISLATION

### The Clean Water Act

The 1972 Federal Water Pollution Control Act has been amended a number of times since initial passage, but it remains a comprehensive system of controls that was designed to end surface-water pollution. The act has been utilized effectively by the EPA to achieve its goals. While there is no single section of the law that deals with groundwater protection, most of the programs act to limit potential sources of aquifer contamination. For example, the use of "best available control technology" is required for all point sources of effluent discharge. The pre-treatment of industrial wastewaters is required prior to their discharge into a municipal sewer system. Through a permit system, siting of all wastewater treatment plants must be approved. Each state must adopt water quality standards that limit the concentration of toxics in surface streams. Monitoring and permits are required for major sources of storm-water runoff. A "no net loss" policy of wetlands has been adopted. The overall effect has been to reduce greatly the production and discharge of industrial chemicals that might otherwise have resulted in groundwater pollution.

### The Safe Drinking Water Act

This 1974 federal law has had a major impact in limiting groundwater contamination. Parts of the act that have contributed to the protection of groundwater are:

- the sole-source aquifer protection program that provides for a review and approval process for all federal activities on the recharge zone of a groundwater system that is found to be the only available water supply source for a community;
- the rural water supply study that made funds available to sample water supplies in small villages across the country, giving a comprehensive view of the nature of the nation's groundwater contamination problems;
- the protection of all groundwater aquifers where the concentration of total dissolved solids is less than 10,000 mg/L, as future potential sources for public water supplies;
- the underground injection program that provides for a permit system, monitoring, and inspection of wells that discharge pollutants into subsurface aquifers;
- the siting and monitoring requirements placed on all public water supply systems; and
- the national groundwater protection strategy that was adopted by EPA in an effort to stimulate interest at the state level in the adoption of pollution prevention programs.

### The Resource Conservation and Recovery Act

Enacted in 1976, the Resource Conservation and Recovery Act (RCRA) has been, by far, the most important act passed by the U.S. Congress to insure control of potential groundwater pollutants. When the law was initially passed, it was thought that the act's greatest impact would be to control and/or eliminate the discharge of industrial chemicals into pits, ponds and lagoons. The act certainly has achieved that goal as there are now only a few unlined surface impoundments in existence that receive hazardous wastes. In the mid 1970s, there were over 250,000 surface industrial-waste ponds in the U.S. The permit process and site review provided under RCRA, and the site closure and post-closure requirements are potentially so expensive, that the major effect of the law has been to reduce the volume and toxicity of the wastes generated in America and to encourage the recycling of these materials. RCRA has become a resource conservation act. The act's reporting requirements stipulate that EPA must be notified when "reportable quantities" of a hazardous material are spilled or lost; when community representatives use and ship "planning " quantities of a hazardous material; and when manifest is used to track the movement of hazardous materials. These requirements have made serious groundwater contamination much more unlikely. The establishment of action levels for emergency cleanup is another important element in the RCRA regulations.

Perhaps the most important element is a ban on a very large number of toxic chemicals (over 450) from disposal on or near the land or to injection wells. This EPA rule will require EPA treatment for over 40 million tons of hazardous wastes that traditionally have been sent to landfills, lagoons, and injection wells.

A few RCRA regulations will limit the opportunity for groundwater pollution:

- groundwater protection and monitoring
  40 CFR 264.90-.109
- landfill closure and post-closure rules
  40 CFR 264.110-.120
- rules on containers and tanks
  40 CFR 264.170-.199
- monitoring rules on surface impoundments
  40 CFR 264.220-.249
- operation, siting and design of landfills
  40 CFR 264.300-.339
- land treatment and disposal rules
- 40 CFR 264.270-.299

### The Underground Storage Tank Act

Because of the many metal storage tanks located underground and containing products such as gasoline and farm and industrial chemicals, Congress passed an act requiring that existing tanks be monitored. This assists in the detection of leakage and the eventual replacement and upgrading of tanks (Federal Register Vol. 53, No. - 185, Sept.23,1988) so that by 1996:

- all underground tanks will have corrosion protection;
- all tanks will be equipped with spill and overfill equipment; and
- monthly monitoring will be provided to detect releases.

**Superfund (Comprehensive Environmental Response, Compensation and Liability Act)**

The so-called "Superfund" was initiated in 1981 as a tax on industrial chemicals and oil to provide funds for the cleanup of the four to five hundred abandoned hazardous waste disposal sites initially identified. In the 10 years since the program was started, this number has increased to over 10,000. While many sites have been investigated and some remedial action taken, the majority remain as potential groundwater pollution problems that will take many years to rehabilitate.

## NEW MEXICO LEGISLATION

**New Mexico's Water Rights Laws**

New Mexico has some of the oldest and most effective laws that control an individual's right to take and use water. While they have seldom been used as a means of controlling groundwater contamination, the potential is there as laws require that water be conserved, and that it be put to beneficial use in an efficient manner. The New Mexico State Engineer Office issues permits for the drilling of wells in all of the state's declared basins and it has a series of rules that restrict the manner and method of drilling wells.

**The New Mexico Water Quality Act**

This act provided for a commission that reviews water quality issues and adopts regulations to prevent pollution. The most important, in the context of this paper, are the rules requiring a state approved groundwater discharge plan for any discharge of a liquid waste to a surface impoundment. The Water Quality Control Commission also sets the stream standards as to the acceptable quality in each reach of the state's stream system.

**New Mexico Solid Waste Management Regulations**

These rules, first established in 1988, should provide an effective means of controlling pollution from municipal landfills. Some provisions of this comprehensive set of regulations are:

- requirements for periodic inspection of materials brought to a landfill and restrictions that preclude the placement of petroleum wastes, septage, sewage sludge, or any bulk liquids in a landfill with municipal solid wastes;
- requirements that certain wastes be placed in special fill areas such as asbestos, infectious wastes, and incinerator ash;
- establishment of a number of site selection criteria such as a minimal distance to groundwater, location in a flood plain, and location near an active fault;
- requirements for a closure and post-closure plan that provides a "cap" that must meet specific design criteria, monitoring for methane and groundwater contamination for a 25-year period, and a plan for corrective action if necessary; and
- requirements for certain operating procedures such as daily cover of the filled material, maintenance of inspection records, and operator training.

## SUMMARY

While there is no single piece of legislation that can be used to limit or control groundwater pollution in New Mexico, there are national and state laws and regulations that, taken in their totality, provide the state with all the authority and tools needed to manage and protect its groundwater resources.

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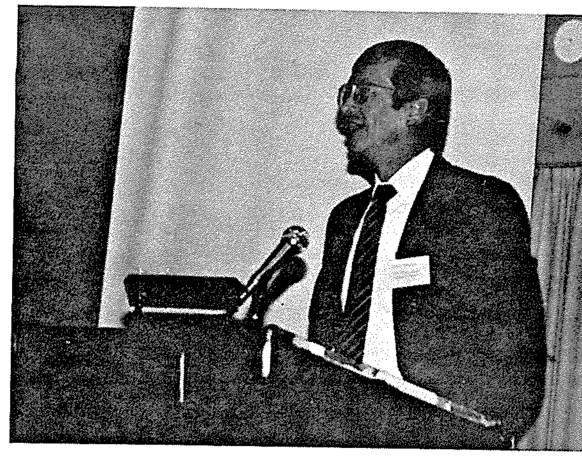

# WHAT IS GROUNDWATER AND HOW DOES IT BEHAVE?

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## WHAT IS GROUNDWATER?

" . . . groundwater is . . . subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated" (Freeze and Cherry 1979).

Figure 1 is a schematic diagram of an unconfined aquifer. "An aquifer is . . . a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients" (Freeze and Cherry 1979). The groundwater lies below the water table, or free water surface, designated by the inverted triangle in Figure 1. A hole drilled below the water table will fill with water to the same elevation as the water table if, as in Figure 1, the groundwater is unconfined. In situations where a confining layer exists within the saturated zone, the groundwater may be pressurized and can rise above the level in the aquifer.

The capillary fringe is a zone of saturation above the water table where the water is held by capillary forces at less than atmospheric pressure. Between the capillary fringe and the land surface lies the vadose zone, which contains air as well as water within the pore space. Perched groundwater may exist within the vadose zone due to the presence of low-permeability layers of soil or rock.

Groundwater occurs almost everywhere. Even in very arid climates, a small fraction of the rainfall manages to avoid evaporation and percolates downward. Eventually this percolating water usually encounters a layer of low permeability that hinders its downward mobility. The water builds up and a saturated zone develops. The water table may be as shallow as the land surface—in which case you have a lake, river or ocean—or may be many thousands of feet deep.

## HOW DOES GROUNDWATER BEHAVE?

Groundwater obeys the same laws of physics as surface water. Thus, in Figure 2, we expect water in a tube to flow from the upper end of the

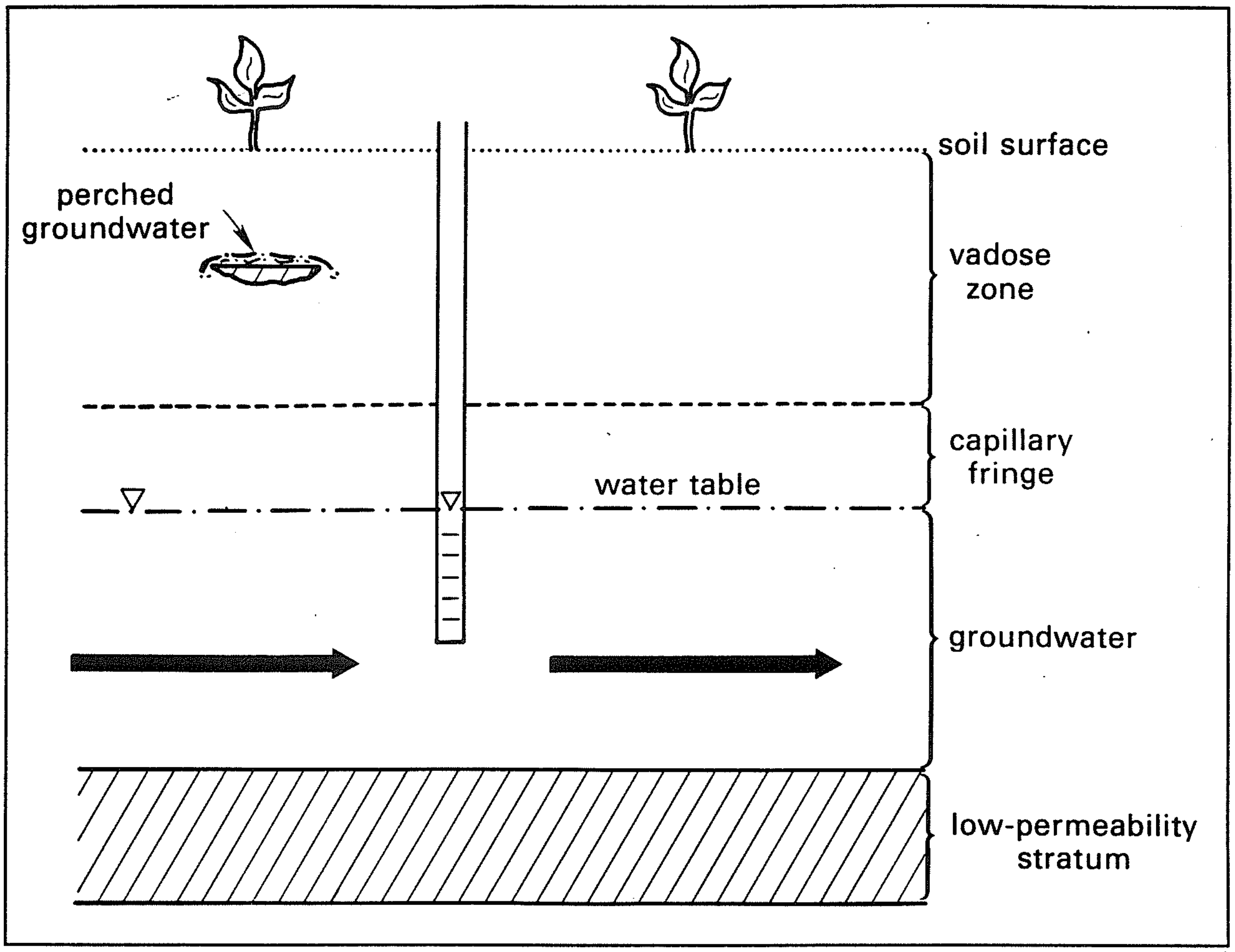


**Figure 1.** Cross section of the subsurface showing saturated zone and water table.

tube and out the lower end. Similarly, groundwater flows from regions of high potential energy (higher elevation in Figure 2) to regions of lower potential energy (lower elevation). If the water is pressurized and/or is moving, the pressure and the velocity, along with its elevation, determine the water's total energy at a given point.

Water moving from regions of higher energy to regions of lower energy results in interactions between surface water and groundwater. Thus, in Figure 3, water from a stream percolates through the stream channel to recharge underlying groundwater. In Figure 4, the water table is at a higher elevation than the stream channel, and groundwater is fed into the stream and discharged by surface flow. Figure 5 shows an example of an artesian system, where pressurized water formed by an upper confining layer comes to the surface downgradient through a well or a spring.

Groundwater pumping changes the water table's elevation in the vicinity of the well and alters the groundwater flow pattern. Thus in Figure 6, a "cone of depression" forms in the vicinity of the pumping well. If the well bore is too shallow, the well may "go dry" even though there is ample groundwater at greater depths. Pumping also alters the regional groundwater flow pattern, as shown in Figure 7. Some water in the vicinity of a well will be pumped into the well bore, while other water will escape the effects of the pumping and flow past the well. This pattern results in a "capture zone" for the well. Within the capture zone (defined by a given well configuration and pumping rate) all groundwater will ultimately be

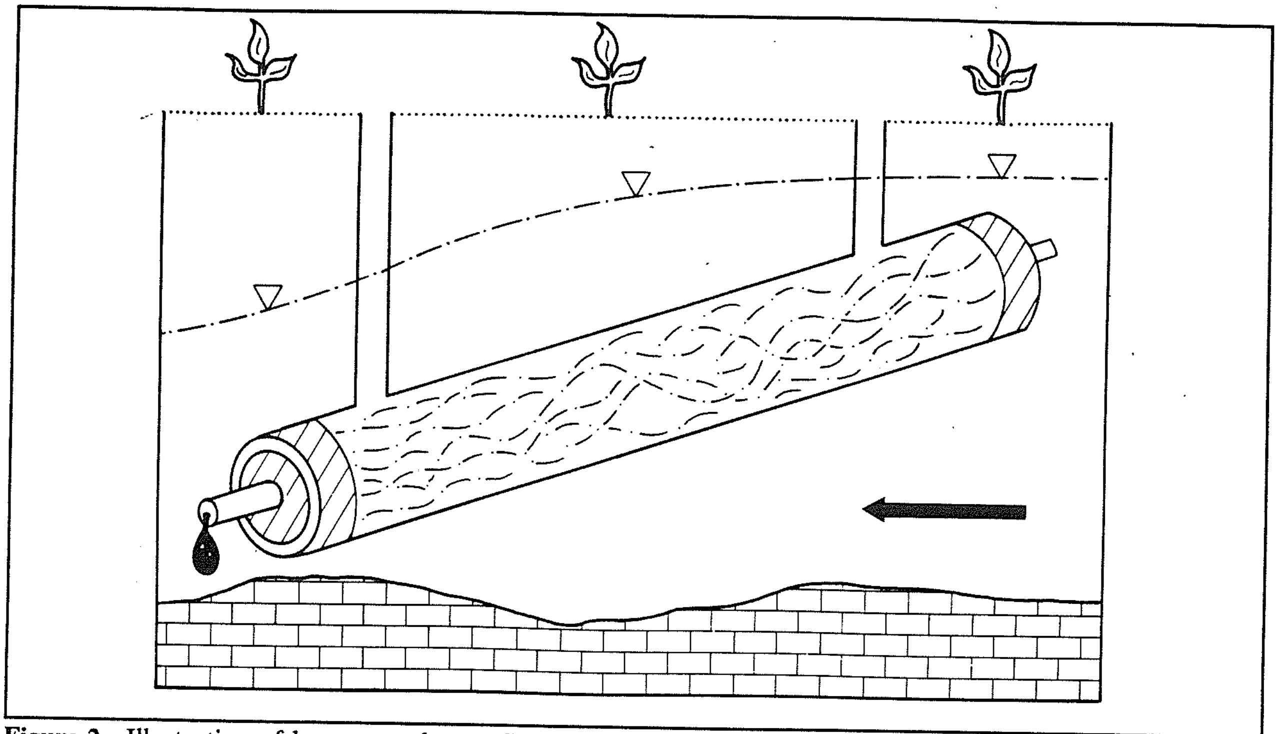

**Figure 2.** Illustration of how groundwater flows from region of high potential energy (elevation, in this case) to region of lower potential energy (after Freeze and Cherry 1979).

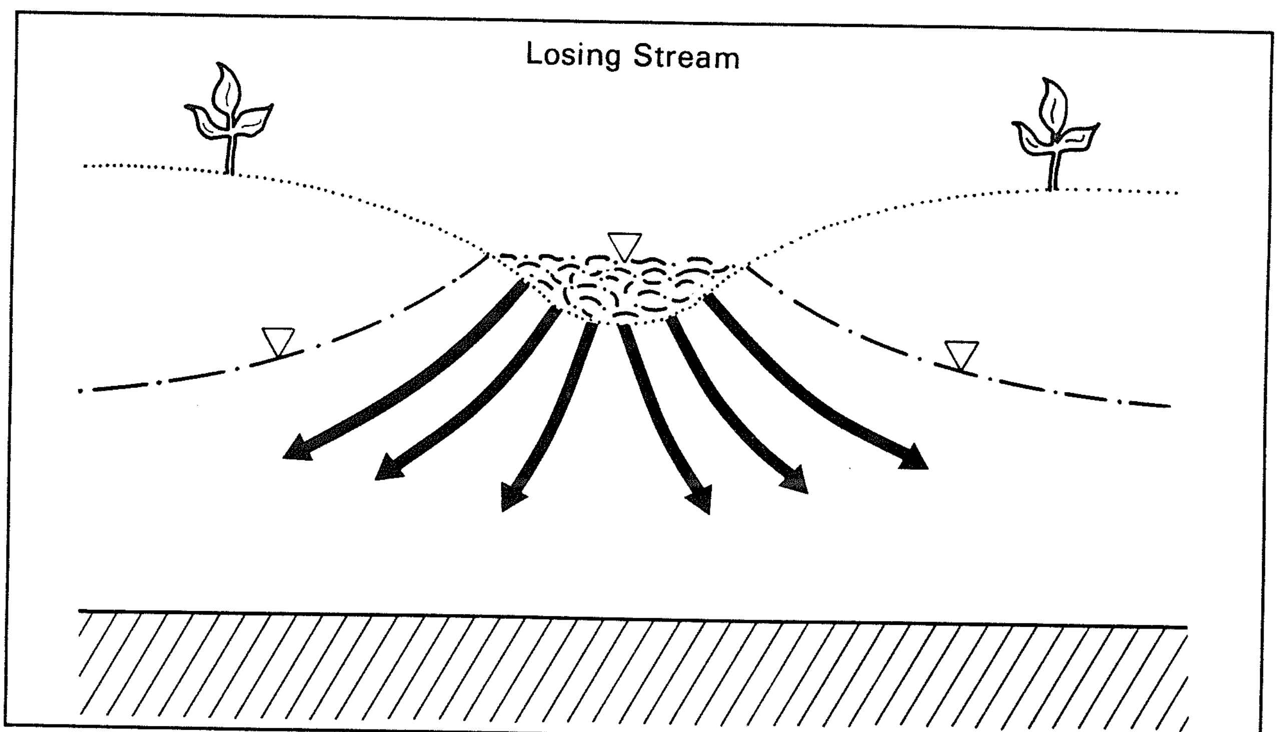


**Figure 3.** Illustration of a losing stream, where the groundwater elevation is lower than the stream elevation.

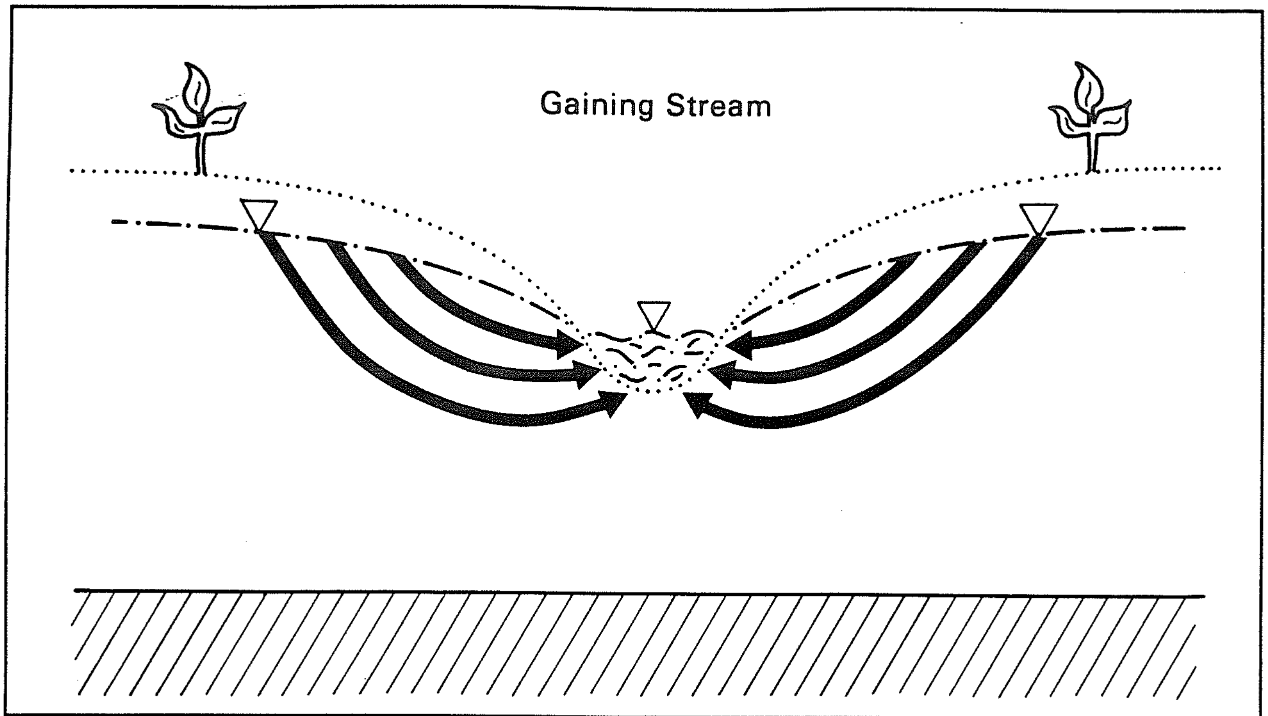


**Figure 4.** Illustration of a gaining stream, where the groundwater elevation is higher than the stream channel elevation.

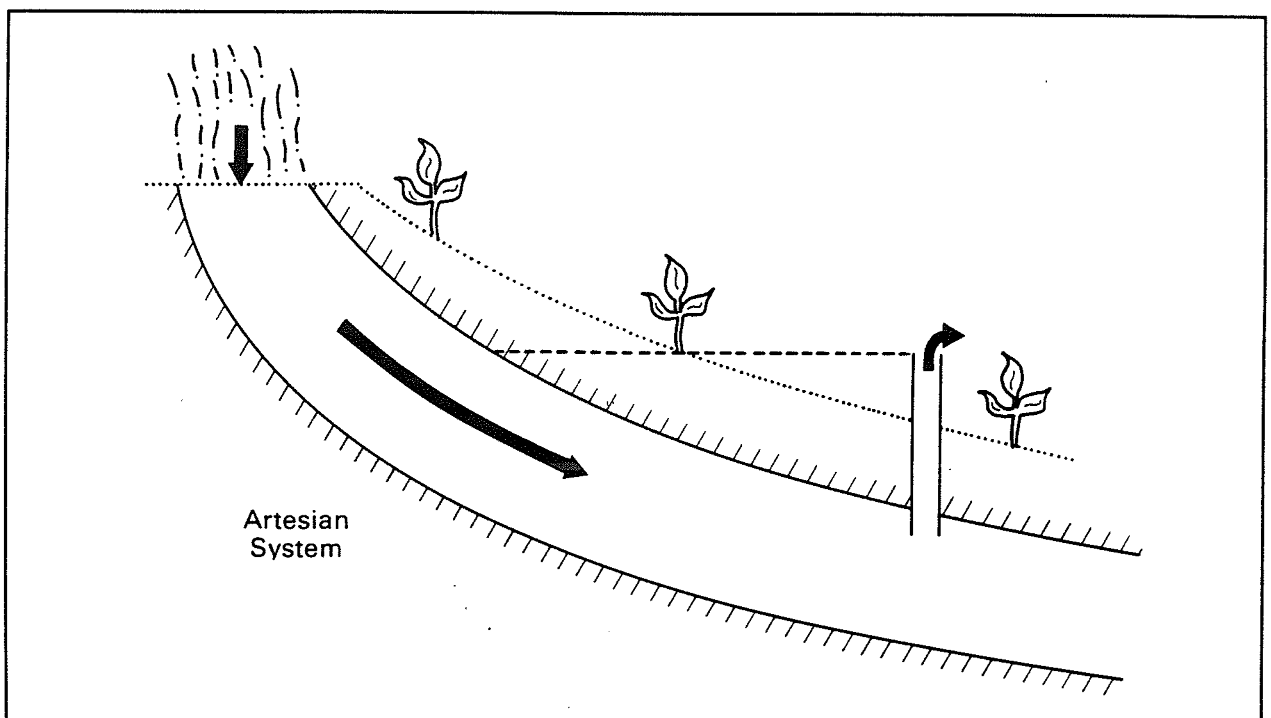


**Figure 5.** Example of an artesian well resulting from a confined aquifer.

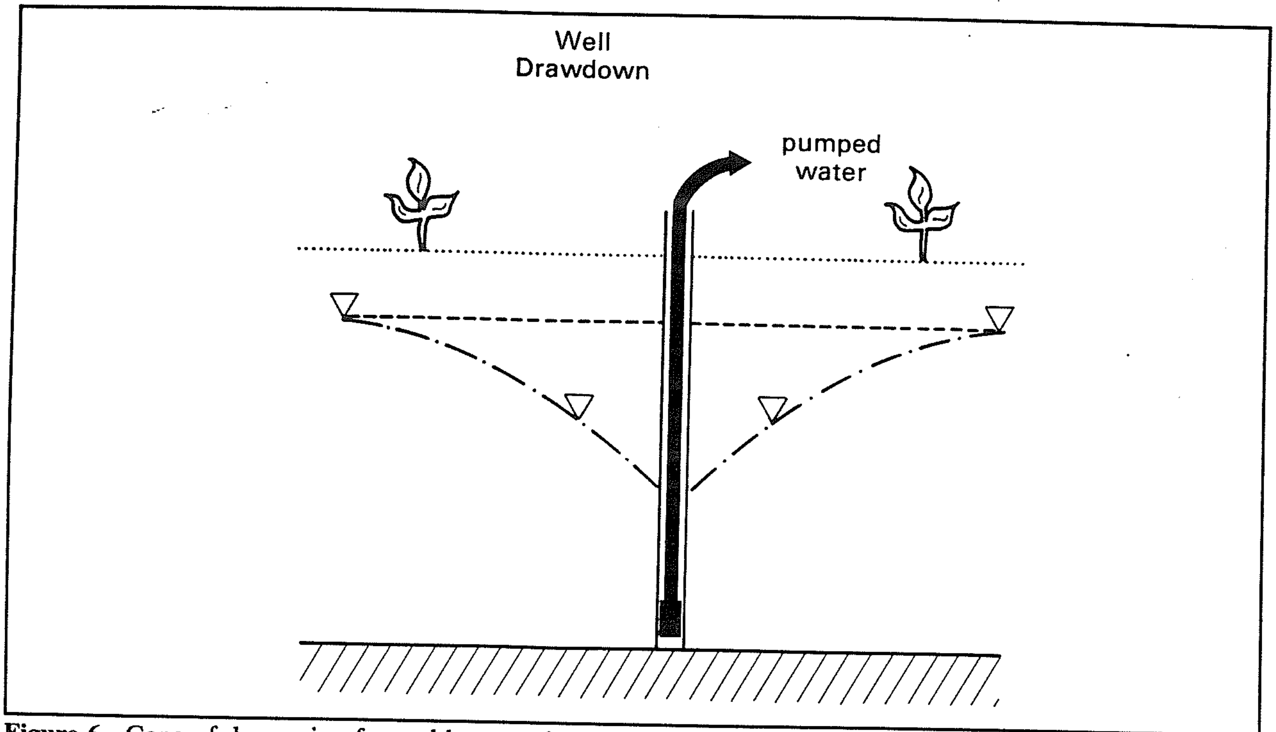


**Figure 6.** Cone of depression formed by pumping a well in an unconfined aquifer.

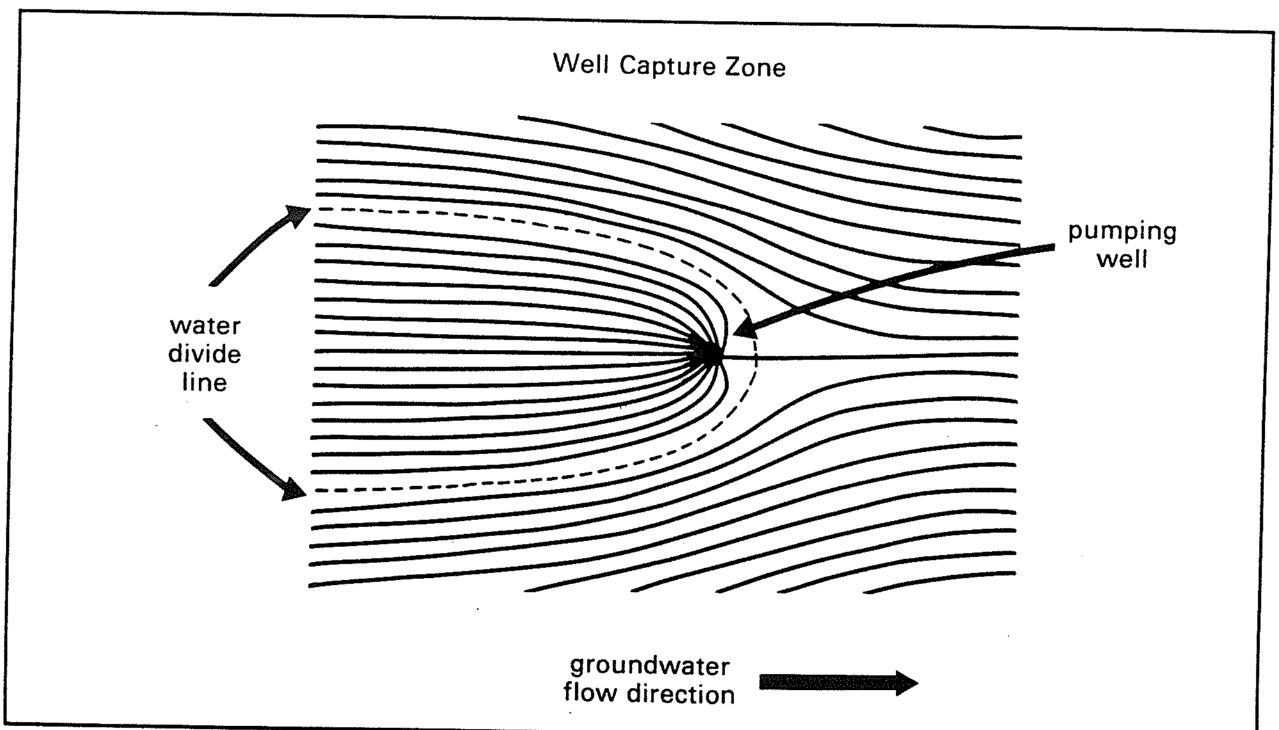


**Figure 7.** Illustration of a capture zone in the vicinity of a pumping well.

delivered to the well. Delineating capture zones is important to prevent activities within them which might lead to groundwater quality degradation.

## GROUNDWATER CONTAMINATION

Almost any human activity can contribute to groundwater contamination. Waste disposal, industrial activities, and agricultural inputs immediately come to mind when we think of potential sources of groundwater pollution. More subtle activities such as changes in land use can result in mobilization and transformation of potential pollutants naturally present in the environment. The selenium groundwater contamination in California, resulting from irrigation of formerly low-water input desert land, is a good example.

Groundwater pollution may be chemical or microbial. In the United States and other developed countries, microbial water pollution has been largely controlled, and the main concern is with chemical contamination. In less-developed countries, microbial contamination is usually a greater problem.

There are many factors controlling the ability of a chemical contaminant to move from the land surface, through the vadose zone, and ultimately to groundwater. These include the specific properties of the chemical, the subsurface geology, and environmental conditions. Often the contaminant's mobility is highly correlated with its solubility in water. Thus, as shown in Figure 8, high-solubility species such as nitrate can migrate rapidly to groundwater, while lower-solubility chemicals such as pesticides are less mobile. This is why in agricultural areas the appearance of nitrates from fertilizer or animal wastes is often the first evidence of groundwater contamination. The nitrate may be followed later by the appearance of slower-moving chemicals.

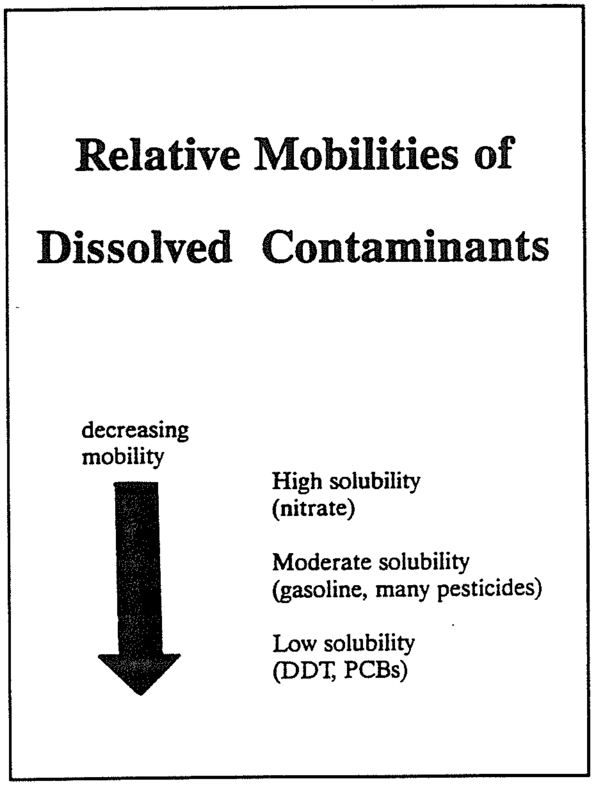


**Figure 8.**

Chemicals only partially miscible with water represent special groundwater pollution problems. These chemicals, usually fuels or solvents, can exist as separate liquid phases in the subsurface environment. If the liquid is less dense than water, as are most fuels and oils, a situation such as depicted in Figure 9 can result. After leaking out of its storage container, gravity moves the oil downward. Some of the oil is trapped in the vadose zone. If there is enough oil, eventually it reaches the water table and floats downgradient on the water surface. The oil slowly dissolves into the water until it is fully dissolved or dissipated due to other processes such as volatilization or degradation. Free oil phase trapped in the vadose zone (and in the saturated zone as well) remains as a contaminant source which may be difficult or impossible to reclaim or displace.

Figure 10 shows a similar situation for an organic liquid having a density greater than that of water. Chlorinated solvents such a carbon tetrachloride or trichloroethylene (TCE) are examples of this liquid type. Again the fluid leaks downward, leaving some residual material in the vadose zone. When it hits the water table, however, this dense fluid continues to migrate downward until it encounters a low-permeability layer. Depending upon the slope direction of this layer, the polluting liquid may then proceed to migrate in a direction unrelated to the groundwater flow direction, while continuing to dissolve into and pollute the water.

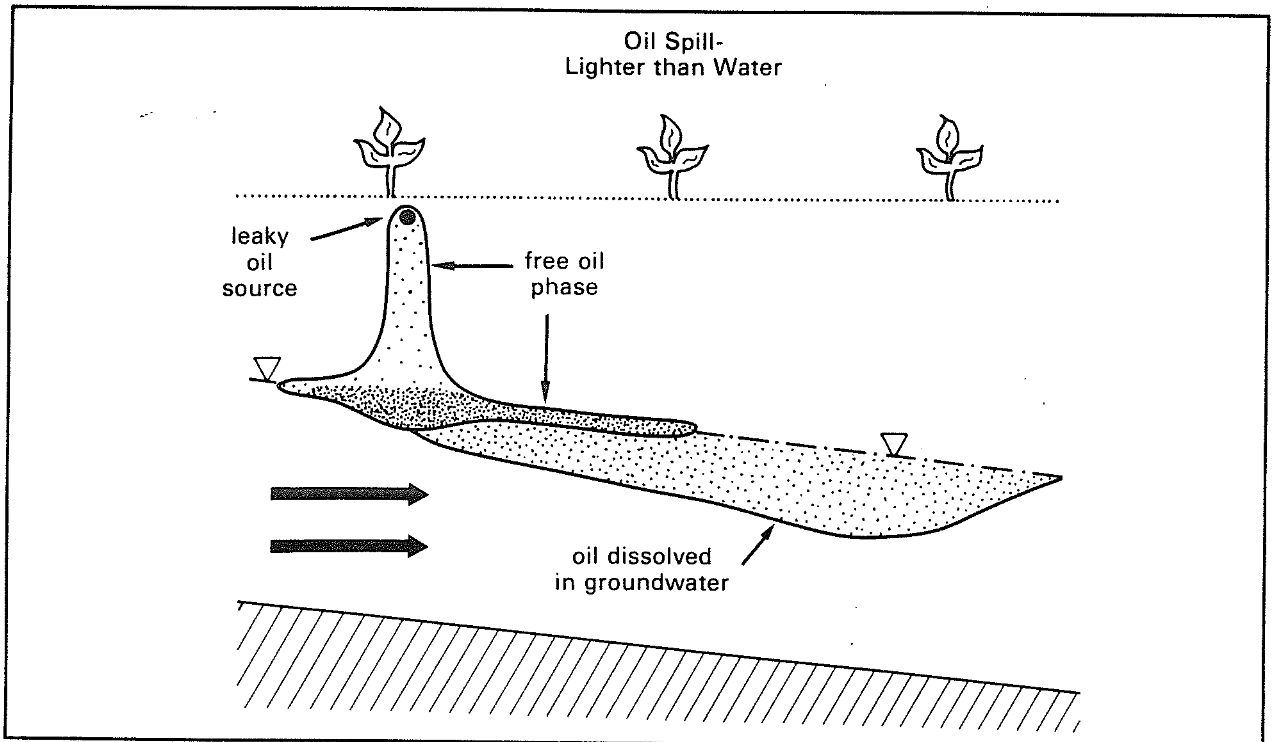


**Figure 9.** Schematic diagram of a spill of oil which is less dense than water (after Schwille 1984).

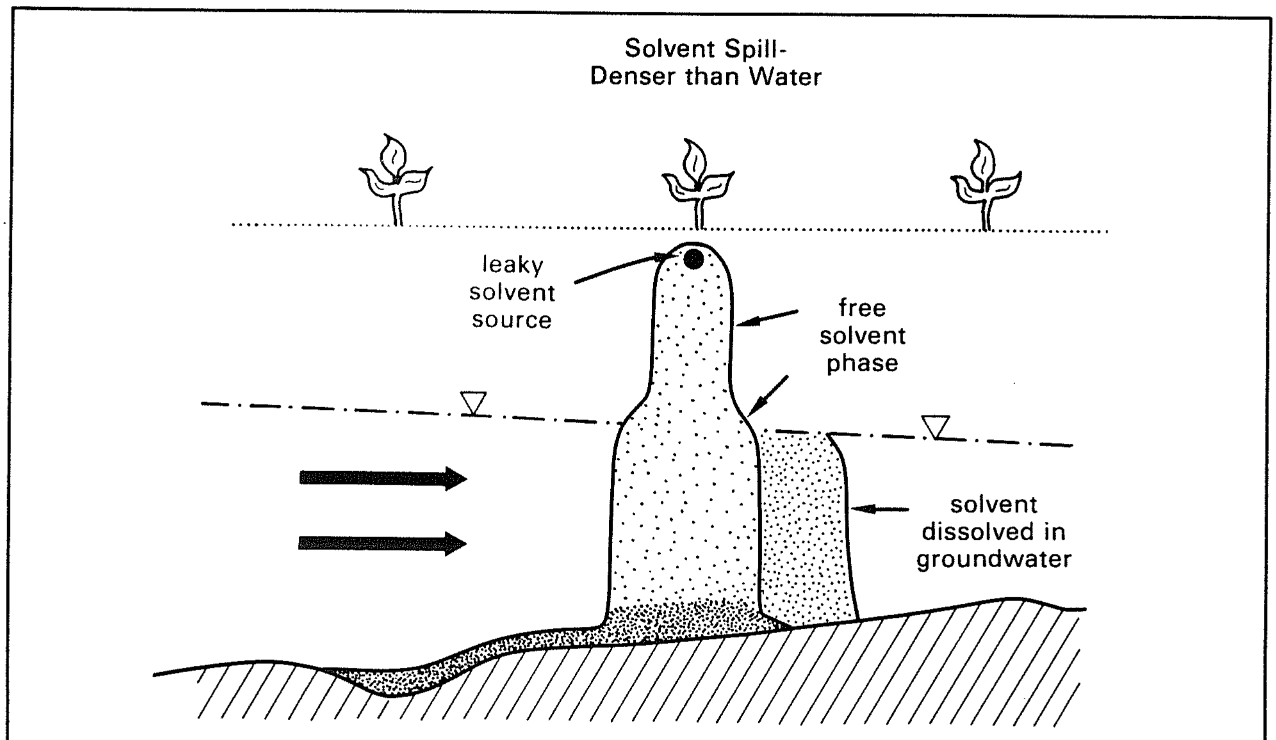


**Figure 10.** Schematic diagram of a spill of oil which is more dense than water (after Schwille 1984).

Locating the fluid source and remediation of an aquifer contaminated in this manner is very difficult.

## PROTECTION OF GROUNDWATER RESOURCES

Although groundwater behavior follows simple laws, the complexity of subsurface geology makes predicting groundwater movement a difficult problem. Chemical migration in groundwater is even harder to predict. While as recently as 100 years ago most groundwater was essentially pristine, today we find ourselves with many aquifers contaminated with anthropogenic chemicals (whether these chemicals represent significant health hazards is a separate but related issue.) This isn't surprising, given the small amount of chemical required to contaminate a large volume of water. For instance, the drinking water standard for TCE is 5 ppb (parts per billion.) One gallon of TCE is enough to contaminate 293 million gallons (900 acre-feet) of water to this level. The costs associated with pumping and remediation of such large volumes of water are almost always prohibitive. Contamination prevention by better source control and the use of chemicals which break down rapidly in the environment are the only viable alternatives for long-term groundwater quality preservation.

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Schwille, F. 1984. Migration of organic fluids immiscible with water in the unsaturated zone. In *Pollutants in porous media.* Edited by B. Yaron, G. Dagan, and J. Goldshmid. Ecological study series 47. Springer-Verlag, Berlin.

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## USGS NATIONAL WATER QUALITY ASSESSMENT PROGRAM

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A "Cadillac Desert" is how author Marc Reisner (1986) recently described the arid lands of the West such as California, Nevada, Arizona, and New Mexico. These naturally barren areas lacked only the West's most precious resource—water—to yield a multitude of agricultural products, to create recreational opportunities, and to spawn urban growth.

For three decades starting in the 1930s, federal agencies (primarily the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers), state governments, and local conservancy districts spent billions of dollars on water development. Some of that development yielded hydroelectric power and municipal water supply. Most of it, however, was for irrigation. Irrigation brought life to the arid and semiarid lands of the Southwest; an Edsel became a Cadillac.

Then came the 1970s and a revival of the benefit-cost concept. Economical, political, and (hopefully) hydrological considerations caused the federal government to abandon several major water development projects. Water quantity—groundwater development and reservoir storage—was the primary issue in the recent past.

But times have changed....

- 1970: The U.S. Environmental Protection Agency was established by Congress.
- 1972: The Clean Water Act promulgated a non-point source pollution-control program to be implemented by each state.
- 1976: The Resources Conservation and Recovery Act was enacted.
- 1982: Large concentrations of selenium at the Kesterson Reservoir, California, were identified as the cause of waterfowl mortalities.
- 1990s: Will this be the decade of the environment?

Now water quality, rather than water quantity, is the major focus of attention. The limited (sometimes finite) quantity of "clean" water has in many areas been overshadowed by the increasing quantities of "dirty" water. It's no longer true that "the solution to pollution is dilution," but "these concentrations are an abomination to the population."

I've referred to the so-called "Cadillac Desert," the age of water development in the West, and to the evolving water-quality concerns that are now facing this state and nation. How does this relate to the specific topic of the USGS National Water Quality Assessment (NAWQA) Program? I will focus on two points:

- The NAWQA Program reflects a growing concern by Congress (i.e., the states) about the nation's water resources—specifically, the effectiveness of recent legislation aimed at improving the nation's water quality.
- The NAWQA Program provides an opportunity—a stimulus—to align federal, state, and local interests toward the common goal of identifying water-quality concerns in large, multistate river basins.

To begin, let me briefly describe the overall program. The goals of the National Water Quality Assessment Program are:

- to describe the status of, and trends in, the quality of the nation's groundwater and surface-water resources; and
- to provide a sound understanding of the natural and human factors that affect the quality of these resources. The program will involve detailed study of groundwater and surface-water quality in 60 carefully chosen basins.

Regarding New Mexico, I'm very pleased that the Rio Grande basin from its headwaters in Colorado to El Paso, Texas, is among those selected for study beginning this year. The southern High Plains unit, which underlies parts of New Mexico and Texas, will be studied later in the program.

The NAWQA Program will provide data not currently available to answer basic questions regarding the nation's water quality. From a national perspective, there are currently three major water-quality monitoring networks that contribute to the understanding of water-quality conditions and trends. These networks include the Hydrologic Benchmark Network and the National Stream-Quality Accounting Network operated by the USGS, and the National Contaminant Biomonitoring Program maintained by the U.S. Fish and Wildlife Service. These three networks address surface-water quality; there is no national equivalent dealing with groundwater quality. On a state-by-state basis supplemental data do exist. However, these frequently are collected for site-specific regulatory reasons and have little regional value, or the data do not have a level of consistency or quality assurance to be a basis for conclusive interpretation. A study of two states, Colorado and Ohio, determined that only 10 percent of the $63 million spent on laboratory analyses by federal, state, and local agencies in 1984 would be potentially applicable for regional, ambient water-quality assessment.

In addition to providing a consistent, national data base of chemical, physical, and biological information, interpretation of data in the NAWQA Program will address cause-and-effect relationships such as water-quality impacts of land use, wastewater-treatment practices, and natural conditions. The data will also address basin-specific issues such as toxic contamination, nutrient enrichment, erosion/sedimentation, salinity, and suitability for various uses.

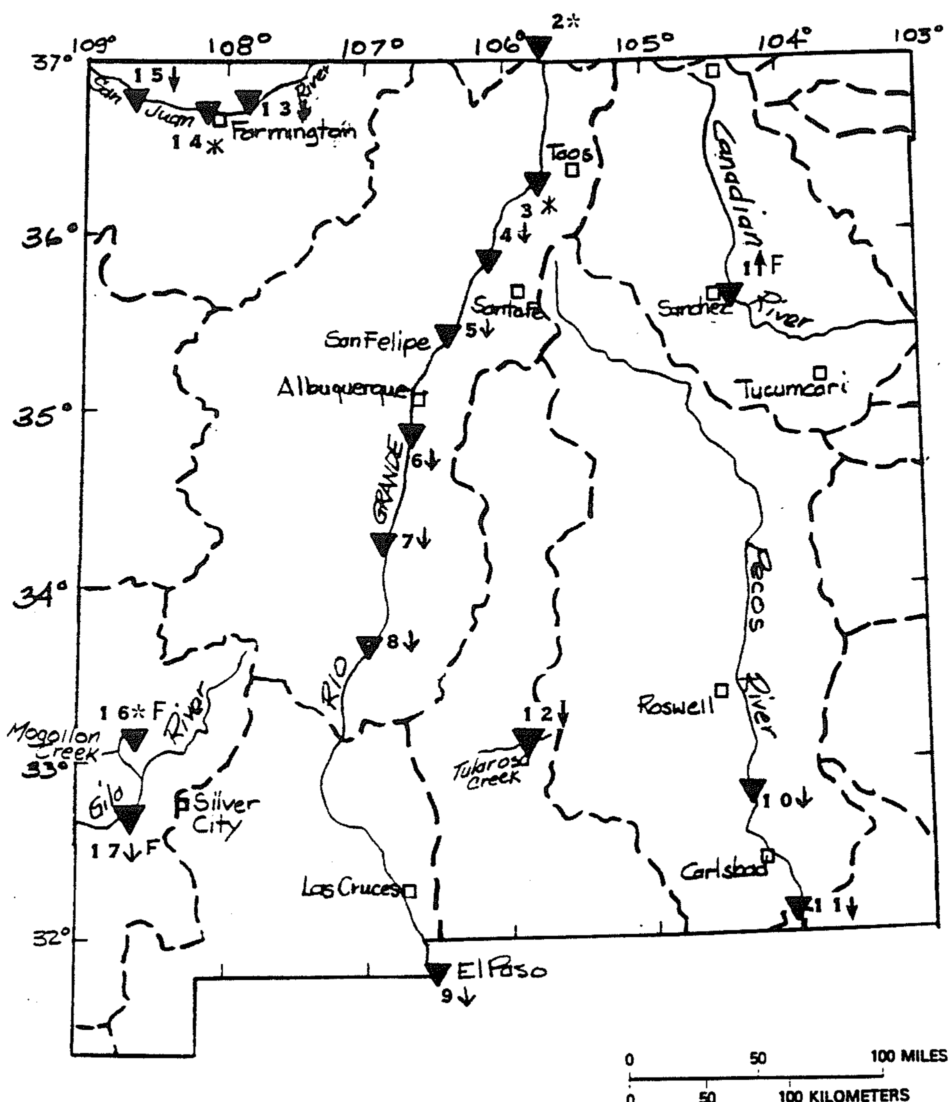
What is the current water-quality situation in New Mexico? The 1990 report of the New Mexico Water Quality Control Commission provides much of the answer. The report identifies a number of stream reaches and aquifers that have undergone impairment or contamination. However, not surprisingly, the specific causes of these problems were not addressed, in many cases because of insufficient data.

The information presented here on New Mexico's surface waters is from the 1990-91 National Water Summary that will be published by the USGS in 1992, the 20th anniversary of the Clean Water Act. The report will include a state-by-state perspective on water-quality trends that are based on statistical analysis of available data for the past 20 years. For New Mexico, this analysis was based on data for 17 sites (Table 1) and on the 15-year period 1975 through 1989. We will look at trends for four water-quality constituents: dissolved solids, nitrite plus nitrate, fecal coliform bacteria, and sediment.

TABLE 1. SURFACE WATER QUALITY MONITORING STATIONS IN NEW MEXICO SELECTED FOR ANALYSIS OF TRENDS

| Site Number | Station Name | USGS Station Number |
|---|---|---|
| 1 | Canadian River near Sanchez | 07221500 |
| 2 | Rio Grande near Lobatos, Colo. | 08251500 |
| 3 | Rio Grande below Taos Junction Bridge near Taos | 08276500 |
| 4 | Rio Grande at Otowi Bridge near San Ildefonso | 08313000 |
| 5 | Rio Grande at San Felipe | 08319000 |
| 6 | Rio Grande at Isleta | 08331000 |
| 7 | Rio Grande at San Acacia | 08355000 |
| 8 | Rio Grande at San Marcial | 08358500 |
| 9 | Rio Grande at El Paso, Tex. | 08364000 |
| 10 | Pecos River near Artesia | 08396500 |
| 11 | Pecos River at Red Bluff | 08407500 |
| 12 | Tularosa Creek near Bent | 08481500 |
| 13 | San Juan River near Archuleta | 09355500 |
| 14 | Animas River at Farmington | 09364500 |
| 15 | San Juan River at Shiprock | 09368000 |
| 16 | Mogollon Creek near Cliff | 09430600 |
| 17 | Gila River near Redrock | 09431500 |

As shown in Figure 1, dissolved solids concentrations as estimated from specific conductance measurements were analyzed for trends at 17 sites. Specific conductance is an electrical property related to the amount of salts that are dissolved in water. Results indicated either no trend or a decreasing trend in concentrations at almost all sites. The only increasing trend is for the Canadian River near Sanchez, which is suspected to be due in part to less precipitation and runoff during the period of analysis.




– – – – Regional or subregional drainage boundary

▾ Surface water quality monitoring site and number

↑ indicates increasing trend

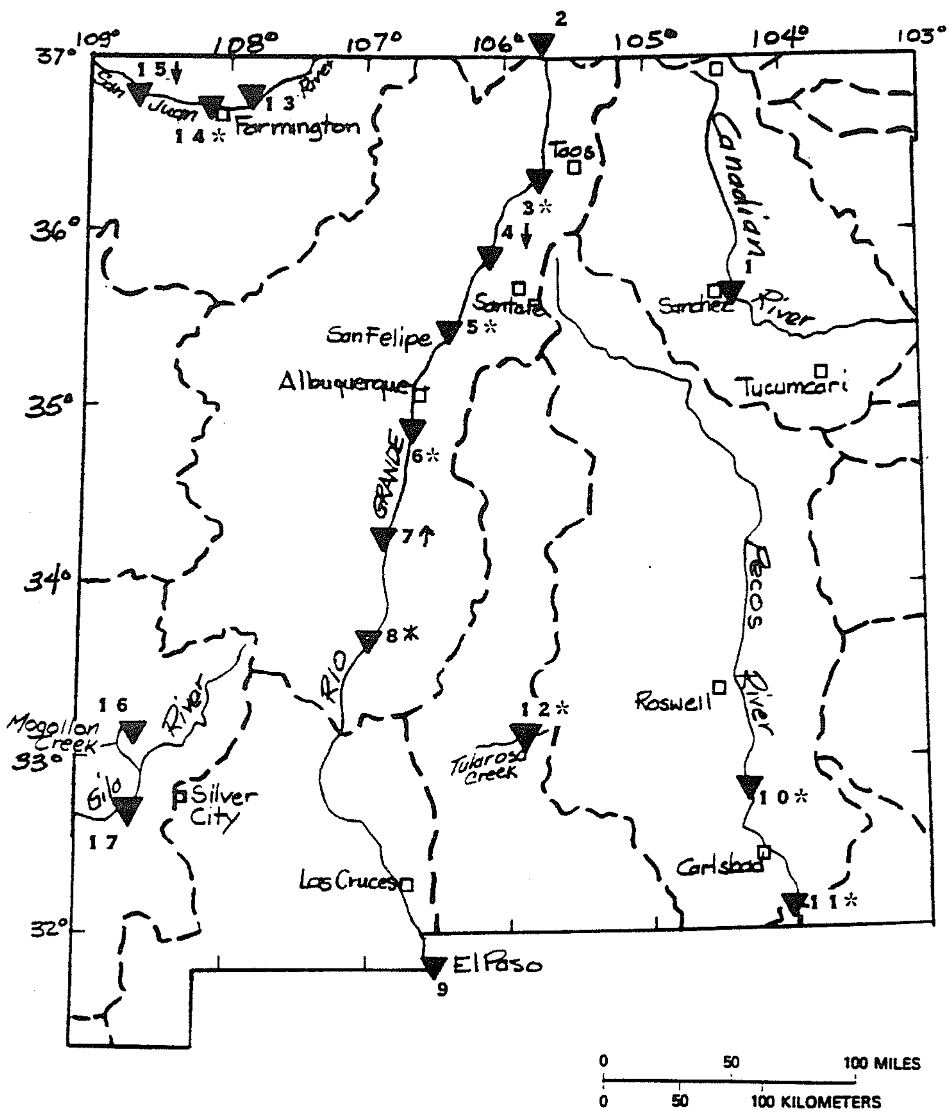
↓ indicates decreasing trend

* indicates no trend

F indicates data were flow adjusted

**Figure 1.** Dissolved solids concentration trends in water at U.S. Geological Survey surface water quality monitoring sites, water years 1975-89.

Concentration data for nitrite plus nitrate (Fig. 2) indicated no trend for eight stations, an increasing trend for one station, and a decreasing trend for two stations. The remaining seven stations had insufficient data for analysis. These data reflect improved wastewater treatment practices and suggest that non-point sources of nitrogen have not increased significantly in recent years. The one increasing trend may be attributed to increased rural development along the Rio Grande valley downstream from Albuquerque.




– – – – Regional or subregional drainage boundary

▾ Surface water quality monitoring site and number

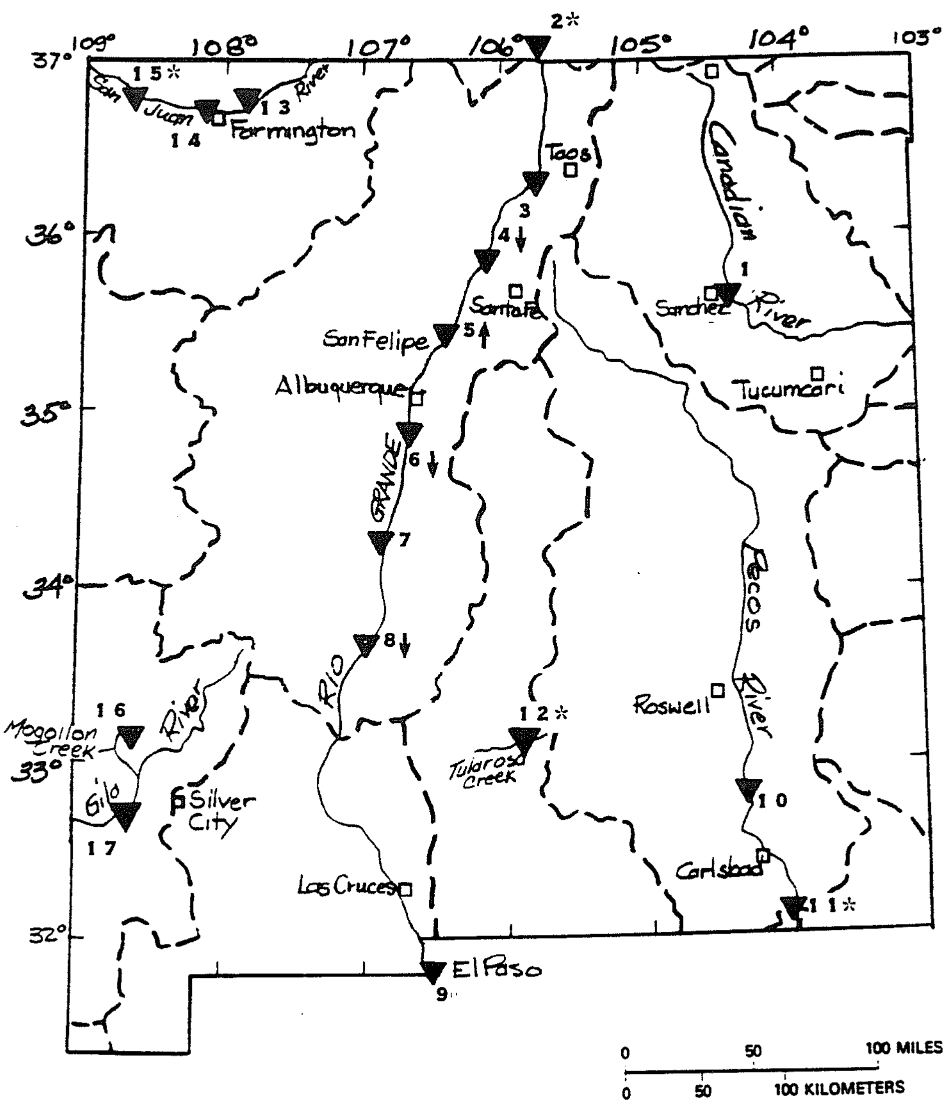
↑ indicates increasing trend

↓ indicates decreasing trend

* indicates no trend

**Figure 2.** Dissolved nitrite plus nitrate concentration trends in water at U.S. Geological Survey surface water quality monitoring sites, water years 1975-89.

Figure 3 shows that only one of the eight stations with adequate data indicated an increasing trend in fecal coliform bacteria: the Rio Grande at San Felipe (site 5). Though this is likely due to a growing rural population upstream from the site, sites on the Rio Grande both upstream (site 4) and downstream (site 6) indicate a decreasing trend in coliform bacteria. This suggests a possible water-quality concern that may be the result of a growing rural population in the vicinity of San Felipe.




– – – – Regional or subregional drainage boundary

▾ Surface water quality monitoring site and number

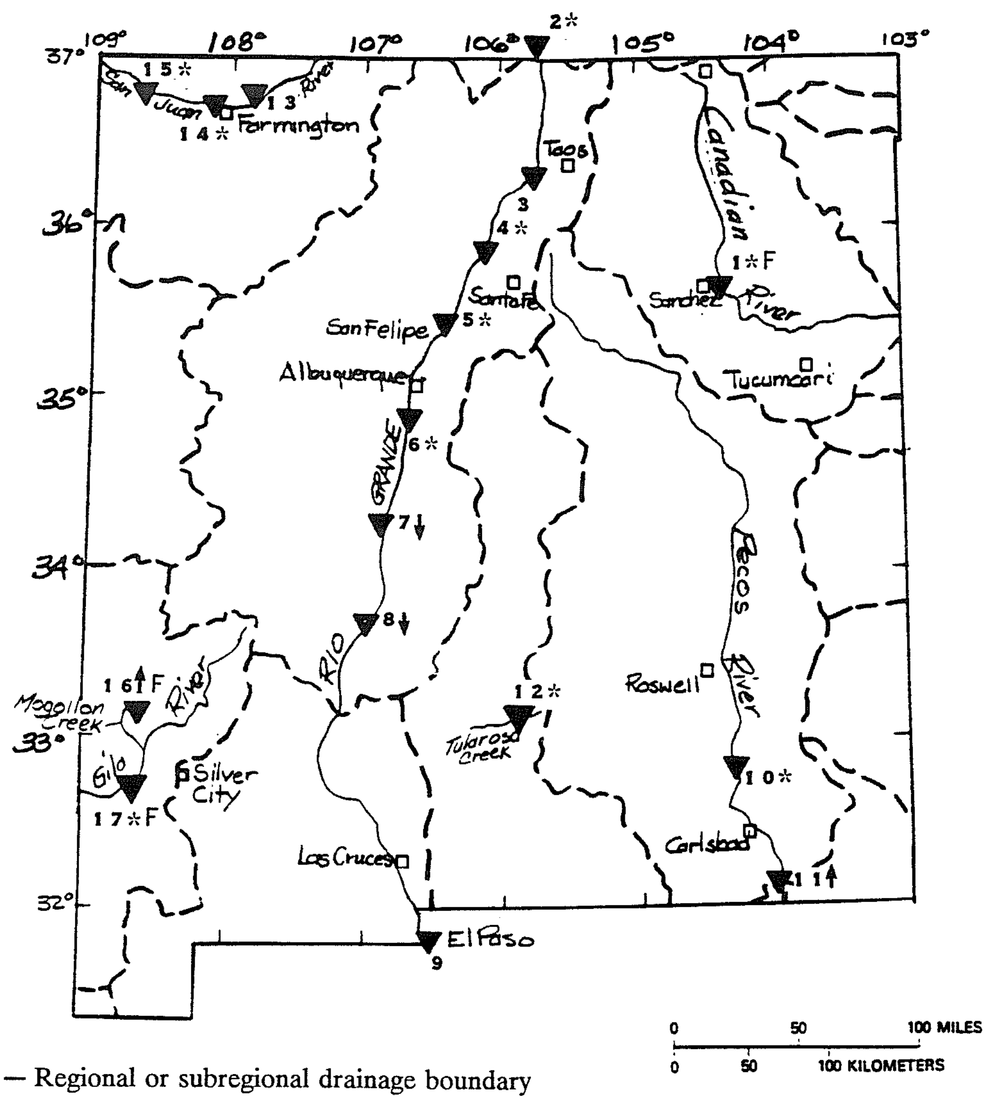
↑ indicates increasing trend

↓ indicates decreasing trend

* indicates no trend

**Figure 3.** Fecal coliform bacteria trends in water at USGS surface water quality monitoring sites, water years 1975-89.

Lastly is suspended-sediment concentrations. The trend analysis for this constituent (Fig. 4) indicated no trend for 10 stations, a decreasing trend for 2 stations, and an increasing trend for 2 stations. Improved rangeland conditions related to increased precipitation during water years 1979-87 resulted in more vigorous vegetative cover that tended to reduce rangeland erosion during this particular period. The increasing trend at Mogollon Creek was caused by increased erosion because of a larger number of rain storms, and the increasing trend on the Pecos River site may be the result of dam construction for Brantley Lake during 1986-88.




– – – – Regional or subregional drainage boundary
▼ Surface water quality monitoring site and number
↑ indicates increasing trend
↓ indicates decreasing trend
* indicates no trend
F indicates data were flow adjusted

**Figure 4.** Suspended-sediment concentration trends in water at USGS surface water quality monitoring sites, water years 1975-89.

Hopefully, the digression to water-quality conditions and trends here in New Mexico highlights the deficiencies of a relatively sparse, fixed-station monitoring network that is characteristic of most states. This approach, particularly if areal coverage is inadequate, makes cause-and-effect determinations difficult.

To achieve consistency in the data base for the program, NAWQA will require sampling for a list of both national target constituents and regional target constituents. The regional constituents will be developed by the project team after consultation with appropriate state and local agencies. Support data such as land use, soils, and point sources will be collected to assist in later interpretations.

NAWQA will include a combination of an expanded fixed-station network and an extensive synoptic-sampling program. The purposes of fixed-station sampling are to:

- estimate transport and mass balances between stations;
- determine long-term trends; and
- estimate frequency distributions of concentrations of selected constituents.

Synoptic sampling, on the other hand, provides a "snapshot" of water-quality conditions in a specific area at a specific time. This approach assists in the detection of sources of water-quality problems and the identification of problem areas requiring further study.

In addition to a fixed-station network and synoptic sampling, a third component of the NAWQA Program will be intensive studies. Intensive studies will focus on small areas where severe water-quality problems have been identified. Special sampling or hydrologic modeling may be used, and the areas will be revisited throughout the program to document changes (improvements) and to better understand system response.

As previously mentioned, the study of groundwater quality will be an important aspect of NAWQA. NAWQA groundwater activities will:

- determine the distributions of trace elements, organic compounds, and other chemical substances in the aquifer system;
- identify aquifers that have or are likely to have water-quality problems;
- where possible, identify the relative susceptibility of aquifers in the unit to future water-quality degradation;
- examine cause-and-effect relationships in the system;
- identify problems requiring more intensive investigations; and
- establish a data base for future assessment of long-term trends in groundwater quality.

Regarding groundwater sampling, emphasis will be placed initially on shallow systems. However, "deep" groundwater will be included where it is a source or potential source of water supply or subject to possible contamination from shallow aquifers.

As previously mentioned, the NAWQA Program will be characterized by simultaneous study of groundwater and surface-water systems. For the Rio Grande basin, the overall study plan is expected to consist of 1 planning year (fiscal year 1991), 1 year of available data analysis (fiscal year 1992), 3 years of intensive data collection and interpretation (fiscal years 1993-95), and 1 year of report preparation (fiscal year 1996). There will then be about 4 years of low-intensity sampling (fiscal years 1997-2000), after which detailed analysis and intensive sampling will resume beginning in fiscal year 2001. This cycle is planned to continue indefinitely.

The NAWQA Program can provide an impetus, a stimulus, an opportunity for us to work together toward a common goal: forging water-quality partnerships. The next two years will be devoted to working with the many federal, state, and local agencies concerned with the water resources of the Rio Grande basin to develop a comprehensive work plan for this long-range program. It was a wise man who said: "Learn from the mistakes of others—you can never live long enough to make them all yourself." We want to do it right the first time (or have lots of company to share the blame if something goes wrong).

I'm excited about the NAWQA opportunity. I sincerely hope NAWQA will bring the water-resource community closer together, and make more effective use of our limited financial resources but abundant expertise. If this is a "Cadillac Desert," we must begin now to work as closer water-quality partners to assure the Caddy doesn't rust out in the future.

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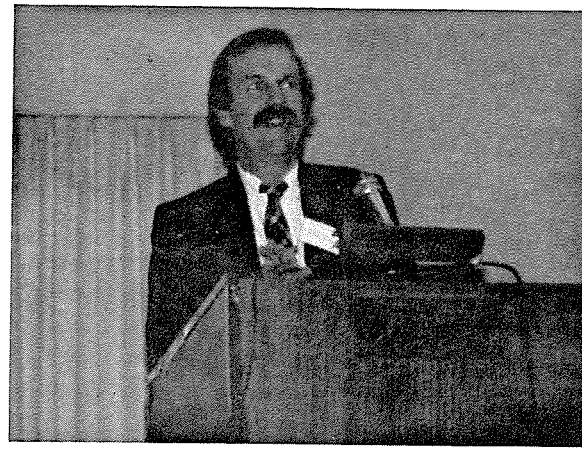

# DRINKING WATER PROTECTION STRATEGIES

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## INTRODUCTION

Development of management strategies and engineering technologies for providing safe drinking water to the public is arguably one of the greatest public works achievements of the 20th century in the United States. This success is so complete that it is usually only recognized when one travels abroad and is constantly aware of the potential hazards presented by local water supplies.

The first federal standards for drinking water were promulgated in 1914 and principally addressed bacteriological water quality; microorganisms being the causative agents of most acute water borne problems. With improved understanding of potential problems associated with drinking water came increasingly stringent standards in 1925, 1942, 1946, and 1962 (Cotruvo and Vogt 1990).

National Interim Primary Drinking Water standards were promulgated in 1975 based in large part on the 1962 U.S. Public Health Service standards, and established under authority granted to the Environmental Protection Agency (EPA) by the 1974 Safe Drinking Water Act. The 1986 amendments to the Safe Drinking Water Act identified 83 contaminants, most already regulated, which must be addressed by the EPA in its regulatory process. Current regulations are presented in Tables 1 and 2. These standards apply to all public water supply systems, which are defined as systems with 15 or more connections, or those serving at least 25 individuals. The development of these standards has progressed from the relatively straightforward objective of preventing immediate threats of water borne diseases, to providing a water supply, which if consumed for a lifetime (approximately 70 years), would have a vanishingly small probability of causing any excess mortality due to any water associated cause. It is equally clear that procedures to measure these benefits, the treatment technology needed to provide this level of quality, and the analytical methods needed to validate water quality are all taxing current levels of technology.

Groundwater is the source of over 90 percent of public drinking water supplies in New Mexico. Communities relying entirely or in part on

TABLE 1. U.S. ENVIRONMENTAL PROTECTION AGENCY NATIONAL PRIMARY DRINKING WATER STANDARDS (1989)
Primary Standards

| Constituents | Maximum Contaminant Level |
|---|---|
| **Physical Parameters** | |
| Turbidity | 1 (Turbidity Unit) |
| **Inorganic Chemicals** | |
| Arsenic | 50 (μg/L) |
| Barium | 1000 (μg/L) |
| Cadmium | 10 (μg/L) |
| Chromium | 50 (μg/L) |
| Fluoride | 4 (mg/L) |
| Lead | 50 (μg/L) |
| Mercury | 2 (μg/L) |
| Nitrate | 10 (mg N/L) |
| Selenium | 10 (μg/L) |
| Silver | 50 (μg/L) |
| **Organic Chemicals (Pesticides & Herbicides)** | |
| Endrin | 0.2 (μg/L) |
| Lindane | 4 (μg/L) |
| Methoxychlor | 100 (μg/L) |
| Toxaphene | 5 (μg/L) |
| 2,4-D | 100 (μg/L) |
| 2,4,5-TP Silvex | 10 (μg/L) |
| **Organic Chemicals (Volatile Organic Compounds)** | |
| Trichloroethylene | 5 (μg/L) |
| Carbon tetrachloride | 5 (μg/L) |
| Vinyl chloride | 2 (μg/L) |
| 1,2-Dichloroethane | 5 (μg/L) |
| Benzene | 5 (μg/L) |
| 1,1-Dichloroethylene | 7 (μg/L) |
| 1,1,1-Trichloroethane | 200 (μg/L) |
| p -Dichlorobenzene | 75 (μg/L) |
| **Bacteriological Factors** | |
| Coliform bacteria | Presence/Absence |
| **Radioactivity** | |
| Gross Alpha | 15 (pCi/L) |
| Radium-226 and 228 | 5 (pCi/L) |
| Tritium | 20,000 (pCi/L) |
| Strontium-90 | 8 (pCi/L) |

TABLE 2. U.S. ENVIRONMENTAL PROTECTION AGENCY NATIONAL PRIMARY DRINKING WATER STANDARDS (1989)
Secondary Standards (nonenforceable)

| Constituents | Maximum Contaminant Level | Effect On Water Quality |
|---|---|---|
| Chloride | 250 mg/L | Salty taste |
| Color | 15 color units | Objectionable appearance |
| Copper | 1 mg/L | Undesirable taste |
| Corrosivity | Noncorrosive | Stains, corrosion |
| Fluoride | 2 mg/L | Stains teeth |
| Foaming agents | 0.5 mg/L | Objectionable appearance |
| Iron | 0.3 mg/L | Taste, stains |
| Manganese | .05 mg/L | Taste, stains |
| Odor | 3 threshold odor number | Undesirable smell |
| pH | 6.5 - 8.5 | Corrosion, taste |
| Sulfate | 250 mg/L | Taste, laxative effect |
| Total Dissolved Solids (TDS) | 500 mg/L | Taste, appearance |
| Zinc | 5 mg/L | Taste, milky appearance |

surface water for its drinking supplies include Aztec, Bloomfield, Shiprock, Santa Fe, Las Vegas, Ruidoso, Tularosa, and Chama. There are several advantages with using groundwater as a public water supply.

- Groundwater does not require large storage facilities (reservoirs) to provide supplies during seasonal variations in water availability. Generally only a few weeks' capacity is sufficient.
- Trunk lines in a community's water distribution system can be much smaller compared to those for a single surface water source due to the fact that the aquifer, and therefore the source of water, is distributed over a much larger area.
- Groundwater almost never requires surface treatment. Traditional treatment is limited to chlorination and occasionally, fluoridation. Recognition of groundwater systems contamination is recent, due in part to the very long travel times before a pollutant may be detected in a water supply well.
- There is little or no variability in the quality of uncontaminated groundwater supplies. Surface water sources on the other hand may have diurnal fluctuations in temperature, seasonal variations in water chemistry, hourly changes in suspended solids concentrations during storm events, and are vulnerable to pollutants resulting from upstream spills and discharges.
- Groundwater sources are almost always less expensive to develop because there is no need for large surface storage facilities, no treatment needs, and the ability to develop the distribution system as the community grows.

Groundwater's principal disadvantages as a source of public water supply are:

- Groundwater resources are extremely difficult to quantify.
- Once a groundwater system is polluted, it is extremely difficult to restore it to its original quality.

In contrast to New Mexico's almost total reliance on groundwater resources, communities in the northeastern U.S. depend almost entirely upon surface water sources for public water supply. This contrast is relevant to the present discussion because most federal policy and regulatory decisions regarding water supply and wastewater treatment are initiated in Washington D.C. It is perceived that decisions made in this environment do not fully recognize and account for the technical and institutional constraints experienced by managers of water systems relying upon groundwater. Indeed, formal incorporation of groundwater considerations into policy developed by the EPA did not occur until 1984 (USEPA 1990), and even now regulations pertaining to groundwater quality are entirely within the purview of the individual states.

This paper addresses three areas:

- groundwater protection programs;
- groundwater quality problems and technologies available for meeting programs; and
- consideration of possible future problems which may face groundwater resource managers.

## GROUNDWATER PROTECTION PROGRAMS

### Wellhead Protection Areas

Until recently there has been little institutional recognition of the relationship between surface development and threats to underlying groundwater resources. This has been true at the federal, state and local levels, although public health agencies have attempted to protect shallow groundwater supplies from contamination by onsite wastewater disposal systems (for example, septic tank systems) for decades. Although limitations on the type and extent of surface development in many communities were possible through zoning ordinances, possible impacts on groundwater quality were not considered.

Furthermore, until passage of the Resource Conservation and Recovery Act (1976), there was little regulation of hazardous materials discharge to groundwater. To its credit, New Mexico was one of the first states to develop regulations pertaining to groundwater discharges, and the standards are nearly identical to federal drinking water criteria.

The 1986 Safe Drinking Water Act Amendments provide states with federal assistance to develop Wellhead Protection (WHP) programs. WHPs address problems associated with surface development in areas dependent upon groundwater for public supply. The program philosophy is to place realistic controls on most surface sources of contaminants. The EPA (1990) notes that 11 European countries have some form of WHP program at present. It is interesting to note that although the law requires all states to participate, no sanctions are provided for states which do not. The objective of the WHP program is to protect areas surrounding public wells or well fields from activities which may pose a threat to the underlying water quality. In developing a WHP program, seven elements must be addressed (USEPA 1987):

- The WHP program must specify the duties of appropriate state and local water and health agencies which will be involved in program implementation.
- Procedures must be developed for defining the extent of the Wellhead Protection Area (WHPA). WHPA's are defined as the surface and subsurface area surrounding a water well or wellfield.
- Procedures must be developed for determining the anthropogenic contaminants which may be present in the WHPA.
- The WHP program must describe procedures which might be implemented to protect water supplies.
- Contingency plans must be developed for an alternative water supply in the event contamination forces closure or abandonment of the current supply.
- The WHP program must require that potential sources of contamination within the WHPA of new wells be considered prior to their construction.
- Procedures to ensure public participation in the WHP program must be developed.

One major element of the WHP program is determination of WHPAs. These are defined as the surface and subsurface area surrounding a water well or wellfield supplying a public water system through which contaminants are reasonably likely to reach the well. An important concept in determining the WHPA is the Zone of Contribution (ZOC), which is distinct from the more familiar Zone of Influence (ZOI), both illustrated in Figure 1. The ZOI is that portion of the aquifer in which drawdown occurs due to stress from the pumping well. The ZOC is the entire area which contributes water to a well or wellfield. These concepts are important as they likely must be considered in delineating a WHPA.

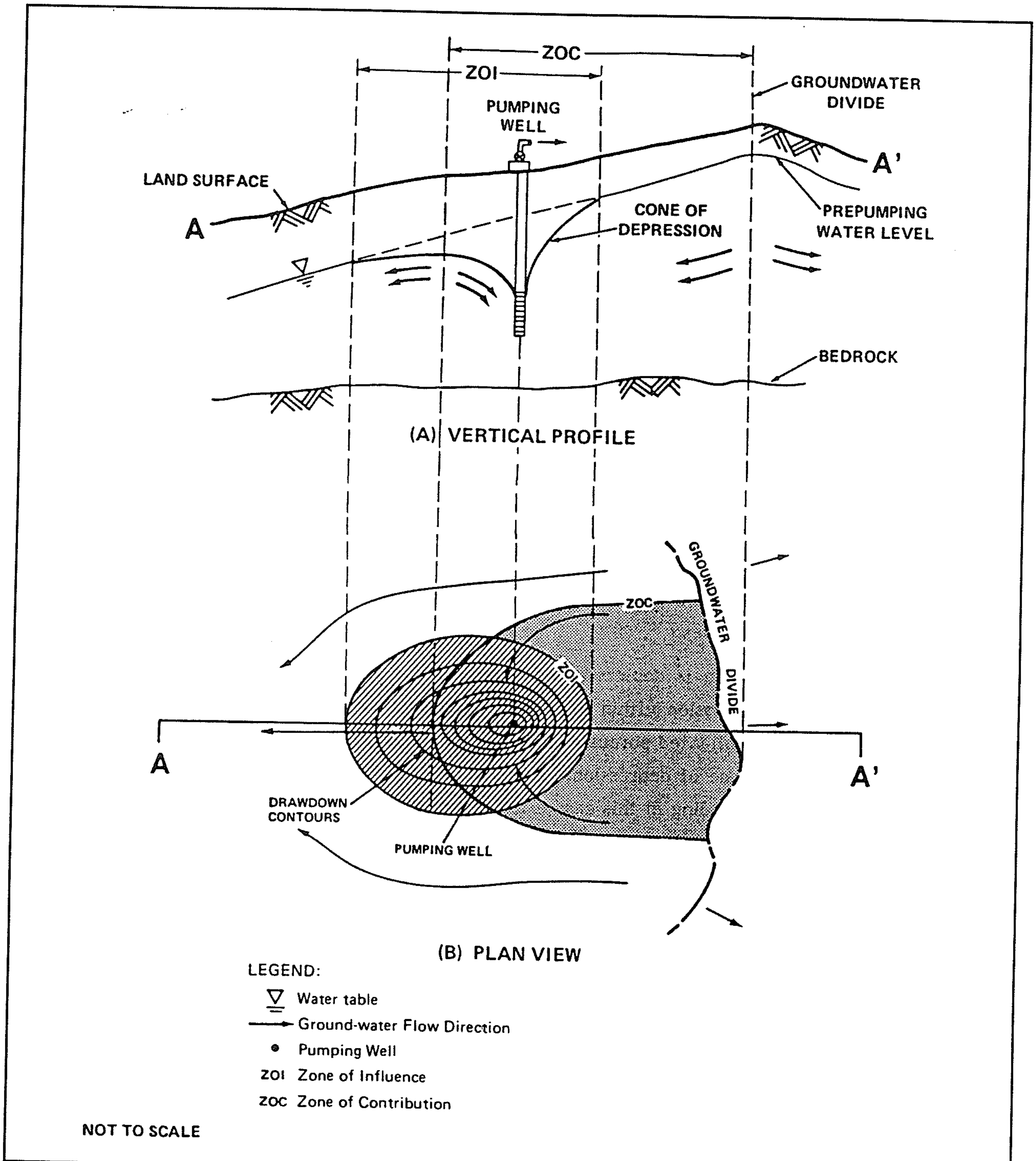


**Figure 1.** Terminology for Wellhead Protection Area delineation (hypothetical pumping well in porous media) (EPA 1990).

Delineation of a WHPA may be designated using the following criteria, which are generally in order of increasing cost and technical sophistication:

- arbitrarily select the WHPA
- calculate a fixed radius from each well or wellfield
- use simple geometric shapes which account for regional flow patterns to determine the WHPA
- use analytical solutions of groundwater flow patterns
- base the WHPA on hydrogeologic mapping
- develop numerical groundwater flow and contaminant transport models to justify the WHPA

Most likely a combination of two or more of these approaches will be practical. The relationship between each of these approaches is presented in Figure 2. Factors considered in determining which approaches to take include groundwater flow velocities, flow boundaries, and the capacity of the subsurface environment to stabilize, dilute, or degrade possible pollutants.

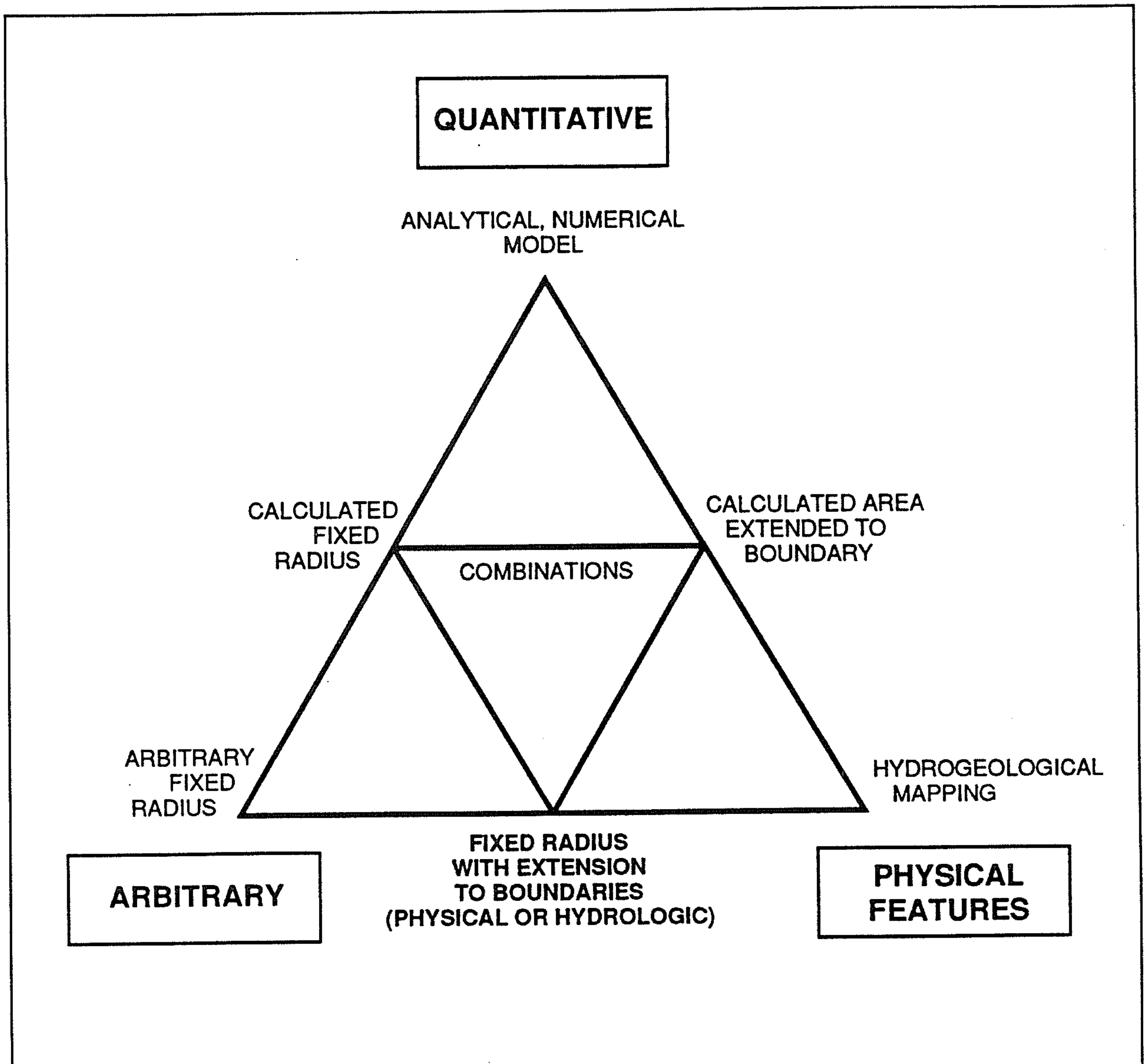


**Figure 2.** Interrelationships of Wellhead Protection Area delineation methods (EPA 1990).

Three possible management objectives in a WHPA are:

- Establish a remediation zone as protection from unexpected contaminant release. Once pollutants have escaped into the soil, adequate time and distance must be designated for a remediation program, before the contamination affects the water supply.
- Identify an attenuation zone which will reduce contaminants to acceptable levels through degradation, stabilization, or dilution before it reaches the water supply.
- Provide a wellfield management zone in which development and land use are regulated to control potential groundwater threats.

It is possible that a WHPA will be subject to future redelineation as additional information on aquifer characteristics is developed through monitoring programs (Meyer 1990).

**Groundwater Protection Policy and Action Plan**

In 1988, an independent approach was initiated whereby the city of Albuquerque and Bernalillo County formally recognized the importance of high quality groundwater to the community's continued development. They funded a major three-year study to develop a comprehensive groundwater protection policy (CH2M-Hill 1989). This plan will be known as the Groundwater Protection Policy and Action Plan (GPAP). A very important component of this planning effort is the development of a Hazardous Materials and Waste Storage (HMWS) policy.

The GPAP begins by characterizing the threats to groundwater resources in the Albuquerque basin. This has been accomplished in part through a geographic information system (GIS) compilation of known sources of contamination, and potential sources of pollutants, together with a semi-quantitative ranking process for assigning threat potentials (Aller, et al. 1987). Subsequently, possible aquifer protection strategies will be identified. Finally, a policy will be developed, with considerable emphasis on public involvement, which identifies strategies for minimizing contamination risks to the region's groundwater resources. The planning program is expected to be complete in early 1992.

The HMWS' objectives are to identify appropriate measures which the city and county might implement to minimize the threats to the community from activities which generate or store hazardous materials. This is being accomplished by characterizing all HMWS activities in the area, assessing the vulnerability of groundwater resources to these activities, and reviewing other HMWS programs around the country. The final product will be the HMWS Policy, together with an Action Plan proposing how this policy might be implemented by the local governments.

Two comments regarding this program are relevant here. First, by virtue of the effort's magnitude, the program is producing a large amount of information regarding the basin's groundwater resources that otherwise never would have been compiled. Much of the raw data is cataloged onto the GIS, thus making it readily available in graphic form to assist in this and future planning efforts. This facilitates the use of this information in other projects. Also, the enabling ordinances mandated formation of a Groundwater Protection Advisory Committee consisting of approximately 20 citizens representing various institutional, environmental and citizen groups within the community. This group has worked very closely with governmental agencies and consultants to facilitate development of plans and policies acceptable to the public and the business community. Including the public in the planning process from its inception is unique and in marked contrast to more normal procedures in which the public is simply given an opportunity to comment on a final draft policy.

**Groundwater Remediation**

A technology still very much in a primitive stage of development is that used to clean up contaminated groundwater. Once an aquifer has become contaminated, two objectives of a remediation program must be achieved to assure protection of a community's potable water supply. First, the pollutant's source must be located immediately and stopped, contaminant migration must be halted, and if necessary, an alternate source of water provided to the community. Once the community's health and safety have been assured, the second objective is to remove or stabilize the contaminants from the subsurface environment. Conventional aquifer restoration alternatives can be broken into four categories:

- containment of the aquifer contaminants
- removal of mobile pollutants, followed by surface treatment of contaminated water or recovery of free product, and subsequent disposal or reuse of treated water
- removal of contaminated soil, followed by treatment and/or disposal
- in situ stabilization of aquifer contaminants

Frequently a combination of these methods is used to maximize the performance of the treatment process. These alternatives are described briefly below.

Pollutant containment is the most immediate concern following determination of a groundwater contamination problem. It can be achieved either by using a physical barrier such as a grout curtain, slurry cutoff wall or sheet piles, or by creating a hydraulic barrier resulting from pumping and injection wells. Containment technology is reviewed by Spooner, et al. (1985) and Keely (1984).

Mobile contaminant removal from the groundwater system is achieved by directing pollutant migration toward wells or trenches from which it can be recovered or removed. A schematic of a traditional pump-and-treat process using combined pumping and injection wells to bring contaminants to the surface is presented in Figure 3. Variations of this process include free product recovery of petroleum products floating on a water table, vacuum extraction of volatile organic compounds, and pump-and-treat processes for soluble constituents. These processes are limited to volatile, liquid, or soluble pollutants; insoluble compounds remain attached to soil particles in the aquifer or vadose zone. Bouwer, et al. (1988), Wagner, et al. (1987) and Guswa et al. (1984) have prepared reviews of processes for management and treatment of groundwater contamination problems involving mobile contaminants.

In situ stabilization of hazardous wastes is a relatively new treatment process which shows considerable promise as an alternative to conventional

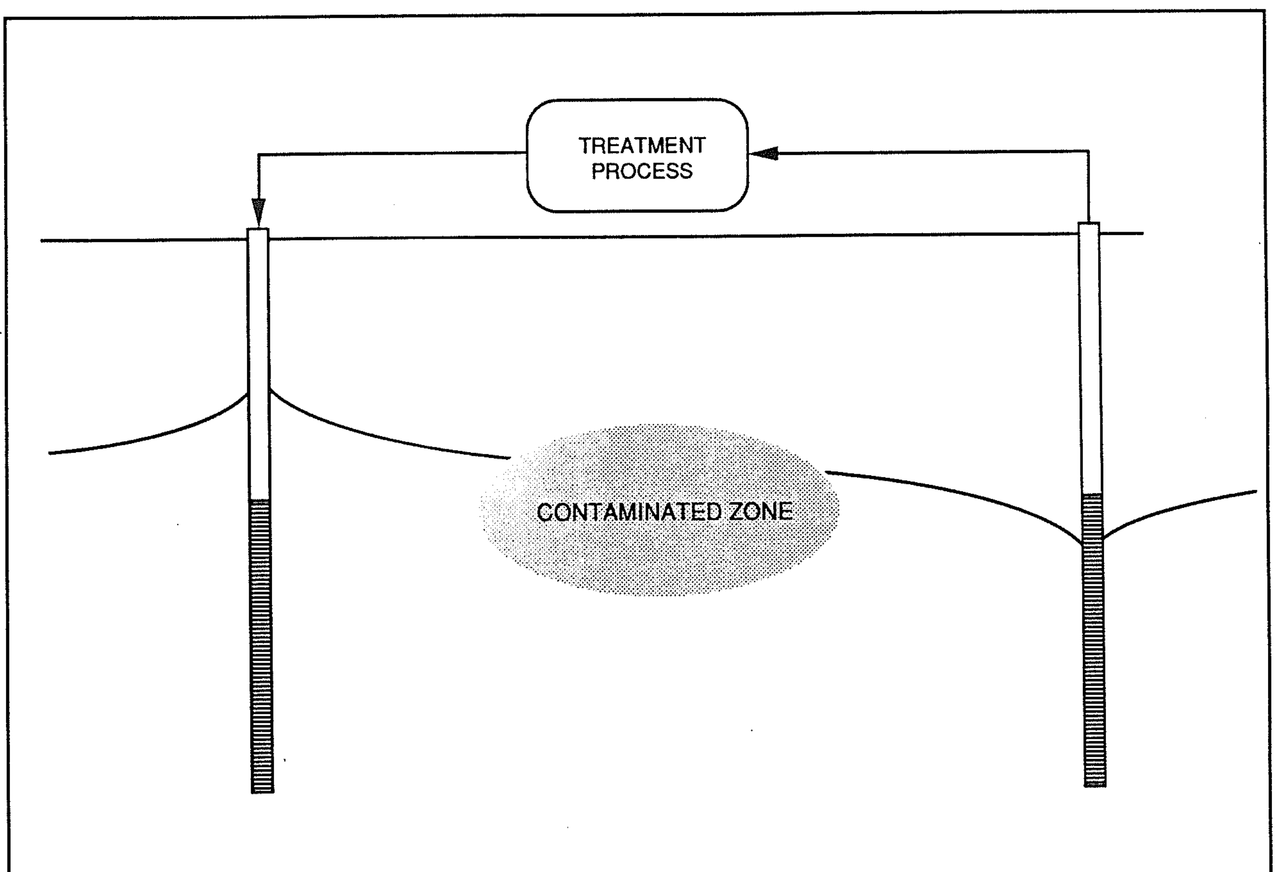


**Figure 3.** Diagram of conventional pump-and-treat groundwater restoration process.

pump-and-treat methods. Its principal application to date has been in groundwater systems contaminated with biodegradable organic materials. In situ treatment is accomplished by stimulating the growth of naturally occurring soil microorganisms by introducing essential nutrients (for example, nitrogen and phosphorous) and appropriate electron acceptors (for example, oxygen or hydrogen peroxide) required for the organism's growth. Lee, et al. (1988), Wilson, et al. (1986), Borden, et al. (1989), and Amdurer, et al. (1986) have prepared reports and reviews of in situ biological waste stabilization technology, while Sims, et al. (1984) discussed in-place remediation of contaminated soils. In situ technology is limited to applications in which the contaminants are degradable.

Although conventional groundwater restoration programs when properly designed and implemented are generally effective, they have numerous problems which include:

- requiring management of large volumes of water which generally are contaminated at very low levels
- frequently producing difficult to manage by-products, like sludges
- conventional pump-and-treat alternatives requiring large surface disruptions for long periods
- conventional alternatives may affect hydraulic characteristics in uncontaminated parts of the aquifer
- methods which remove mobile contaminants, such as vapors, free liquids, or those which are soluble, may not work in aquifers with low hydraulic conductivity
- surface disposal of large volumes of treated groundwater may pose institutional obstacles such as requirements for ground or surface water discharge permits and possible purchase of groundwater rights

From a drinking water perspective, groundwater restoration operations are enormously expensive. A good rule of thumb is that complete remediation at a leaking underground storage tank site will start at close to $100,000 and may exceed this value by a factor of 10 or more if complicating factors arise. Also, remedial actions take a very long time to complete. For example, in the 1970s, chlorinated solvents were detected in Albuquerque's San Jose Number 6 municipal well, New Mexico's oldest Superfund site. The Remedial Investigation and Feasibility Study (RIFS) was completed in 1989. Remediation activities may take an additional 20 years, and even then it is unlikely that all contaminants will ever be removed from the subsurface environment. This last example, admittedly a worst case study, illustrates the enormous challenges facing the manager of a water utility dealing with a polluted aquifer.

## DRINKING WATER TREATMENT

As stated previously, one of groundwater's most important advantages as a source of public supply is that no treatment is traditionally required. However, the combination of more stringent regulations governing drinking water quality, and increasing anthropogenic abuse of groundwater systems has forced some water utility managers to consider the possibility that treatment may be required. Conventional water treatment technology consists of physical and chemical processes. A brief summary of the capabilities of these processes is presented. The reader is referred to a recent treatise on the subject for detailed information (ASCE and AWWA 1990).

Physical treatment processes are those which rely on physical phenomena to achieve treatment. Sedimentation and filtration are processes which remove particulates, down to and including colloidal-sized material if used in conjunction with appropriate chemical addition. Aeration may be used to remove volatile constituents, such as chlorinated solvents or hydrocarbons. One of the most common groundwater treatment technologies is use of packed column air stripping to remove volatile organic compounds (VOCs). In most applications, this process involves exchanging a groundwater pollution problem for a less objectionable air pollution problem.

Chemical treatment processes utilize chemical principles to provide removal of soluble constituents, or in the case of colloids, to achieve destabilization of particulates prior to physical removal. Chemical disinfection using gaseous chlorine or one of its aqueous salts is practiced by virtually all public water utilities in the U.S. It is cheap and very effective at destroying pathogenic organisms. Adding coagulants and flocculating agents is perhaps the second most common process, and precedes either sedimentation or filtration operations.

Chemical precipitation is closely related to flocculation, and relies upon altering the source water chemistry to effect precipitation of otherwise soluble parameters, most commonly metals, which are subsequently removed by sedimentation.

Two other common treatment processes, which are relatively expensive and thus have applications limited to waters with special problems, are activated carbon adsorption and ion exchange. Activated carbon adsorption is a very effective process for removal of most soluble hazardous organic pollutants as well as tastes, odors, and color from organic compounds. Activated carbon is used widely in home water treatment devices. Ion exchange is used for selective removal of ionic constituents, almost always at the water's point of use. The two most common applications are home water softening and demineralization applications where very high purity water is needed for industrial utilization. It is unlikely that either treatment process will ever be used for treating public water supplies except in very unusual circumstances due to their high capital and operating costs.

A block diagram illustrating the treatment sequence for a generic surface-water treatment plant is presented in Figure 4. Pretreatment consists of screening to remove sticks and rags, and also includes pumping the raw water up to the treatment plant. Coagulating and flocculating chemicals are added to improve the sedimentation and filtration process. An implicit assumption in this diagram is that no water quality problems exist which might require special treatment processes such as softening or removal of VOCs. Finally the water is chlorinated and possibly fluoridated, and enters the storage and distribution system. The treatment scheme for a water system using groundwater as its supply is presented in Figure 5 for contrast.

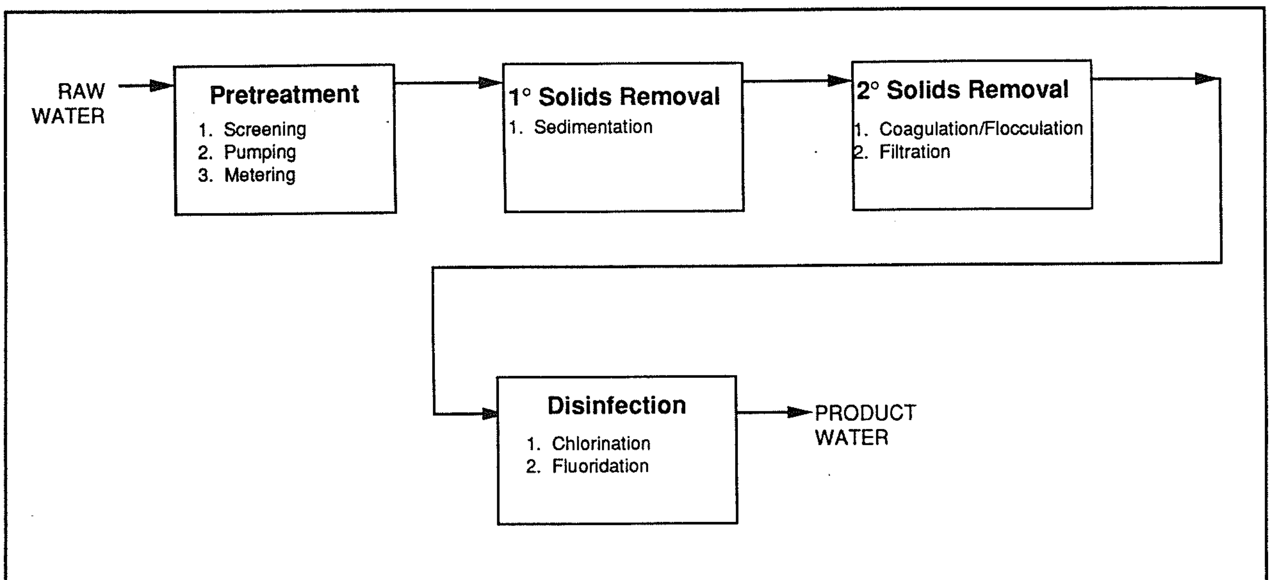


**Figure 4.** Diagram of common drinking water treatment process for treating surface water.

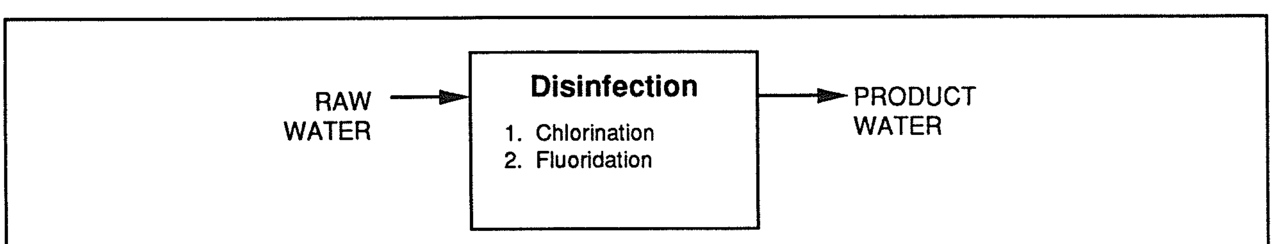


**Figure 5.** Diagram of common drinking water treatment process for treating groundwater.

**Drinking Water Regulations: Gazing Into The Future**

Current Safe Drinking Water Act regulations (Table 1) can be readily met by nearly all water utilities using groundwater for supply, provided no anthropogenic contaminants are present. This is because water utility managers historically have not considered groundwater resources which are not of sufficiently high quality to meet Safe Drinking Water standards as possible sources of potable water. Therefore, an aquifer with total dissolved solids (TDS) concentrations greater than 1,000 mg/L, or with elevated arsenic levels, or other naturally occurring constituents present above drinking water standards have not been developed for public water supply. Several New Mexico communities have faced this problem when seeking new water resources for community growth; nearby groundwater resources are available, but water quality considerations preclude their use for potable supply.

New more stringent standards (Table 3), however, are increasing the possibility that many New Mexico communities will have to consider some type of treatment in the near future. These new standards will present three types of problems to water utility managers.

First, new standards consist of ever lower Maximum Contaminant Levels (MCLs). For example, reducing the arsenic standard from 0.5 mg/L to .03 mg/L (Cotruvo and Vogt 1990) will place several major Albuquerque wells out of compliance with primary drinking water standards (Summers 1990). It is interesting to note that not all proposed changes are more stringent; proposed MCLs for barium, chromium, and selenium are higher than present.

The second problem involves establishing regulations for constituents not currently regulated. Parameters which fall into this category include many new VOCs and synthetic organic chemicals, four new microbiological characteristics including viruses, and the radionuclides uranium and radon. Several New Mexico communities, particularly in the northwest, use groundwater supplies with relatively high concentrations of uranium. Radon levels in the state's groundwaters are not well characterized. It is interesting to note, however, that the drinking water standard for radium-226 is 3 pCi/L, while radon which is not regulated, is commonly present at concentrations exceeding 1,000 pCi/L. Another consideration is the cost of monitoring. Sample collection and analysis for the entire suite of organic compounds identified in the proposed regulations may exceed $500 per sample.

TABLE 3. POSSIBLE NEW STANDARDS WHICH MAY AFFECT WATER UTILITIES USING GROUNDWATER AS THEIR SOURCE OF SUPPLY

| Parameter | Nature of Standard | Possible Implications |
|---|---|---|
| Arsenic | Reduced MCL | May place source out of compliance |
| Synthetic & volatile organics, uranium, radon, microbial characteristics | New standards | May place source out of compliance<br>Expensive monitoring costs |
| Lead | Reduced MCL & new application | May force treatment<br>Monitoring uncertainties |
| Disinfection by-products | New standards | May force treatment |

The last problem facing water utility managers as a result of continued regulatory development is that new regulations may change the point of compliance from water quality in the distribution system, to water quality at the tap. This is exemplified by proposed lead and copper regulations which seek to address high lead levels in tapwater resulting from corrosion of lead services, lead solder, and brass fittings (USEPA 1988). The regulations propose a more stringent standard than the current 0.5 mg/L (the exact value has not yet been decided). The point of enforcement will be at the customer's tap, not at the distribution system. The implications of this regulatory approach are enormous in that utilities will have to develop strategies to insure that their water will not accumulate lead regardless of the construction practices used by its customers. Furthermore, a monitoring program that provides proof will have to be developed. This in itself is a significant challenge because in the worst cases, a sample of water standing overnight in a household tap must be drawn. This sample must be collected early in the morning before any water has been drawn. The American Water Works Association Research Foundation has published an extensive monograph on the technologies available (Economic and Engineering Services, Inc. 1990). The EPA's official position is that lead corrosion control is relatively easily controlled at the utility's treatment plant, a position that is not particularly relevant to Albuquerque which operates over 80 wells, 40 reservoirs, and no treatment plants.

## CONCLUSIONS

The above example of a more stringent lead standard, coupled with a change in the point of enforcement, illustrates a very important difference between surface water and groundwater as a source of supply. A community relying upon surface water will have only one or two water treatment plants, thus quality control of the product water is relatively straightforward, and as problems appear they can be readily addressed. On the other hand, a community utilizing groundwater must monitor the quality at numerous wells and/or reservoirs, and will have few if any options for addressing water quality problems. Yet groundwater resources have provided high quality drinking water for nearly half the U.S. population for decades with very few problems.

The traditional drinking water regulatory approach is not particularly responsive to utilities which rely upon groundwater resources. However, there is no denial that the subsurface environment is becoming increasingly contaminated by man's surface activities. It is likely that the most effective drinking water protection strategies will include a combination of wellhead protection programs and possibly innovative treatment methods. Hopefully, the regulatory environment will also include some flexibility to allow utilities using groundwater sufficient options to continue to provide high quality water on a cost-effective basis.

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# GROUNDWATER ISSUES AND CONFLICTS: THE DECADE AHEAD

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The fundamental causes of water quality problems lie in seemingly unrelated aspects of life: how we live, the way we farm, produce and consume, transport people and goods, and plan for the future. Many aspects of modern life and past practices put pressure on water quality. Until recently, these activities proceeded with little recognition of the effects they had on surface water, groundwater, and aquatic habitats.

Typically, individuals and society make choices that reflect values specific to farming, producing, consuming, or working—but not necessarily to achieving clean water or healthy ecosystems. Sometimes these values conflict with clean water goals. Until very recently, conflicts remained largely unrecognized, at least until water quality problems became so apparent that the public demanded action. Historically, such conflicts were resolved through relatively narrow legislation to restore and protect water quality by altering the direct sources of impairment but not necessarily the root causes of declining water resource quality. **Even today, when we are beginning to recognize some of the basic conflicts between human activities and environmental quality, few contemporary solutions address the basic economic and social forces at the root of water problems.**[2]

If there is any single characteristic that will define groundwater issues and conflicts in the decade ahead, it is the growing recognition that such issues and conflicts are a function of "basic economic and social forces." Addressing them will require a clear understanding of the social and economic milieu within which they arose. It is unlikely that any attempt to resolve such issues and conflicts would be successful if it did not recognize the "interconnectedness" of the social, cultural, economic, technical and ethical forces that have produced them.

In essence, resolving groundwater issues and conflicts requires an "ecological" approach to policy. This is an approach that recognizes the interconnections and interdependencies that have created issues and conflicts and that must be utilized to resolve them. Currently, the emergence of this approach can been seen in at least six areas:

- prevention of groundwater contamination
- remediation of existing groundwater contamination
- compensation for individuals harmed by groundwater contamination
- legislative issues
- educational requirements
- environmental ethics

**Prevention of Groundwater Contamination**

The Clean Water Act's (CWA)[3] stated goal was zero discharge of pollutants. This goal focused on what came out of the pipe, not what went into it. The decade ahead will see a much greater focus on pollution prevention. This is especially true regarding groundwater because it is much easier to prevent contamination of the resource than it is to restore the resource.

The wellhead protection area programs authorized by § 205 of the Safe Drinking Water Act Amendments of 1986[4] reflect this approach. Under § 205, state and local governments are authorized to develop plans to protect groundwater recharge areas. Once the plans are approved by the Environmental Protection Agency (EPA), all activities within the recharge area (including activities by the federal government) must be consistent with the protection plan.

In essence, these plans may include land use plans for lands located within the recharge area. This is one example of the interconnectedness of groundwater issues: Land uses have a direct impact on groundwater quality.[5] This recognition has prompted the EPA to propose regulations regarding the land disposal of toxic sludge from wastewater treatment facilities. In part, the intent is to prevent the treatment of surface water from contaminating groundwater.[6]

Another example of such an approach is the proposed Waste Reduction Act, H.R. 1457. The intent of this act is to shift national policy from waste disposal to waste elimination and recycling. This would be accomplished by new technology, by changes in processes and procedures, by substitution of materials, by inventory control and by improved maintenance and training. Businesses would be eligible for matching grants to implement new methods and procedures for eliminating waste or implementing recycling.[7]

Waste reduction and recycling, according the EPA Administrator William Reilly, is one of President Bush's funding priorities. Funding for programs intended to prevent groundwater contamination will be critical. Despite the assurances of Administrator Reilly, however, it is likely that most funding will have to come from the states.

Another example of the interconnectedness of the groundwater issues relates to funding. Revisions in federal law that placed limitations on tax-exempt bonds had the effect of limiting the amount of money available to local governments for water and wastewater treatment facilities. Given the size and scope of the federal deficit, it is unlikely that federal law will be changed in the near future. Absent such a change, however, it is equally unlikely that advanced wastewater treatment facilities will be constructed in many areas. The result may be continued contamination of both surface water and groundwater.

The Clean Water Act will expire in 1992. Amendments to the CWA to be considered in the reauthorization process reflect a reorientation from pollution treatment to pollution prevention. Proposed amendments to the CWA would require both water conservation and changes in manufacturing processes to prevent water pollution. EPA Administrator Reilly has indicated that the EPA will advocate biomonitoring (as opposed to the current use of chemical concentrations to determine water quality) and may mandate water recycling to meet water quality goals. An approach to water management based on watershed boundaries has also been advocated by Reilly as has a national water quality monitoring system. Many of these provisions are likely to be included in the CWA when it is reauthorized and will shape federal law for the decade ahead.

**Remediation of Existing Groundwater Contamination**

The closer an aquifer is to the surface of the land, the more likely it is to be contaminated. EPA recently surveyed 124,000 shallow aquifer wells. Nearly 25,000 of these wells showed nitrate contamination from fertilizers, septic systems and animal wastes. Approximately 20 percent of all groundwater samples tested by EPA from all aquifers have shown contamination by man-made chemicals.

A major issue for the decade ahead is financial responsibility for groundwater contamination. In essence, who pays for the cleanup? In theory, the party responsible for the contamination is responsible for the cost of remediation. This assumes both that the responsible party can be determined and that the responsible party is not judgment proof. In fact, if a drinking water supply has been contaminated, it is frequently the consumer who must pay either to clean-up the water supply or for an alternative water supply.

With regard to financial responsibility, two proposals that reflect the interconnectedness of groundwater contamination issues may be considered when the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)[8] is considered for reauthorization in 1991. The first, a waste-end tax, would be assessed when hazardous substances regulated under the Resource Conservation and Recovery Act (RCRA)[9] are received at hazardous waste facilities.[10] The second proposal calls for the establishment of a National Environmental Trust Fund which would be capitalized by a 2 percent fee on commercial and industrial insurance premiums. Either the tax or the Trust Fund (or both) would be utilized to pay for remediation. Because of state requirements and federal funding limitations, it is quite likely that similar programs will emerge in the states.

**Compensation for Individuals Harmed by Groundwater Contamination**

Historically, individuals harmed by groundwater contamination initiated litigation seeking damages against the responsible party. While a boon to the legal profession, such litigation is expensive, time-consuming and provides relief (if any) only to the prevailing party.

The decade ahead will see the emergence of alternative means by which individuals harmed by groundwater contamination might be compensated. For example, the State of Minnesota, with the enactment of the Minnesota Environmental Response and Liability Act (MERLA)[11] established a state fund to compensate victims of environmental degradation. The state fund, which has yet to be used extensively, is intended to function as an insurance program.

Similar programs are sure to emerge in the coming years. Such programs may be funded from the same revenue sources discussed in the preceding section.

**Legislative Issues**

There is a hodge-podge of federal legislation affecting groundwater quality.[12] These laws were enacted at different times and with different purposes.

The result is a series of redundancies, duplications, inconsistencies and vacancies. Certain groundwater quality issues are addressed in several statutes, other issues are not addressed at all.

The decade ahead will see a concerted effort at the federal level to create a comprehensive and consistent approach to environmental protection including, of course, groundwater quality protection. Existing laws will be either rewritten or supplemented. It is likely that this will occur in the context of reauthorization and may begin with the reauthorization of the CWA.

A similar approach may also emerge at the state level for those issues historically within state jurisdiction. State water quantity laws and land use issues that affect groundwater quality must be addressed at the state level. Should the state and local governments fail to act, the federal government undoubtedly will. The issue for the decade ahead, in essence, is not if groundwater quality will be protected. The issue is which branch of government will retain primary responsibility to provide that protection.

### Educational Requirements

Another area in which the interconnectedness of groundwater issues and conflicts can be seen is in education. If the goal is to protect the quality of groundwater, one requirement is public education. People need to know, and must be taught, how their activities affect the environment generally, and groundwater quality specifically.

Furthermore, the decade ahead will see a serious shortage of specialists trained to handle environmental issues. This is especially true with regard to environmental engineering and environmental management. The Water Pollution Control Federation, for example, estimates that 40 percent of today's chemists and engineers will be eligible for retirement within five years.

New educational programs that focus on the interconnectedness of environmental issues are developing nationwide. That development will (and must) continue in the decade ahead. At least forty colleges and universities now have graduate programs in environmental studies. One of those programs, a graduate program in Water Resources Administration, has been established at the University of New Mexico. Those individuals who had the foresight to establish the Water Resources Administration program at UNM are to be commended.

### Environmental Ethics

One of the more interesting aspects of the decade ahead will be the growing involvement of the theological and ethical communities in environmental issues. By the new millennium, this annual water conference may be attended by as many ministers and theologians as it is now attended by lawyers and engineers.

New organizations are emerging.[13] New books are being written.[14] Even the mainline denominations are becoming involved with environmental issues.[15]

While it is difficult to anticipate all that will occur in the decade ahead regarding environmental ethics, some things will certainly occur. Genesis 1:26-29, for example, may require reinterpretation. It is simply not possible for one species to survive if it attempts to exercise "dominion" over all other species in a shared biosphere.

Our perception of time is likely to change. In Washington, D.C., it is difficult to find a planning horizon in excess of eighteen months because that is the maximum amount of time available between one Congressional election and the beginning of the campaign period for the next Congressional election. There are Native American beliefs, however, that mandate planning for the seventh generation into the future. Human impacts on the environment, the capability of the environment to accommodate such impacts and the need to prevent those impacts must be understood within a proper time frame. The acceptance of a short-term gain for a long-term cost, implicit in the suggestion that environmental protection must be balanced against economic growth, is unacceptable because it does not reflect an appropriate time frame.

With a realistic perception of time will come a realistic perception of responsibility. In the decade ahead, short-term gain, irrespective of long-term cost, will be seen as irresponsible. Our perspective will change from what we have inherited from our parents to what we will leave for our children.

It is even possible that our concept of God will change. New Testament theology is based in part on the writings of the Apostle Paul whose beliefs reflected the beliefs of the Greeks regarding the duality of human nature. This duality suggested that humanity was both very-God (reflected in human intellect; to be praised and developed) and very-man (reflected in human nature; to be rejected or suppressed).[16] The result, in simple terms, was the removal of nature from our conception of God. We came to believe in a God of history, a God "out there" or within individuals, but not in a God within nature.

That perception is being challenged and may change in the decade (or decades) ahead. If life on a shared planet is to be sustained, it is essential that forests be perceived as a manifestation of God's presence rather than as board-feet of lumber, that rivers be seen as a manifestation of God's grace rather than as acre-feet of water.

## Conclusion

One of the primary objectives of the Clean Water Act was to restore and maintain the chemical, physical and biological integrity of the nation's groundwater. Unfortunately, as a nation, we have not achieved that objective.

One other certainty about the decade ahead is that all of us gathered here today will share the responsibility to achieve the objectives of the Clean Water Act. Simply stated, the alternatives are unacceptable.

## Endnotes

[1]Of Counsel, Will & Muys, P.C., 1015 18th Street N.W., Suite 600, Washington, DC 20036 and member of the Associate Faculty, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. THE OPINIONS EXPRESSED HEREIN ARE STRICTLY THOSE OF THE AUTHOR AND MAY NOT REFLECT THE OFFICIAL POSITION OF THE COLLEGE OF WILLIAM AND MARY.

[2]Water Pollution Control Federation, *Water Quality 2000 Phase II Report: Problem Identification* 19 (draft, 1990) (emphasis added).

[3]33 USC §§ 1251 et seq.

[4]42 USC § 300h-7.

[5]This is especially true with regard to agriculture, the largest single source of groundwater contamination.

[6]A possibly apocryphal story regarding the proposed EPA toxicity regulations for land disposal of sludge concerns the Blue Plains sewage treatment facility in Washington, D.C. According to the story, the proposed EPA regulations would limit the land disposal of sludge from Blue Plains to a thickness of approximately 1/2" per year. This limitation, it is said, would result in an annual requirement for an area approximately the size of the state of Texas for the land disposal of Blue Plains sludge.

[7]H.R. 1457 was passed by the House of Representatives on June 26, 1990. No action has been taken in the Senate.

[8]42 USC §§ 9601 et seq.

[9]42 USC §§ 6901 et seq.

[10]In addition to raising revenues, such a tax could have the effect of discouraging the generation of hazardous wastes. Conversely, it could also encourage the illegal disposal of hazardous wastes at unauthorized or unlicensed waste facilities.

[11]Minn. Stat. Chap. 115B.01 et seq.

[12]To the list of those laws already mentioned must be added the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), 7 USC §§ 136 et seq., and the Superfund Amendments and Reauthorization Act (SARA), 29 USC § 655, 42 USC §§ 9601, 9611, 9671-9675.

[13]For example, the North American Conference on Religion and Ecology in Washington, D.C.

[14]For example, *The Dream of the Earth* by Thomas Berry.

[15]For example, the Presbyterian Church has established an Eco-Justice Task Force, the papers of which have been published as *While the Earth Remains* (Lancaster, ed., 1990).

[16]It has been argued, for example, that the concept of "original sin" in Catholic theology is predicated on the belief that what is natural, is sinful.

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# RISK ASSESSMENT: HOW SAFE IS SAFE?

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The assessment of risk is a pervasive and complex task. No matter how comprehensive the investigation, significant flaws can be identified due primarily to the complexity of accounting for all components of the environment. Most risk assessments performed address only a subset of the overall environmental risk—human health risk. Even with this enormous simplification, most complexities remain.

Perhaps the most comprehensive broad-range risk modeling tool for assessment of human health risk due to environmental exposures was developed by the United States Environmental Protection Agency (EPA) in 1982. This model, commonly known as the EPA Risk/Cost Policy Model (A.D. Little, Inc. 1979, Booz-Allen et al. 1980) provided the foundation for many human health risk assessment tools, including the indexing tools currently used by EPA regulators.

The EPA Risk/Cost Policy Model systematically compares human health risk and economic cost imposed by different regulatory approaches to hazardous waste management. This policy model, with subsequent enhancements since 1982, has been used by EPA to guide ongoing regulatory impact analyses on current and planned hazardous waste regulations under the Resource Conservation and Recovery Act. While the model has become more sophisticated over the past eight years, the initial concept presented in the Federal Register on December 13, 1982 remains:

> ...the model is designed to assess and compare the costs and risks of different waste management strategies... ...The model will be used as a screening tool to identify those combinations of wastes, environmental settings, and technologies that either pose a greater

or lesser risk than the majority of combinations. (Federal Register 12/13/82)

EPA is not the only entity interested in developing strategies for hazardous waste management. State and local governments face challenges similar to those faced by EPA in developing hazardous waste regulations. In the private sector, commercial hazardous waste management firms and companies which generate hazardous waste as a by-product of manufacturing operations are faced with the need to develop corporate strategies for managing hazardous wastes. This paper examines the operation of EPA's Risk/Cost Policy Model, and suggests that a similar model be developed and used by the private sector to develop a more cost-effective approach to hazardous waste management. Although presented from the public sector viewpoint, the methodology discussed should be of interest to policy makers in all sectors.

## OPERATION OF THE EPA RISK/COST POLICY MODEL

### Concept

Previous attempts to develop a "degree-of-hazard" approach for hazardous waste management have been criticized for failing to consider the differences among management practices. As noted by EPA, in the December, 1978 Hazardous Waste Proposed Rulemaking (Booz-Allen et al. 1980), even relatively low-hazard wastes can present a significant risk to human health if managed improperly. The risk/cost policy model was developed to consider not only the hazardous waste characteristics, but the management technology employed and the environmental setting where the practice occurs.

On the basis of these three interrelated elements—the waste, the technology, and the environmental setting—the model assigns risk and cost scores (ICF 1981, ICF 1982). A given hazardous waste may contain several harmful constituents, some more inherently dangerous than others. A particular treatment technology applied to that waste will affect the various constituents differently, rendering some less hazardous and leaving others unchanged (Shelton 1983a, Shelton 1983b, Shelton 1983c).

As the treated waste is transported to an ultimate disposal site and discarded, losses to the environment through the air, groundwater, and surface water may occur; the amount released depends upon the characteristics of the waste (solubility, vapor pressure, concentration, etc. of waste constituents) and the treatment, transport and disposal technology employed (A.D. Little, Inc. 1979, Shelton 1983b). Once released, waste constituents will behave differently depending upon the medium to which they are released and applicable removal and attenuation mechanisms. Finally, the nature of the release's location may make some releases more or less significant in terms of human exposure risk than others (USEPA 1979).

### Wastestreams

The risk/cost policy model currently uses a preliminary list of 83 hazardous wastestreams to characterize the types of hazardous waste generated nationwide (ICF 1981, ICF 1982). Each of the 83 wastestreams was defined using average generation rate (kg/day), non-water mass fraction (kg/kg), non-water mass fraction in the form of suspended solids, specific gravity, BTU content, and a list of potentially hazardous constituents. Each potentially hazardous constituent was identified by name, total mass fraction (kg/kg) within the waste, mass fraction (kg/kg) present (dissolved or liquid phase) and physical properties (vapor pressure, solubility, and molecular weight)(ICF 1982, Shelton 1983c).

### Treatment Technologies

In addition to the waste characteristics discussed above, each wastestream was assigned a list of feasible treatment technologies. As presently configured, the model (ICF 1981, ICF 1982, Shelton 1983a, Shelton 1983b, Shelton 1983c) includes 21 different treatment technologies. These may be arranged in series; for example, a waste may be treated using chemical precipitation followed by a filter press. By convention, the model accepts up to three treatment "steps" in series, as determined by the user. The 21 treatment technologies are shown in Table 1.

TABLE 1. TREATMENT AND DISPOSAL TECHNOLOGIES

| Treatment (Considered Alone or in a Series) | Disposal Technologies |
|---|---|
| 1. Chemical Stabilization/ Fixation | 1. Double-lined Landfill |
| 2. Chemical Precipitation | 2. Single-lined Landfill |
| 3. Chemical Destruction | 3. Unlined Landfill |
| 4. Chemical Coagulation | 4. Double-lined Surface Impoundment |
| 5. Filter Press | 5. Single-lined Surface Impoundment |
| 6. Centrifuge | 6. Unlined Surface Impoundment |
| 7. Vacuum Filter | 7. Land Treatment |
| 8. Evaporation | 8. Deep Well Injection |
| 9. Air Stripping | 9. Ocean Disposal |
| 10. Steam Stripping | |
| 11. Solvent Extraction | |
| 12. Leaching | |
| 13. Distillation | |
| 14. Electrolysis | |
| 15. Reverse Osmosis | |
| 16. Adsorption | |
| 17. Ion Exchange | |
| 18. Incineration at 99.99% DRE* | |
| 19. Incineration at 99.9% DRE | |
| 20. Incineration at 99% DRE | |
| 21. Incineration at 90% DRE | |

* Destruction Removal Efficiency

The purposes of treating a hazardous waste are to render the waste less hazardous, to make the cost of subsequent treatment, transportation and disposal less expensive, and/or to recover wastestream constituents for recycle or reuse (ICF 1981, Shelton 1983a, Shelton 1983c). Each of the 21 treatment alternatives available in the model was designed to meet one or more of these purposes, as appropriate for a given wastestream. Each step included a set of computer algorithms which alter the wastestream characteristics; in most cases the algorithms depend heavily on physical and chemical properties of the waste constituents. Where multiple treatment steps are specified, waste effluent conditions from the first treatment step are used as input conditions for the subsequent step in the model.

**Cost of Treatment**

In addition to altering the hazardous wastestream, each treatment step in the model (ICF 1982) also computes the treatment cost. Costs represent capital and variable direct resource costs only, on the theory that this measure is an accurate reflection of the relative cost of different treatments (ICF 1982, Shelton 1983a). However, use of direct costs does not account for other costs (such as overhead and insurance) which must be paid in the real world. There is also an important distinction to be made between the cost of a service and the price of a service in a commercial context. Price usually includes all costs plus a profit.

**Releases from Treatment**

The final computation made by the model for each treatment step is an estimate of the quantity of hazardous constituents released from the process (ICF 1982). Releases to each of three media (air, surface water, and groundwater) are computed based upon the nature of the waste constituent (solubility, vapor pressure, molecular weight, and concentration) and the characteristics of the treatment technology (e.g., an open tank process will release more volatile constituents than will a closed process).

**Transportation**

Once the wastestream has moved through the treatment portion of the model (ICF 1982), it is transported to final disposal. Transportation includes the loading and unloading of the waste from vehicles, as well as the actual movement of the treated waste from one location to another. The EPA model considers three kinds of transport:

- on-site, which includes handling at the generator's site;
- local, which moves the waste off-site a distance of 25 miles; and
- long distance, which moves the waste off-site a distance of 250 miles.

Transportation does not change the physical characteristics of the waste, but imposes additional cost and releases within the model. It is interesting to note that releases attributable to handling the waste (loading and unloading the waste) are larger, on the average, than those caused by accidents in transit for all but the long distance transport (A.D. Little, Inc. 1979).

**Disposal Technologies**

Nine different disposal scenarios are considered by the model (ICF 1982). These were listed in Table 1. The disposal scenarios are currently undergoing major revisions to reflect the new Land Disposal Regulations and peer review (ICF 1982). The characteristics of the various disposal technologies are specified in some detail, and reflect "typical" scales of operation. In the case of landfills, the model now distinguishes between the typical scale of operation for an on-site landfill (500 metric tons per year) and that for an off-site landfill (60,000 metric tons per year). Direct costs for disposal reflect these typical scales of operation.

For some of the disposal technologies (i.e., landfills and surface impoundments) there are several different scenarios to reflect different levels of regulatory stringency. The unlined landfill and surface impoundment scenarios may be thought of as "worst case" scenarios (Booz-Allen et al. 1980).

**Environmental Settings**

At this point, the model (ICF 1982) has taken a hazardous wastestream and subjected it to a management technology (including treatment(s), transport, and disposal). The model has accumulated all of the constituent releases and incremental costs associated with the management technology. Now the model is ready to assign specific risk and cost "scores" for using this management technology for this wastestream in each of several environmental settings. The model currently considers 13 different environmental settings, as shown in Table 2. The environment categories reflect differences in local population density, surface water assimilative capacity, and groundwater contamination potential. Also included is a special category for deep ocean waters.

**Risk Scores**

Risk scores are assigned by taking the Log (Base 10) of the annual release rate for each constituent in each medium, adding a persistence score for the constituent in that medium, adding (or subtracting) an environmental adjustment to account for particularly sensitive or durable environments, and finally adding a toxicity score for the constituent (USEPA 1979). Each score or adjustment added to or subtracted from the Log of the annual release rate, is itself logarithmic. Since the risk score is assigned on a logarithmic scale, the difference between a score of 6 and 7 is a 10-fold increase in risk. Mathematically, the risk score is derived from the classic expression of risk:

TABLE 2. CATEGORIES OF ENVIRONMENTS

| Population Density* | Surface Water Assimilative Capacity** | Groundwater Contamination Potential*** |
|---|---|---|
| High | Low | Low |
| High | Low | Low |
| High | High | Low |
| High | High | Low |
| Medium | Low | High |
| Medium | Low | Low |
| Medium | High | High |
| Medium | High | Low |
| Low | Low | High |
| Low | Low | Low |
| Low | High | High |
| Low | High | High |
| None | Deep Ocean Waters | None |

* Population Density: High (520 people/sq kilometer and above); medium (between 52 and 519 people/sq kilometer); and low (fewer than 52 people/sq kilometer).

** Surface Water: Low (flow rate less than 300,000,000 cu m/day or drinking water intake within 6 hrs flow); and high (flow rate more than 300,000,000 cu m/day or lakes with capacity greater than 30,000,000,000 cu m).

*** Groundwater: Low (soil permeability less than 31.5 cm/yr and depth to groundwater saturation zone greater than 10 m; or soil permeability less than 31.5 m/yr and depth to groundwater saturation zone greater than 100 m); and high (all others).

Risk = (Exposure) (Population at Risk) (Probability of Response)

Exposure is a function of the annual release rate and the persistence of the constituent. Population at Risk is determined by the environmental characteristics and persistence of the constituent. The Probability of Response is given by the constituent's inherent toxicity (USEPA 1979).

### Cost Scores

Cost scores are determined by converting the sum of all direct costs to a per unit of original wastestream on a dry mass basis (ICF 1982, Shelton 1983a), and taking the log (Base 2). This means that the difference between a cost score of 6 and 7 is a doubling of direct cost. Using a per-unit of original dry mass basis for cost scores assures comparable scores for a given hazardous wastestream.

### Current Applications of Model

EPA will use the risk and cost scores to analyze different approaches to regulating hazardous waste management. For example, the model can suggest a list of hazardous waste candidates for banning from landfills. The list, which results from using the model, would require further analysis before any such action; however, the model can be useful in screening wastes initially in this fashion. The EPA Risk/Cost Policy Model is best used generally to address broad policy questions.

It is important to recognize that any use of the risk/cost policy model will require further analysis before regulatory conclusions can be reached. The many simplifying assumptions made in constructing the model must be understood by the user before the implications of any particular model evaluation may be understood. Nevertheless, the model has proven useful in framing issues for further analysis, and in examining general risk-cost tradeoffs between different regulatory strategies (ICF 1981, ICF 1982, Shelton 1983b).

## DEVELOPMENT OF A RISK/COST MODEL FOR PRIVATE SECTOR USES

Several assumptions which form the basis for the EPA Risk/Cost Policy Model are not appropriate to assist private decision making. For example, the model uses only direct resource costs as a cost measurement of using different technologies. If the generator wishes to use a commercial waste management facility, the waste generator must consider the commercial firm's price (including profit) in comparison to internal fixed and variable costs for in-house treatment.

Some technologies considered by the EPA model are not available to private waste generators. In particular, the "worst case" landfill and surface impoundment scenarios are not legally available to the waste generator for its untreated wastes (Federal Register 12/13/82, Federal Register 5/19/80).

Some may contend that private decision makers will be guided by only the cost portion of the risk/cost model. It probably is true that over the short term, the cost score alone would reflect the relative total cost of using a particular technology. However, over the longer term, the risk score could serve as a rough indicator of the relative amount of financial liability to which a fire might be exposed as a result of a particular hazardous waste management practice. In light of the apparent trend toward imposing strict liability upon generators of hazardous wastes found at uncontrolled disposal sites (A.D. Little, Inc. 1979), decision makers in the private sector might welcome such a measure of risk.

If a waste generator elects to dispose of waste on-site, it will be required to obtain insurance coverage for potential long-term environmental impairment caused by its facility. The premium to be charged for such insurance coverage will reflect the relative risk of the facility, as measured by a risk assessment performed by the insurance company. The risk scores generated by the risk/cost model might assist the generator in estimating the extent of its on-site exposure (ICF 1981, ICF 1982).

The model (ICF 1981, ICF 1982) necessarily generalizes the national hazardous waste management picture. It uses average or typical values for waste characteristics and waste treatment and disposal capacities. EPA has recognized that the risk/cost model is limited by the general nature of input data. The agency discourages site-specific application of the model as it presently exists; its purpose is to assist in narrowing a large number of waste management alternatives for further analysis in support of rule making. Nevertheless, the concept of developing a risk/cost model using a specific set of waste characteristics, available technologies, and environmental settings would be valuable to the private decision maker.

For the purpose of distinguishing this new model from the risk/cost model, the private sector model will be referred to as the Hazardous Waste Management Cost Effectiveness Model, or simply COSTEF. The following section describes how such a COSTEF model might be applied.

## HYPOTHETICAL APPLICATION OF COSTEF MODEL

Consider the case of Acme Automobile Corporation. Acme has six manufacturing facilities in the eastern United States, one each near towns named Amity, Stepford, Salem, Sleepy Hollow, Transylvania, and Metropolis. Acme's new Vice President for Environmental Affairs has been requested to develop a corporate strategy for managing hazardous wastes generated by the company.

### Hypothetical Wastes and Treatment Technologies

The Vice President has prepared a detailed inventory (shown in Table 3) of hazardous wastes generated at each Acme plant. The Vice President wants to prepare a cost-effective strategy consistent with company legal and moral obligations to prevent damage to the public health and environment.

TABLE 3. INVENTORY OF HAZARDOUS WASTES GENERATED BY ACME

1. Metal Finishing Wastes (suspended solids = 0.1% by weight), containing 0.037% Hexavalent Chromium and 0.0043% Cyanide by weight. Generated at the average rate of 110 kg/day (Amity), 400 kg/day (Sleepy Hollow), and 550 kg/day (Metropolis). Feasible treatment chains include:
   - Electrolysis and Chemical Coagulation.
   - Chemical Destruction and Chemical Coagulation.
   - Electrolysis, Chemical Coagulation, and Chemical Stabilization/Fixation.
   - Chemical Destruction, Chemical Coagulation, and Chemical Stabilization/Fixation.
   - No treatment.

2. Cyanide Sludge (suspended solids = 10% by weight), containing 6% (Amity and Sleepy Hollow) and 0.6% (Metropolis) Cyanide by weight. Generated at the average rate of 1750 kg/day (Amity), 750 kg/day (Sleepy Hollow), and 1750 kg/day (Metropolis). Feasible treatment chains include:
   - Chemical Stabilization/Fixation
   - Chemical Destruction
   - No Treatment

3. Spent Solvents (suspended solids = 2% by weight), containing 80% (Amity, Salem, Sleepy Hollow, and Transylvania), 70% (Stepford), and 85% (Metropolis) Trichloroethylene by weight. Generated at the average rate of 0.1 kg/day (Amity and Transylvania), 55 kg/day (Stepford), 25 kg/day (Salem), 100 kg/day (Sleepy Hollow), and 115 kg/day (Metropolis). Feasible treatment chains include:
   - Distillation.
   - Incineration at 99.99% Destruction/Removal Efficiency ("DRE").
   - Incineration at 99.9% DRE.
   - Incineration at 99% DRE.
   - Incineration at 90% DRE.
   - No treatment.

The waste inventory will be used as the basic input to the COSTEF model. For each wastestream, feasible combinations of treatment steps have been identified. The Vice President has asked one of his environmental engineers to roughly estimate the direct cost of using these treatment technologies, and to develop treatment algorithms for each. He realizes that treatment may render some of his hazardous wastestreams non-hazardous, and thus use of treatment could form the basis for de-listing wastestreams. Since it appears at least possible that some of Acme's waste could be de-listed (Federal Register 12/13/82, Federal Register 5/19/80) after treatment, the Vice President decides to include unlined disposal scenarios in the COSTEF model.

**Hypothetical Environmental Settings**

Using common sense, some general surface and groundwater hydrologic data, and 1980 U.S. Census data, the Vice President roughly categorizes the environmental settings for each Acme plan as follows:

Amity: Medium Population Density, High Surface Water Assimilation Capacity, High Groundwater Contamination Potential

Stepford: Low Population Density, Low Surface Water Assimilation Capacity, High Groundwater Contamination Potential

Salem: High Population Density, High Surface Water Assimilation Capacity, High Groundwater Contamination Potential

Sleepy Hollow: Low Population Density, Low Surface Water Assimilation Capacity, Low Groundwater Contamination Potential

Transylvania: Medium Population Density, Low Surface Water Assimilation Capacity, Low Surface Water Assimilation Capacity, Low Groundwater Contamination Potential.

Amity, Stepford and Salem are within 25 miles of one another, and Sleepy Hollow, Transylvania and Metropolis are within 25 miles of one another. The Salem metropolitan area is some 250 miles from Metropolis. Commercial hazardous waste landfills are located near both Sleepy Hollow and Stepford (each quote Acme a price of $40 per metric ton for its waste). Using these assumptions, Acme is able to develop and operate the COSTEF model.

**Hypothetical Objective Function**

Output from this application of the COSTEF model includes some 3,042 different hazardous waste management practices for Acme's various waste-technology-environment combinations. The model output shows that Cost Scores vary from a low of 2.5 to a high of 18.0; Risk Scores vary from a low of 1.8 to a high 10.1. Acme's Vice President, after reviewing the rough output, formulates an objective function which combines cost and risk scores into a single measure of cost effectiveness:

$$\text{COSTEF} = (\text{Cost Score})^2 + (2 \text{ X Risk Score})^2$$

The lower the value of COSTEF, the better. Using this measure of cost effectiveness, Table 4 was prepared to show the most cost-effective and least cost-effective hazardous waste management practices for each wastestream generated by Acme.

**Discussion of COSTEF Model Results**

Each management practice shown in Table 4 would be a suitable subject for a paper. Much additional analysis of the results shown would be required before any hazardous waste management strategy could be adopted by Acme. These caveats aside, the model output is nevertheless interesting.

The first waste management practice shown for the Amity plant—that of on-site deep well injection of metal finishing wastes—is useful to demonstrate the kinds of further analysis required to use model results. Deep well injection is heavily dependent on the nature of site geology; a detailed site investigation would be required before the

## TABLE 4. SUMMARY OF COSTEF MODEL RESULTS

**Amity Plant**

Most cost-effective waste practices

1. Metal Finishing Waste (110 kg/day): dispose to on-site deep well without pre-treatment; Cost Score = 10.0, Risk Score = 4.7, COSTEF = 13.7.

2. Cyanide Sludge (1750 kg/day): treat with Chemical Destruction and transport to commercial double-lined landfill in Stepford; Cost Score = 10.2, Risk Score = 3.5, COSTEF = 12.4.

3. Spent Solvent (0.1 kg/day): transport to either Salem or Stepford for distillation, residue to unlined surface impoundment; Cost Score = 2.9, Risk Score = 2.5, COSTEF = 5.8.

Least cost-effective waste management practices

1. Metal Finishing Waste (110 kg/day): dispose to on-site, unlined landfill without pre-treatment; Cost Score = 15.4, Risk Score = 7.7, COSTEF = 21.8.

2. Cyanide Sludge (1750 kg/day): dispose to on-site, double-lined landfill after chemical stabilization/fixation; Cost Score = 13.6, Risk Score = 6.3, COSTEF =18.5.

3. Spent Solvent (0.1 kg/day): incinerate to 99.9% DRE and dispose of residuals to on-site, double-lined landfill; Cost Score = 16.9, Risk Score = 4.5, COSTEF = 19.1.

**Stepford Plant**

Most cost-effective waste management practice

1. Spent Solvent (55 kg/day): burn on-site to at least 99% DRE; Cost Score = 7.7, Risk Score = 3.8, COSTEF = 10.8.

Least cost-effective waste management practice

1. Spent Solvent (55 kg/day): burn on-site to 99.99% DRE, with residuals to on-site, double-lined landfill; Cost Score = 16.5, Risk Score = 3.7, COSTEF = 18.1.

**Salem Plant**

Most cost-effective waste management practice

1. Spent Solvent (25 kg/day): distillation, with residue to unlined surface impoundment at Amity or Stepford; Cost Score = 3.2, Risk Score = 5.9, COSTEF =12.2.

Least cost-effective waste management practice

1. Spent Solvent (25 kg/day): incineration to 99.99% DRE, with residue to on-site, double-lined landfill; Cost Score = 16.9, Risk Score = 5.6, COSTEF = 20.3.

TABLE 4. (cont.)

**Sleepy Hollow Plant**

Most cost-effectiveness waste management practices

1. Metal Finishing Wastes (400 kg/day): transport untreated to unlined surface impoundment in either Transylvania or Metropolis, or to deep ocean waters for disposal; Cost Score = 11.1, Risk Score = 5.3, COSTEF = 15.3.

2. Cyanide Sludge (750 kg/day): transport untreated to unlined surface impoundment in either Transylvania or Metropolis, or to deep ocean waters for disposal; Cost Score = 7.7, Risk Score = 3.3, COSTEF = 10.1.

3. Spent Solvent (100 kg/day): burn on-site to at least 99% DRE; Cost Score = 6.6, Risk Score = 4.1, COSTEF = 10.5.

Least cost-effective waste management practices

1. Metal Finishing Wastes (400 kg/day): electrolysis followed by chemical coagulation followed by long distance transport to deep ocean waters for disposal; Cost Score = 18.0, Risk Score = 8.4, COSTEF = 24.6.

2. Cyanide Sludge (750 kg/day): chemical stabilization/fixation followed by on-site disposal to double-lined landfill; Cost Score = 13.6, Risk Score = 5.9, COSTEF = 18.0.

3. Spent Solvent (100 kg/day): incineration to 99.99% DRE, with residual disposed to on-site, double-lined landfill; Cost Score = 16.9, Risk Score = 4.0, COSTEF = 18.7.

**Transylvania Plant**

Most cost-effective waste management practice

1. Spent Solvent (0.1 kg/day): burn on-site to at least 99% DRE; Cost Score = 6.6, Risk Score = 2.1, COSTEF = 7.8.

Least cost-effective waste management practice

1. Spent Solvent (0.1 kg/day): incineration to 99.99% DRE, with residual disposed to on-site, double-lined landfill; Cost Score = 16.9, Risk Score = 4.3 COSTEF = 19.0.

TABLE 4. (cont.)

**Metropolis Plant**

Most cost-effective waste management practices

1. Metal Finishing Wastes (50 kg/day): dispose to on-site deep well with no pre-treatment; Cost Score = 10.0, Risk Score = 5.4, COSTEF = 14.7.

2. Cyanide Sludge (1750 kg/day): treat with chemical destruction, and dispose of residual to commercial double-lined landfill in Sleepy Hollow; Cost Score = 10.2, Risk Score = 3.6, COSTEF = 12.5.

3. Spent Solvent (115 kg/day): distillation, with residual waste to single-lined landfill in either Sleepy Hollow or Transylvania; Cost Score = 3.1, Risk Score = 6.8, COSTEF = 13.9.

Least cost-effective waste management practices

1. Metal Finishing Wastes (50 kg/day): electrolysis followed by chemical coagulation followed by long distance transport to deep ocean waters for disposal; Cost Score = 18.0, Risk Score = 7.5, COSTEF = 23.4.

2. Cyanide Sludge (1750 kg/day): treat with chemical stabilization/fixation followed by long distance transport to deep ocean waters for disposal; Cost Score = 12.3, Risk Score = 7.7, COSTEF 19.7.

3. Spent Solvent (115 kg/day): incineration at 99.99% DRE, with residuals disposed in an on-site, double-lined landfill; Cost Score =16.9, Risk Score = 6.1, COSTEF = 20.8.

feasibility of this practice could be determined. In addition, the nature of this wastestream (a corrosive waste containing 0.1% suspended solids) probably makes the feasibility of deep well injection without pre-treatment doubtful. Further investigation of site suitability and the waste for deep well injection is needed.

The second waste management practice shown—chemical destruction and commercial landfilling of cyanide sludge—demonstrates the apparent cost effectiveness of treatment before disposal. The raw data indicates that commercial landfilling of this waste, untreated, would be slightly less expensive (Cost Score = 9.9 vs. treated Cost Score of 10.2) but much riskier (Risk Score = 5.2 vs. treated Risk Score of 3.5).

The third waste management practice shown—distillation of Amity's spent solvent with residue to unlined surface impoundment in either Stepford or Salem—raises the question of on-site versus off-site waste management. The only difference between the environmental settings of Amity and Salem is that the latter is more densely populated. The suggestion that Amity's waste be transported to Salem for disposal seems at first counter-intuitive. The explanation is that the model distributes transportation losses equally between the generation environment and the disposal environment. Spreading these transportation losses between two environments lowers the overall risk, where releases due to transportation are the most significant releases. The assumption underlying this rationale merits closer examination by Acme.

In general, the least cost-effective waste management practices include sophisticated treatment technologies operated in series. A different objective function, or different assumptions regarding chemical constituents, would probably change the recommended waste management practices.

## CONCLUSIONS

As noted above, the COSTEF model suggests a beginning of analysis, rather than an end. Use of the model as more than a simple screening device is inappropriate at this stage of development. The model is useful in framing questions regarding the most cost-effective hazardous waste management practices and in providing a systematic means of considering risk and cost tradeoffs between different strategies, final decisions regarding the most appropriate set of hazardous waste management practices—whether at the national, state, local or private level—must continue to be made by human decision makers after careful consideration of all technical legal, economic, and institutional factors. Models such as the one described in this paper can serve only as tools in the decision-making process.

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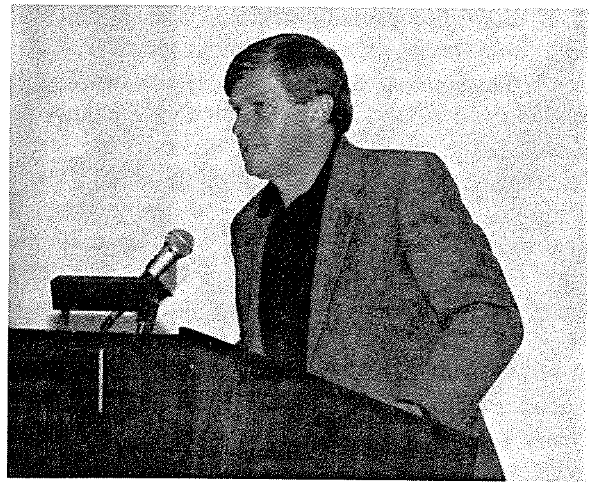

# THE SQUAWFISH THAT ATE FARMINGTON
# INCORPORATING STATE WATER LAW INTO THE ENDANGERED SPECIES ACT

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For many years, western mountain streams flowed unrestrained down the slopes of granite-surfaced mountains until they reached the alluvial plains where they spread out and slowed in momentum, and where the water became warmer. During the spring snowmelt, the streams flowed at high levels leaving their traditional banks and were reduced to a trickle in the late summer when the water surge of the past winter had been spent.

This highly variable hydrograph provided perfect habitat for a number of native species, one of which was the Colorado Squawfish that spawned in the shallow eddies of warm flood runoff at the margin between the traditional bank of the stream and the newly flooded alluvium. As settlers moved West, they recognized that reservoirs on the streams could harness the stream to accommodate their needs. A dam could hold back the snowmelt runoff and provide water for irrigation, domestic use, and hydropower. Dams also provided benefits for many living below the reservoir.

A classic example is the Navajo Dam and reservoir on the San Juan River system. That dam now provides extensive benefits to all in the area. It has the potential for furnishing water to three Native American tribes: the Ute Mountain Utes, the Southern Utes, and the Jicarilla Apaches. In addition, it currently provides benefits for a fourth tribe, the Navajos. The Navajos receive extensive water rights from Navajo reservoir for the Navajo Indian Irrigation Project. Further, the non-Indian municipal and rural water users also benefit from a domestic water supply. The city of Farmington generates hydroelectric power revenues from waters that flow through the dam on a regular and even basis. There is potential and existing economic development through coal-fired power production providing extensive benefits. The reservoir's final by-product has been the creation of one of the best trout fishing waters within a five hundred mile radius. These waters exist just below the dam where the water flows out at a consistent rate and temperature—a perfect habitat for trout.

Designating the Colorado Squawfish on the endangered species list, under the Endangered Species Act, could potentially affect all the above interests. According to the United States Fish and Wildlife Service, squawfish need the traditional hydrograph to survive in the stream. However, no one can be certain returning to the traditional hydrograph will help improve survival because there are equally plausible alternative explanations for their demise. These include the fact that the squawfish were poisoned from the stream in earlier years when priorities were different by the same agency seeking to protect them now; the fact there are over forty non-native species that prey on the squawfish may be relevant; and that spawning routes were interrupted by the construction of Lake Powell. Whether the fish could ever be "recovered" is also problematic, since at no time have there ever been more than twenty fish found in the river. In very recent times, none have been found.

Thus, the balance is clear. The needs of four Native American tribes, of small municipal interests, of those who may consume electrical power, and of sportsmen who seek to fish for the game fish must be balanced against the needs of the squawfish. While this may appear to be a perfect case for reaching a balance, no balancing process is possible under the Endangered Species Act.

Under prevailing law, the remedies are absolute—the squawfish needs are paramount to all other interests unless one can receive an exemption from a federal committee—a remedy that to date has been virtually impossible to obtain. For the short-term, it appears that Navajo Reservoir will have to be operated to provide releases virtually as though it were not there. The result will be to eliminate many further beneficial uses of water in the area, foreclose hydropower production dramatically, and conceivably destroy the trout fishery.

The above scenario raises a number of interesting questions regarding the Endangered Species Act itself.

- A fair law allows one to plan for its application, and punishes those who have caused the problem—invoking the law by requiring they pay for the consequences of what they have done. The Endangered Species Act reflects the antithesis of this principle. It does not allow one to plan because one does not know which species might be listed. Further, once a species is listed, those who previously took the action to use water that resulted in the endangerment of the species are usually allowed to continue as before. It is the persons who have done nothing but hope to use water who pay the price because they cannot develop at all.
- The law of prior appropriation is the law in New Mexico but the Endangered Species Act may totally change that principle as to new appropriations of water. The key to going forward on a stream that contains an endangered species is the ability to conduct a "Section 7" consultation and propose alternatives to protect the species and allow one to use water under the federal project. Since there is limited water on the stream, the first person to achieve a Section 7 consultation has a better right than subsequent consulters because all the remaining water will likely be reserved for the fish.
- Section 9 of the act makes the "taking" of a squawfish or the destruction of its habitat a crime. While Section 7 only applies to federal projects and the remedy is to prevent the construction of a federal project, Section 9 is not limited to federal projects. What if the United States Fish and Wildlife Service determines that the act of a senior irrigator on the stream of diverting water under state law results in the destruction of the habitat of the squawfish? Is the senior irrigator subject to criminal punishment even though he is using the water under a state water right law? Is the irrigator entitled to compensation?

The above questions and the wisdom of the policy choices made under the Endangered Species Act raise difficult issues for the Congress and the courts in the future.

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# AQUATIC HABITAT AND CRITTERS IN A DRY STATE

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## INTRODUCTION

The theme of this conference encourages water-resource management adaptation to social and ecological change. Wildlife resources have become an increasingly important and controversial component of change related to water management and water quality. Because changes in aquatic environments and social values are inevitable, the need for proactive planning flexibility and coordination for water and wildlife managers is clear. The more difficult issue is how to follow through. Here I try to provide a brief overview of the ecological and social constraints and opportunities facing aquatic wildlife managers, and illustrate how they fit into western water management planning systems.

Past water development has both reduced and increased the extent to which habitat constrains wildlife production and diversity. Although aquatic habitat has been expanded greatly by construction of reservoirs for irrigation and flood control, that expansion has occurred at a cost in specific kinds of habitats, particularly habitats needed by certain native, rare species. Increasingly, wildlife management must encompass social values that influence water laws, economics and decision making in the western United States. New, tough laws and regulations have evolved as the perception of wildlife value has shifted (see Bean 1983 for an overview of federal wildlife law and Steinhoff et al., 1987 for economic perspective).

Values and laws are likely to continue changing, increasing the authority and responsibility of wildlife managers. Inadequate information about wildlife and other water-based values hampers the ability of wildlife managers to easily assume their expanding role in sound water management. Also, like other water-management agencies, wildlife agencies are fundamentally constrained by a lack of revenues.

Wildlife agencies are challenged with increasingly complex social demands to provide a greater diversity of wildlife habitats and life-forms. Most western wildlife agencies face stable or decreasing revenues as public demands for more diverse services increase. In response to changes in public attitude and behavior, concepts of wildlife and their management have changed dramatically. Much has occurred since the second world war, when wildlife value was virtually synonymous with a few harvested and widely observed species.

The public has never been more disturbed about environment and wildlife trends, yet the voting majority remains ambivalent about corrective costs and who should bear them. The recent flurry of proposed environmental law and wholesale rejection of environmental referenda, most notably in California, demonstrates the public's ambivalence. Concern for wildlife and environment is complicated by confusing expressions of ecological and economic values, and promotion of biocentric ethics without clear economic expression.

Wildlife and environment professionals who provide for New Mexico's ecological and public welfare will be increasingly challenged to retain appropriate local control by assuring the public that the best combination of ecological and social values is being provided. With those challenges foremost in mind, I will survey trends in wildlife-related attitudes and values, problems relating wildlife values to water quality standards, the increasing need for improved planning, and an interdisciplinary approach that provides for greater planning flexibility. First, a little about values and their measurement.

## WILDLIFE VALUES

Past sport-fishery management in the western U.S. has taken advantage of reservoirs developed for other purposes, increasing the value of impounded water without diminishing other economic benefits. For the most part, wildlife managers working as public servants seek to add value to water use while otherwise encouraging the most beneficial uses. The specific objectives chosen to complete that task are, in some cases, controversial, usually due to an incomplete understanding of and agreement about wildlife and other water-based values.

Because of western water scarcity, the ecological and economic stakes associated with aquatic wildlife are high (see data presented in USFWS 1988) and continue to assume a greater share of the state's financial resources. Aquatic habitat in dry regions is more valuable than habitat in wetter regions with similar human population. Expenditures for aquatic wildlife-based activities in New Mexico average roughly $2,500/surface acre ($1,000/hectare) and about $500/acre-foot ($4,000/hectare-meter) of evaporated water. These expenditures represent economic activity but are inappropriate estimators of value.

Wildlife's economic value to New Mexico residents is more appropriately expressed by other economic measures (Bishop 1987, Steinhoff et al. 1987). The quality of in-state recreation, for example, attracts the dollars of out-of-state recreationists (who might otherwise recreate elsewhere), thereby increasing in-state net income and buying power as long as state residents also benefit enough to keep from recreating outside the state. Providing high-quality wildlife opportunity in New Mexico discourages residents from spending dollars out-of-state for water-based recreation. In economic terms, the direct benefits to resident recreationists and indirect benefits to state businesses are now much higher than if no water-based wildlife opportunity existed in New Mexico. Undoubtedly, high-quality aquatic habitat directly benefits wildlife resource users and sustains a substantial wildlife-based economy in New Mexico. Economists also can quantify public willingness to pay for non-use values such as wildlife bequests to future generations, option value associated with sustaining future wildlife choices, and simply knowing that wildlife exist in natural settings. Although estimating economic value needs refinement, acceptable or provisional methodology is available to do so for decision-making purposes.

Non-economic ecological values, associated with biocentric concepts of inherent ecological worth or good as described by Taylor (1986), cannot be estimated using economic methodology.

Certain ecological methods may be useful, however. But comparing non-economic ecological measures of inherent value and economic measures of social value for decision-making purposes is troublesome. Public attitudes and values seem to incorporate both non-economic ecological rationales and economic rationales.

Water quality standards in New Mexico and elsewhere are designed partly to protect existing and attainable economic values of wildlife and do it reasonably well. Water quality standards, however, are not always designed to maximize social welfare as indicated by economic benefits. In some cases, they appear to protect non-economic ecological values, whether or not that was the intent. The uncertainty illustrates the need for a clearer definition of the values actually assigned by the standards to wildlife and other water-based resources.

Water quality standards are not easily expressed in ecological or economic terms partly due to the diverse conditions that exist in the west compared to the region where most standards developed and evolved. Water standards most effectively protect social values where demand for wildlife resources and the aquatic environment are both spatially and temporally uniform. In the eastern U.S., where most standards were first applied, the water supply is uniformly close to sea level, stable, low in carbonate-based salinity, and usually flows to the sea without first drying up. The topographic, geologic and climatic variety of western states creates diverse habitats occupied by a mix of unique natural and highly modified communities with diverse ecological and economic values. This ecological and economic diversity complicates development of appropriate water quality standards.

As shown in Figure 1, public attitudes, values and behavior are interrelated as described by Steinhoff (1980). Public attitudes and preferences determine values and motivate behaviors which in turn reinforce or reform preferences and attitudes exhibited later. Behavior is expressed mostly through economic activity, education including research, and the legal process. Usually, when economic activity is insufficient for behavioral expression, education and law are shaped by concerned interests to promote new attitudes and values. For planning purposes, understanding the dynamics of human attitudes helps narrow the range of anticipated social behavior.

According to Kellert and Berry (1980), most people's attitudes toward animals can be classified as naturalistic, ecologistic, humanistic, moralistic, utilitarian, or negativistic. Scientistic and doministic attitudes are more rare. People usually incorporate more than one attitude into their values structure. People with naturalistic and ecologistic attitudes view animals as part of an ecological whole. The humanistic attitude embraces sentient animals much as if they were human. People with a moralistic attitude toward animals believe that animals have an inherent worth independent of economic value and deserving of human respect. Utilitarian people typically assign material or economic value to wildlife. When combined with ecologistic attitudes, utilitarian people tend to view

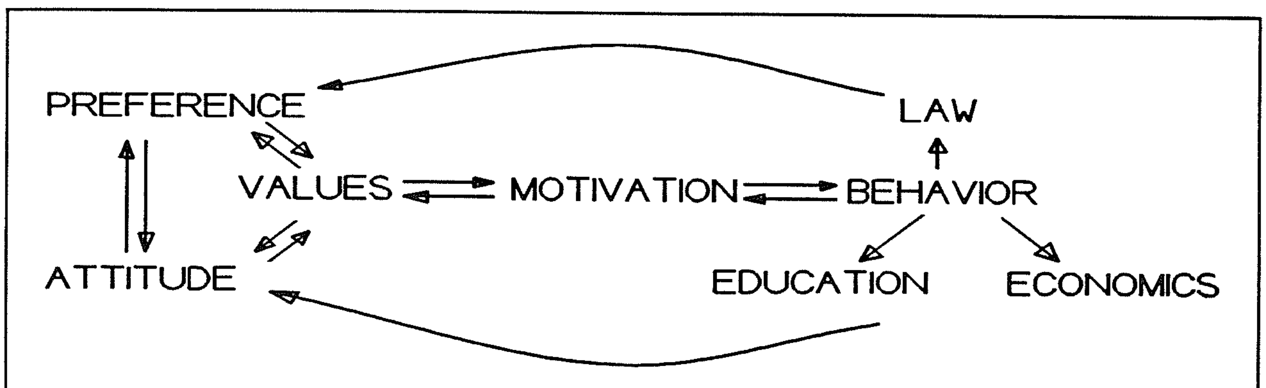


**Figure 1.** General relationships among social attitude, preference, values and behavior that influences aquatic wildlife issues (modified Steinhoff 1980).

ecological value in a social framework, believing that healthy ecosystems promote beneficial social systems. Nearly one third of the attitude expressed by people in the surveys of Kellert and Berry (1980) was negativistic. This attitude reflects total disinterest, fear and loathing for animals.

Attitudes shape ethics and values that motivate educational outreach and legislation designed to redirect economic activity. Utilitarian and negativistic attitudes shape anthropocentric ethics and values, which focus on human needs. Ecologistic and moralistic attitudes shape biogeocentric ethics and values that consider the inherent worth of ecosystems independently from human needs. Humanistic and moralistic attitudes shape biocentric ethics and values more specifically oriented toward animals. The ethics of many wildlife and environment professionals are based mostly on a mix of ecologistic, utilitarian, and moralistic attitudes toward the wildlife they manage. A growing number are becoming more moralistic and less utilitarian. For increasing numbers of managers, biogeocentric values are gaining with respect to anthropocentric values. Many wildlife and environment professionals seem to believe, like a growing portion of the public, that the non-economic inherent worth of ecosystems and the biosphere deserves protection, even at substantial social expense—the equivalent of an existence value greater than most people are willing to pay.

Future attitudes and values may continue to shift more in favor of biocentric reasoning. The young and the highly educated are more likely to express naturalistic, ecologistic, humanistic, and moralistic attitudes than are older or less educated people (Kellert and Berry 1980). This distribution of attitudes may indicate that the most economically and politically active part of our future society will move farther away from utilitarian and negativistic attitudes and anthropocentric values toward more ecologically based biocentric values. But human preferences and attitudes are dynamic and uncertain, and planning must account for that uncertainty.

Recent environmental events have generated concern for human welfare, some related to wildlife values. Because the market economy does not readily lend itself to many of these issues, public education and legislation are increasingly justified based on the biocentric inherent worth of wildlife in ecosystems rather than anthropocentric values. Preservation of biodiversity is a rallying concept. Wildlife professionals and lay public with biogeocentric agendas are encouraging management that focuses more on the ecological value represented by sustained or enhanced biodiversity. Although much of this ecological value can be translated into economic benefit, some cannot.

A recent Time magazine essay by Gup (1990) addressed this issue with specific regard to modifying the Endangered Species Act by incorporating greater economic perspective.

> Man cannot manage nature through a series of ad hoc rescue attempts, ignoring the underlying causes for the loss of biodiversity. The answer is not to dilute the Endangered Species Act but to better anticipate the consequence of human activity, focusing on entire ecosystems rather than on single species... The anthropocentric arguments legitimatize the notion that species must justify their right to exist by proving their utility to man. That leaves the vast majority of species defenseless and debases the fundamental reason for preserving them—their intrinsic worth.

Biogeocentric ethics are gaining wider acceptance. Further biodiversity protection is in the legislative process along with numerous related issues. The Endangered Species Act, a tough act to follow, enjoys widespread support despite the controversy that frequently circles it.

With recent changes in social and professional attitudes, it is not surprising that widespread transformation appears to be underway within wildlife and environment agencies. Most eastern agencies have already metamorphosed, redirecting much of their traditional emphasis on a few valued game species toward a wider diversity of game and nongame species. In the west, where wildlife agencies are striving to adapt, communication within and among agencies and public advocates is frustrated by inadequate information about environmental values and how those values relate to ecological, economic, and political processes. Exactly where western wildlife and water management is headed remains unclear.

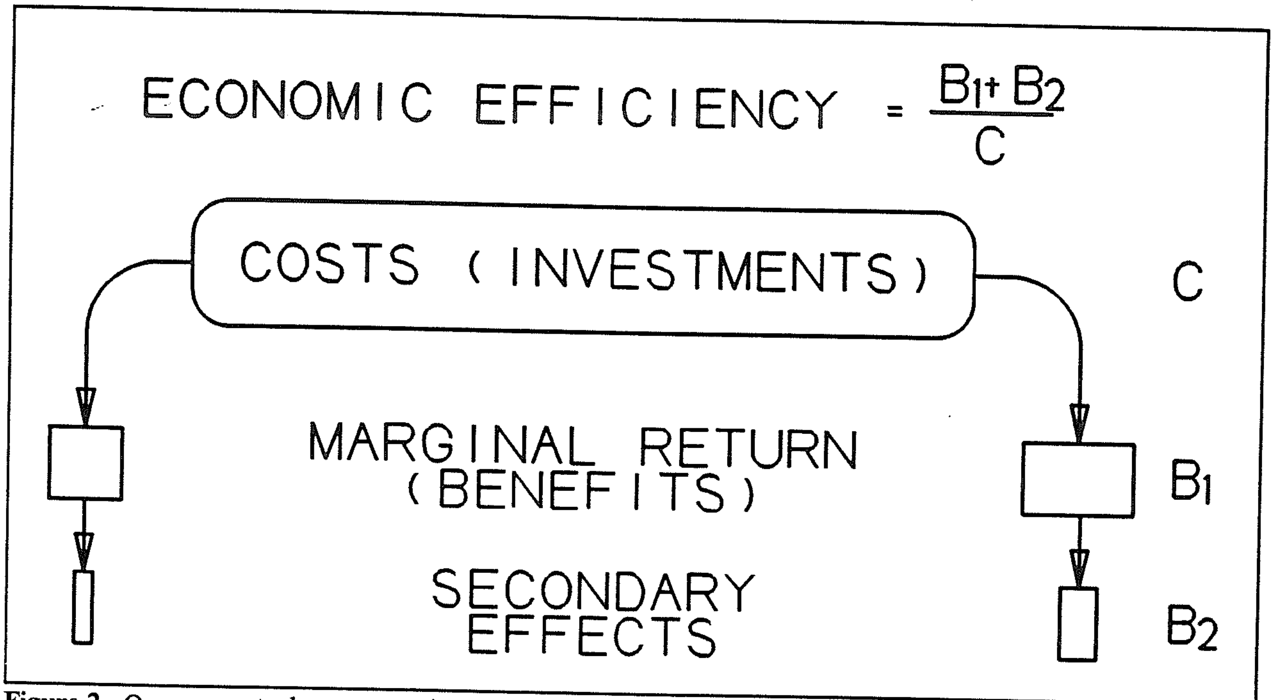


**Figure 2.** One conceptual representation of economic efficiency as the fraction of public investments returned in net public benefits (after cost is deducted).

For more effective aquatic wildlife planning, those with water resource interests need information to compare different water-based values directly. For social welfare values, a variety of economic measures are available, including various measures of economic efficiency usually used in benefit-cost analyses.

One of many possible economic efficiency measures, shown in Figure 2, reflects the increment of value added for the cost investment, the value added being the sum of all economic measures of social welfare including bequest, option and existence values. The unusual expression of economic efficiency presented in Figure 2 is analagous to the concept of ecological efficiency pictured in Figure 3. Many agencies and advocacy groups have been slow to accept economic efficiency, via benefit-cost analysis, as a valid measure of the ecological management impact on social welfare. But the impediments to wider acceptance and use of economic efficiency measures are few compared to alternative measures of non-economic ecological value.

Ecological welfare may be measured in various ways but biodiversity has dominated the recent thinking of conservation biologists (Wilson 1988). A related concept, based on ecological efficiency of aquatic community production, is an estimator more directly comparable to economic efficiency.

The efficiency with which total available energy in a feeding level (herbivores, first-level carnivores and so on) of an aquatic community is converted to production is one measure of ecological efficiency, shown in Figure 3 (see Ricklefs 1990 for a general review). Because biodiversity usually varies directly with ecological efficiency calculated for entire natural communities, ecological efficiency may serve as a more quantifiable measure of the ecological welfare associated with biodiversity.

## WATER QUALITY VALUES

Using ecological and economic efficiency measures, I will present some generalized examples to contrast expected responses of ecological and economic values to changes in oxygen concentration. Oxygen was chosen because it is closely associated with aquatic wildlife values.

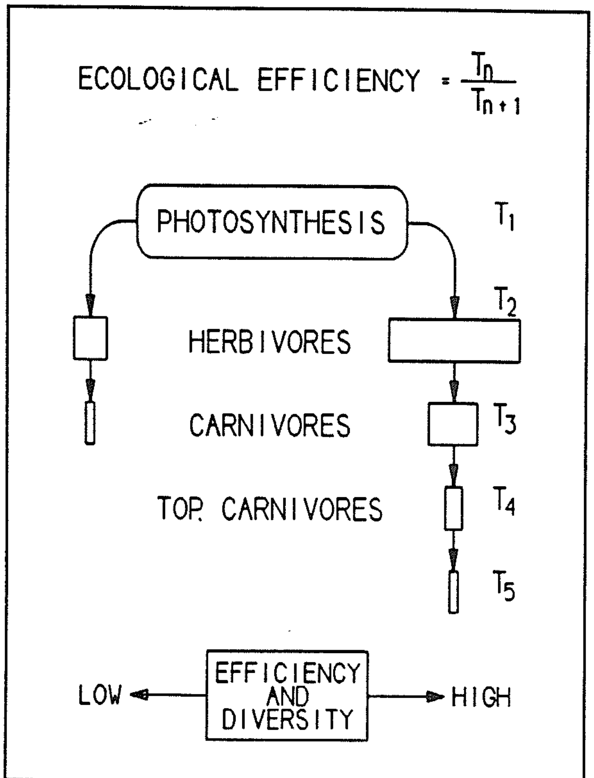


**Figure 3.** One conceptual representation of ecological efficiency as the fraction of energy biologically fixed in one trophic level that is accumulated in the next trophic level. Efficiency, number of trophic levels and diversity are usually positively correlated.

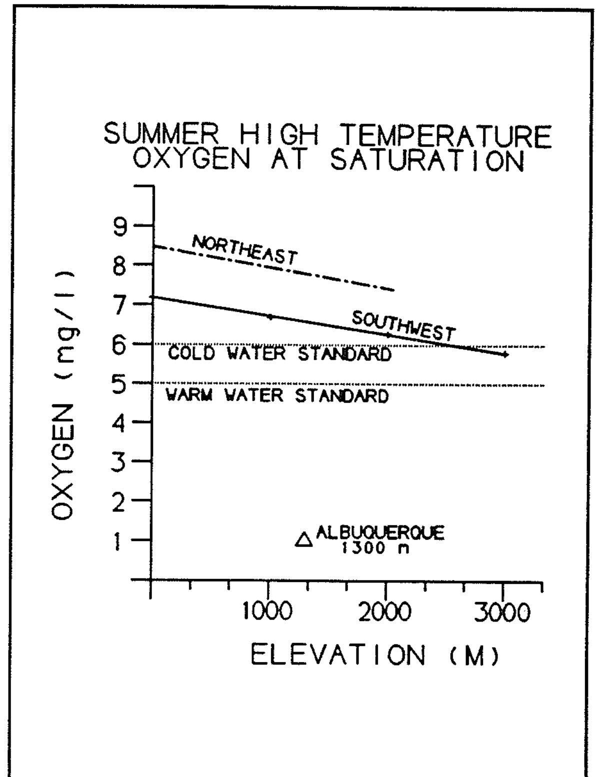


**Figure 4.** The relationship between topographic elevation and the concentration of oxygen sustained in water at equilibrium with summer conditions in the northeastern and southwestern U.S. Oxygen standards for cold- and warm-water habitats are shown.

As shown in Figure 4, the oxygen that can be held in water at saturation depends on the atmospheric pressure exerted by oxygen, which in turn depends on the elevation. New Mexico water standards for most warm and cold water aquatic habitats are also indicated, along with common saturation values encountered in the cooler northeastern U.S. The oxygen standards are based mostly on needs of recreationally valued fish species.

The water quality regulations allow oxygen to be removed down to the minimum allowable concentration, usually 5 to 6 mg/L, if it is socially justified; in other words, if it is economically prudent. The value of prudently used oxygen, therefore, is negotiable if social benefit can be shown. Below the minimum allowed, the oxygen is reserved entirely for the aquatic community even if it is not economically valued. Once an elevation of around 2,000 meters (6,500 feet) is reached, no oxygen is available above the standards and none can be justifiably used for economic benefit beyond the existing use of the aquatic resource. More oxygen is available above the standard for economic benefit at lower elevations because the warm-water fish that live there can do with less oxygen.

Existing water quality standards allow oxygen reduction because oxygen is rarely irreplaceable when waste is properly treated. The option of using oxygenated habitat for fish is not permanently forefeited when the oxygen in water is used instead to assimulate treatable wastes. In other words, the oxygen has no option value. In purely economic terms, the decision to treat the wastes so that oxygen is sustained depends on the benefits accrued from anthropocentric economic value or biocentric ecologic values. The decision does not depend on protecting oxygen from irreplaceable loss. If endangered species are present, however, the option value associated with the oxygenated habitat may be high and prevention of oxygen loss to protect endangered species may therefore be warranted. Otherwise, option values associaed with oxygenated water are hard to demonstrate. Depending on the variation in utility of the aquatic community that is protected by the minimum oxygen allowed, the minimum standard may protect either or both non-economic and economic values. Two examples follow for demonstration purposes.

Many of the most attractive fisheries in New Mexico are in high elevation reservoirs, none of which existed at the turn of the century. Virtually no oxygen can be removed from these lakes without violating standards because of their high elevation.

Figure 5 illustrates a modeled relationship between ecological and economic efficiencies in high elevation lakes inhabited by fish. This model shows that the economic efficiency of aquatic wildlife in this type of ecosystem is reduced more quickly than the ecological efficiency as the oxygen is depleted. The game fish in the lake are among those species that least tolerate oxygen depletion. Therefore, once the gamefish have been killed by oxygen loss, economic value has been greatly diminished, even though ecological value, as measured by efficiency, remains little changed.

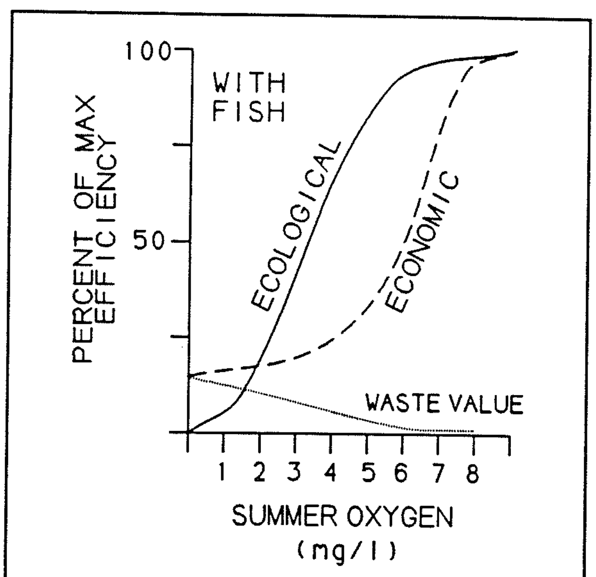


**Figure 5.** General model relationships among ecological efficiency, economic efficiency, oxygen-demanding waste assimilation value, and the summer oxygen concentration in a high elevation lake that supports New Mexico cold-water sport fish.

In Figure 6, representing waters with no game fish or where fish are inaccessible, the oxygen standards still apply. But in this case the economic potential is mostly associated with the use of oxygen for other purposes, such as the oxygen demand caused by camper activity. If enforced, the oxygen standard would appear to protect non-economic ecological values, as long as no option value for protection of endangered species were involved. For many high altitude lakes, virtually any human use of the watershed (including recreation and livestock grazing) could cause material loadings and oxygen depletion in violation of oxygen standards. Anthropocentric ethics would encourage oxygen use if it increased the total social welfare. Biocentric ethics would be less inclined to give up the non-economic inherent worth of the intact aquatic community sustained by the oxygen. That many of our lakes are artificial reservoirs occupied by non-native fish species simply confounds the issue.

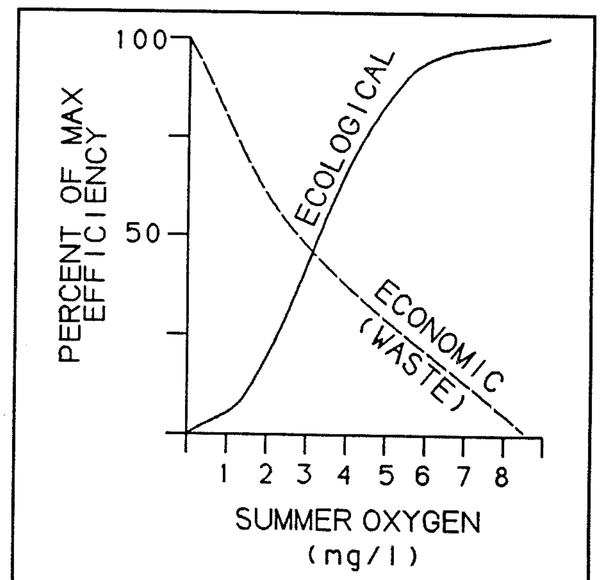


**Figure 6.** General model relationships among ecological efficiency, economic efficiency and oxygen-demanding waste assimilation in a cold-water lake without any sportfish where aquatic value is equal to waste assimilation value. This model assumes waste assimilation in no way detracts from aesthetic or alke values other than the ecological values inherent in integrity of the aquatic community.

In the future, this example could become more relevant if fishery management of remote waters is reduced to provide greater social welfare at more accessible and closer sites. As the economic value of the oxygen for sportfish becomes less relevant, maintenance of the oxygen standards must be based on other considerations.

Another example of poorly understood relationships between values and standards pertains to some of the lower elevation river reaches found in New Mexico's mainstream big rivers. Here natural and artificial accumulation of fine sediments in river channels often causes unstable bottom substrates and poor habitat. Many of these reaches are dewatered seasonally for irrigation purposes.

Past research (Donaldson 1987, for example) has shown that the natural productivity of sediments with small particle size is much lower than for larger, more stable sediment. All else held constant, a sandy bottom supports a small fraction of the productivity that is supported by a rocky bottom. Particularly when combined with dewatering by water diversions, these habitats have low ecological and economic efficiencies.

Although whatever remains of ecological efficiency is protected by oxygen standards in both stable and unstable river bottoms, the economic efficiency is much higher where stable bottoms occur, wherever water flow is sustained. As shown in Figure 7, again as a general model of relationships, most of the economic efficiency is eliminated by an unstable bottom. The oxygen standard mostly protects non-economic ecological value of an unused aquatic community, as long as no endangered species are present. Whether or not protection of non-economic ecological values is worth the cost remains unclear.

Other water-related decisions also influence the valuation. Greater reservation of instream flow could substantially increase the potential attainable use for wildlife. Actions that reduce sediment erosion and transport into stream beds would substantially increase both ecological and economic efficiency.

Figures 6 and 7 show the complexity of the values associated with standards and the need for standards that better reflect underlying values. The data that form the bases of these models are limited and more detailed understanding is needed. Although water quality standards and various other wildlife management strategies appear to have provided for economic and non-economic values, the values are not as clearly quantified as existing techniques allow. Improved wildlife and water management will require more precise measures of values in various environments at a time when the public is especially cost conscious and demanding greater government accountability for its revenue expenditure. The role of non-economic ecological value remains a stumbling block in a decision-making process designed to provide for social welfare.

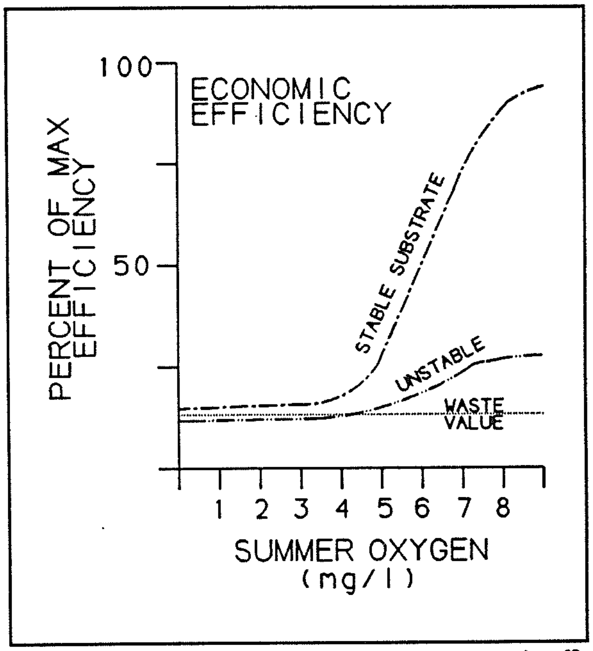


**Figure 7**. General model relationships among economic efficiency, bottom substrate stability, waste assimilation value and the summer oxygen concentration in rivers supporting sport fisheries.

## IMPROVING PLANNING TECHNIQUES

Solving these problems requires improved planning that identifies appropriate objectives and strategies. One of the most difficult planning challenges is reducing complex socio-ecosystems to their critical planning elements. As shown in Figure 8, wildlife and environment agencies manage ecological and economic efficiency to improve ecological and social welfare. Wildlife management and water quality standards form parts of strategies used to modify efficiencies that determine ecological and social welfare. As already discussed, ecological and social welfare do not necessarily respond in parallel to management

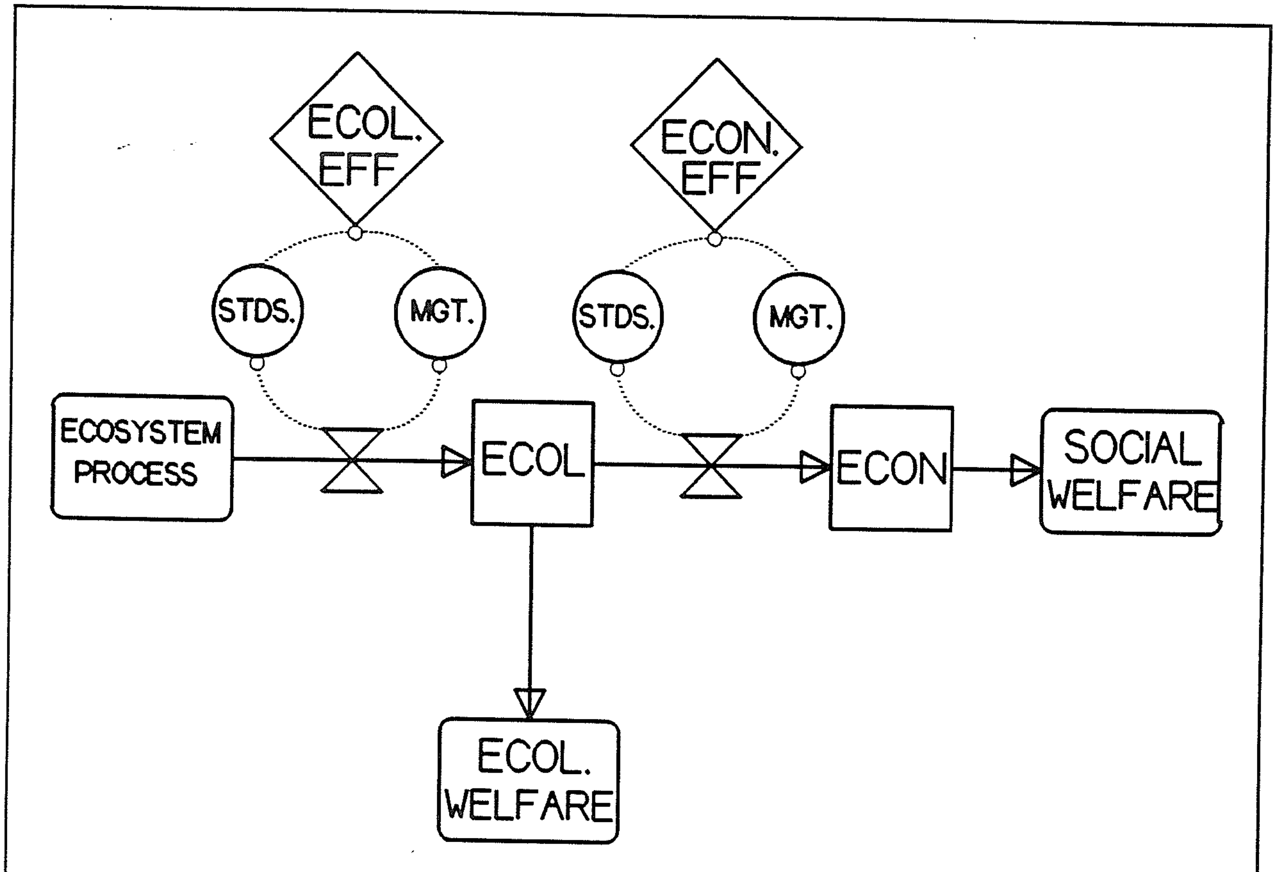


Figure 8. Systems diagram illustrating interactions among ecological and economic process in determining ecological and economic system structure and ecological and social welfare. Both ecological and economic efficiencies are influenced by the water standards used and other management tactics (ECOL EFF= ecological efficiency, ECON EFF=economic efficiency, STDS=water quality standards, MGT=management).

strategies. Welfare-related objectives become disoriented and planning breaks down when divergence is perceived between ecological welfare and social welfare. Therefore, a critical planning challenge is improved measurement of both ecological and social objectives, costs, and benefits. Some optimum distribution of ecological and social objectives needs to be identified to provide long-term public satisfaction.

Planning too often has been paralyzed by overly limiting views of planning environments and overemphasizing simple trend extrapolation toward a single future. Too often, plans for a single future become outmoded as trends change before the plans are completed. Greater flexibility is provided by planning for several possible futures. Manageable computing systems has greatly expanded the potential for alternative futures planning.

Another impediment has been over reliance on procedural objectives instead of welfare objectives. Stocking fish and treating wastewater does not automatically provide improved economic and ecological welfare, and it is the improved welfare that is the true product.

Although wildlife and environment agencies should be applauded for their dedication to improving opportunities at reduced user costs, they have been hamstrung with inadequate planning tools. The agencies must be able to predict the benefits of their management. They need more interdisciplinary integration of ecosystems and social systems designed for analysis of a variety of possible futures influenced by different management strategies. Much ultimately useful data remain out of reach of environmental planners and managers. There is a critical need for data synthesis, interdisciplinary task force analysis, and useful packaging of user-friendly software and other applications. The New Mexico Department of Game and Fish and the New Mexico Water Resources Research Institute have led in promoting data integration and planning advances.

Solving these problems will require more rigorous methods designed to focus, coordinate, and integrate interdisciplinary expertise into workable strategies that meet quantifiable objectives. Part of the solution is further development of cross-disciplinary simulation models that enable analyses of the social opportunities foregone by protection of non-economic ecological values. A prototype example of a sportfishery planning model is described by Cole et al (1990). Such models, developed to their potential, can incorporate a wide variety of management strategies into social and ecological system structures. These models can be used to forecast management impacts on social and ecological welfare. Perhaps more importantly, they encourage improved communication across disciplines as relevant information is distilled from the data.

## CONCLUSION

The need and the potential exists for improved integration of water quality and wildlife management into strategies designed to accomplish appropriate economic and ecological objectives. Although the costs of such planning will require considerable investment, the benefits are likely to be great. Accurate ecological and sociological information is needed to represent water-based values more fully. Planning objectives need to be based more securely on welfare resulting from management and less on the tactics used.

The diversity of western environments, which contributes much to western lifestyle, requires refinement of the present standards approach to better promote the most beneficial assemblage of management tactics, including those pertaining to wildlife-based values. Somehow in this process, non-economic ecological values should be translated into socially meaningful terms. Combined with astute politics, and caring public service, greater use of an interdisciplinary systems approach to planning appears appropriate for attaining improved integration of water management strategies for the greatest social welfare.

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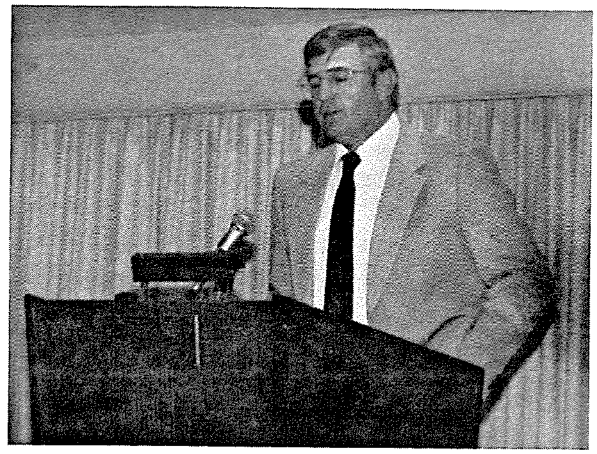
*Note: Commissioner Humphries completed his term in December 1990.*



# COSTS AND BENEFITS: WHAT IS SENSIBLE AND REASONABLE IN THE REALM OF THE POSSIBLE?

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Thank you for the opportunity to address this conference. I want to share a few thoughts from someone who has been in office for almost a full term. That allows one the privilege to be a little more outspoken and also of having a little more experience along with the battle scars to verify and reinforce one's position.

Tom Bahr suggested I talk about Costs and Benefits: What is Sensible and Reasonable in the Realm of the Possible? Those of you who know me well would know that I could never come up with a title like that or come up with a presentation exactly like that. I do think there are some important observations that I can share with you about what is sensible and reasonable related to costs and benefits.

To illustrate my point, I want to tell a story. My apologies to those of you who have been following me for the last month or two and have heard me tell this story.

A young man was traveling with his grandmother. He asked his grandmother how old she was, and the grandmother, slightly offended by this question, said it was a rude question—you don't ask women their age. The little boy went on about his business until a little farther down the road he asked his grandmother, "How much do you weigh?" Again the grandmother was not thrilled about the question and rebuffed the little boy again by saying that it was another rude question—you shouldn't ask those kinds of questions. The little boy was undaunted because not too long after that, he asked his grandmother why she and his grandfather had gotten a divorce.

The grandmother said, "Look you have asked three rude questions, three for three. They're all impolite and I want you to not do that anymore, just behave yourself."

The little boy sat quietly as the grandmother stopped the car and got out for a few minutes. The little boy looked through his grandmother's purse and found her driver's license with all the pertinent information. As they were driving down the road again, the little boy said, "Grandma, I know how old you are."

"Oh, how old am I?"

"Sixty-two years old."

"How do you know that?"

"I just know. I also know how much you weigh."

"You do?"

"Yes. You weigh 155 lbs."

"How did you know that?"

The little boy continued, "I also know the reason you and Grandpa got divorced. It was because you got an F in sex."

My point for telling this story—although its kind of a cute story to listen to—is that bad conclusions can be drawn from good information. Recently, when formulating public policy on water issues, we have generated significant interest in not only water quantity but water quality. A fairly large amount of misinformation has surfaced as well as what appears to be another concentrated effort at making poor public policy under the guise of maintaining water quantity and quality.

This country and perhaps even this state are guilty of failing in the creation and development of public policy. It might be that we have been too linear, our thinking has very seldom been circumspect or comprehensive enough to do anymore than treat the symptom or put a Band-Aid on a particular problem. That kind of linear thinking or simplistic approach to public policy has caused significant problems in the near-term, intermediate-term and almost always over the long-term. Public policy issues cry out for more complex analyses, taking into consideration the economic impact, the social structures and cultures. Somehow we have not been able to put that puzzle together in a very complete fashion. Generally, we approach one or a very narrow range of issues without taking into account all circumstances in a holistic manner.

An important casualty of this type is science. Science seems to be buried under rhetoric somewhere. Those of us who appeal for science over emotion are quite frequently rejected or discounted by the media, by those who oppose a particular position or philosophy, by those politically aligned on the opposite side of the question, or by those having a special interest they wish to espouse. They say science isn't an important issue here any longer because if it hadn't been for science we would not be in this mess in the first place. That is truly a frightening kind of response, especially when it comes to natural resource issues and developing a more comprehensive framework. Without considering social, economic, and cultural questions part of the primary question or analysis, we set a very dangerous precedent. Without including good science on top of that, public policy development becomes folly as opposed to professional resource management.

We must develop and enhance our tolerance of other cultures, positions or ideas. We must consider those positions and ideas as we formulate policy that considers secondary impacts from the initial laws, regulations or management techniques.

There are an endless number of potential resource conflicts other than those between preservationists and resource producers. There is a new responsible environmentalism developing in this country and a vastly increased environmental awareness by business, government and resource producers. When it comes to considering and implementing strong conservation measures and balancing ecology and economics, I think it's incumbent upon us as politicians, policy makers, community leaders and concerned citizens to do the best job we can to find solutions that are comprehensive and balance conservation, community, economic and cultural issues. Without this procedure to develop and implement regulations, laws or management techniques, all such efforts will fail to various degrees. Significant disagreements among production groups exist regarding who uses water first, what condition they leave it in, how much they should use, and how much should be allowed to go beyond our state's borders.

An interesting resource conflict analysis discussed and studied the relationship between the potash enclaves in southeastern New Mexico and oil and gas production. About eighty-five percent of potash reserves, a vital economic resource, are found in southeastern New Mexico overlaying extremely important oil and gas reserves in the Permian Basin. Potash miners are not too thrilled about oil and gas companies drilling through potash mines. Likewise, oil and gas companies are not happy about being unable to develop important reserves. They are also uncomfortable with the thought of a mining operation mining through an established producing well. An appropriate solution would consider the best way to do both with the maximum safety level. The solution would also consider present and future values, and present and future needs. Whether one resource could be used efficiently prior to the development and production of the other resource should be factors in the solution.

Many conflicts have arisen among surface and water users including loggers, recreationists, ranchers, hunters, and mineral producers. Each conflict may not have simple solutions to problems but we can all contribute responsible creative thinking to develop comprehensive public policy that provides effective and sound solutions. Not all problems have solutions and to suggest so is slightly Pollyanna and ignorant of issue complexities and opponents' positions. However, for the most part, answers lie in the wise use of resources, multiple use of federal and state lands, and consideration of the environment, economics, social, and cultural impact associated with each particular conflict.

In closing, one final trend has given me cause for concern. The tendency today is to talk about taking away other people's rights whether it concerns water, land, land uses, private property rights, or other uses. Many say we can take property rights away because it's the right thing to do. That is an extremely dangerous philosophy that threatens the foundation upon which our government and personal beliefs are founded. Whether it's water use or a preferential use of federal or state land or private property rights, the United States Constitution under the 5th Amendment provides for just compensation and for due process to compensate those individuals who have their private property or property rights taken from them in whole or in part.

I believe that adequate resources are available to avoid wholesale violations of our constitutional rights. We have the right to enjoy our investments on private property and our legally acquired rights for the use of federal, state, or private land. When dealing with issues in the realm of the possible, it's absolutely imperative that we not forget that one of the absolute most important rights in this country is the right of the individual to have secure ownership and use of their property and property rights in a reasonable fashion. If some groups can justify and convince policy makers and the rest of the public that it is important to acquire public ownership, then for heaven's sake, let's compensate those people as provided in the 5th Amendment of the United States Constitution. Thank you.

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