1985

Water Quality Criteria And Standards

US Environmental Protection Agency

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This paper describes how the effort to enforce water quality standards for the commercial shellfishing industry in Oregon's Tillamook Bay led first to a federally sponsored 208 water quality study and then to the development of plans to reduce nonpoint source pollution inputs and to establish criteria under which the bay would be closed to harvesting.

First, the characteristics of the Tillamook drainage basin will be briefly described and the problems and programs that preceded the 208 efforts summarized. Next, the results of the 208 research will be presented, focusing on how the lack of results showing straightforward correlations between shellfish contaminations and bay pollution levels necessitated further analyses. Finally, the paper presents the process of using the scientific conclusions drawn from all these considerations in formulating pollution management plans for the bay.

BACKGROUND

The Tillamook Bay Drainage Basin is located on the northern Oregon coast, 48 miles south of the Columbia River and 60 miles west of Portland. Five major rivers drain the basin's 363,520 acres and discharge to Tillamook Bay. Ninety percent of the basin is mountainous, forested, and sparsely populated. Eight percent of the basin is alluvial, relatively flat, and devoted to agriculture and population centers. Dairy farming is the primary agricultural activity. There are about 120 of these dairy farms, whose nearly 19,000 animals generate over 280,000 tons of manure a year. The basin's 13,000 people live in three small cities and rural hinterlands. About 6,300 are served by sewers, with the other 6,700 using on-site sewage systems. The remaining 2.5 percent (9,150 acres) of the basin is occupied by the bay itself.

The Tillamook area is characterized by a strong marine influence, Seventy percent of the rainfall occurs during the months of November through March. Winter storms coming off the Pacific can bring intense periods of precipitation, resulting in sudden rises in river flows and occasionally flooding the alluvial plain low in the basin. The average rainfall is 229 centimeters (90 inches) along the coast and 381 cm (150 inches) inland in the mountains (Natl. Oceanic Atmos. Admin., 1973). The mean annual water yield for the five rivers in the basin is about 2.6 million acre-feet.

As the lowest point in the drainage, Tillamook Bay receives these seasonally-generated large inflows of freshwater. These high flows can result in cumulatively increasing bacterial densities. As shown in Figure 2, the upper bay is generally an area of lower salinity since four of the five rivers enter the bay in that area. During the winter and spring, salinities in the upper bay will approach zero due to high river inflows. During the summer and fall, salinities in the upper bay reach 15 parts per thousand because of a low inflow of freshwater. The water temperatures in the bay also vary seasonally, ranging from 12° to 18°C in the summer to 7° to 9°C in the winter.

Although this paper focuses on the needs of the commercial shellfishing industry, Tillamook Bay serves many different needs. The bay is the receiving water for the effluent discharged by five sewage treatment plants. The bay also supports commercial and recreational fishing and shellfishing and recreational boating. Shellfishing includes recreational and commercial clamming, and commercial oyster cultivation and harvesting. The Pacific oyster (Crassostrea gigas) is seeded on and harvested from the shallow bay floor and sold without rely or depuration. The Pacific oyster has been grown commercially in the bay since the 1930's. Of the 2,084 acres available for leasing from the State of Oregon for oyster cultivation, about 850 acres are leased annually by three growers (see Fig. 1) (Osis and Demowy, 1976). In 1975, 142,144 pounds of oysters were harvested for a value of $280,180 (Forsberg et al. 1975).
HISTORY OF WATER QUALITY STANDARDS AND MONITORING EFFORTS

Estuarine waters that support commercial oyster production are subject to water quality standards developed by the Food and Drug Administration (FDA) as part of its National Shellfish Sanitation Program. The total coliform standard is the bacterial standard that applies in Tillamook Bay, see Table 1.) The State of Oregon through its State Health Division has conducted a Shellfish Sanitation Program that follows the framework established by the national program. The State’s program has been in effect since the late 1940’s. Prior to 1969, the Health Division had full responsibility for monitoring the quality of the growing waters, inspecting the sanitary conditions of processing facilities, and coordinating the State program with the National Shellfish Sanitation Program. In 1969, however, the State legislature created the Department of Environmental Quality and charged it with monitoring estuarine waters (growing waters) and operating sewage treatment plants.

In 1972, the Health Division developed a bay closure plan that would restrict harvesting of oysters whenever it rained 2 inches or more in 24 hours, or whenever a sewage treatment plant upset or bypass occurred. Water sampling done by the Department of Environmental Quality and the FDA in the 1970’s established that these standards were justifiable, as the bay did at times exceed the total coliform standard, especially during periods of heavy rainfall in the winter (Ore. Dep. Environ. Qual., 1981a). The FDA, however, expressed concern that the State Health Division was not being adequately informed about the operations of the five sewage treatment plants that discharged into the bay, and could therefore not know when to close the bay following a bypass or upset. The FDA also expressed concern that the rainfall criteria were not being enforced.

In December 1977, the FDA conducted a special bacterial survey in Tillamook Bay during a major storm event. Results showed bacteria densities in the bay far exceeded the National Shellfish Sanitation Program standard for safe oyster harvesting (U.S. Health Educ. Welf., 1978). The FDA, acting upon the results of the survey, strongly recommended closing the bay to oyster harvesting and developing appropriate control measures. The FDA threatened to withdraw their endorsement of the Oregon Shellfish Sanitation Program if appropriate actions were not taken.

Recognizing the gravity of this situation, the Health Division formed a task force of the State Health Division, the Department of Environmental Quality, Oregon State University, and the shellfish industry to deal with the problem. Their recommendations included: (1) hire a full-time sanitarian whose primary duty would be shellfish sanitation; (2) assess bay water quality using the fecal coliform standard, concurrently sampling shellfish meat for fecal coliform and Salmonella organisms; (3) develop criteria for closing and reopening shellfish growing waters based on those analyses of shellfish meats; (4) intensify bay and shellfish monitoring, especially in growing waters; and (5) develop programs to reduce nonpoint source pollutants.

DESIGN OF THE 208 STUDY

Following the recommendations of the task force for more water quality data on the bay, and for the development of a program to reduce nonpoint source pollution, the Department of Environmental Quality and the Tillamook Soil and Water Conservation District secured U.S. Environmental Protection Agency funding under section 208 of the Clean Water Act of 1972, to conduct a study. The purpose of the study was to identify fecal waste sources in the basin, develop a plan to reduce their input to the bay, and develop monitoring criteria that would allow shellfish harvesting under safe conditions.

Integral to the conduct of this study was the formation of two committees: a Technical Advisory Committee and a Citizens Advisory Committee. These committees provided local input on the field surveys, reviewed the findings, and participated in developing plans to reduce fecal wastes entering the bay and to develop criteria under which the bay would temporarily be closed to shellfish harvesting.

To identify fecal waste sources, field surveys were scheduled flexibly by the Department of Environmental Quality to coincide with conditions of ground saturation and rainfall events. Water samples from the five river systems (71 sites) were collected at 8-hour intervals around the clock for 2 to 5 days. This type of field survey was new to the Department and was a learning experience for the staff involved. Concurrent with the sampling, river flow measurements were taken, rainfall amounts recorded, and the five sewage treatment plants that discharge to the bay were sampled. Bay water samples (14 sites, see Fig. 1) and oyster samples (two sites) were collected on high and low tides during daylight hours. A review of past Department ambient bay monitoring showed that most sampling had occurred during or around high tide, because Tillamook Bay is very shallow in the oyster growing area, and it is easy to go aground while attempting to sample at low tide. However, more data at or near low tide was believed necessary to better understand the impact of freshwater inflows on these areas. Field measurements
for temperature and salinity were also made on the bay and many of the river sampling points that were tidally influenced.

The water samples collected from the rivers and the Tyle sewage treatment plants were analyzed by the Department's laboratory using the membrane filtration method for total and fecal coliform according to procedures in the 14th edition of Standard Methods (1976). Both the water samples and the oyster meats collected from the bay were analyzed by the Health Division's laboratory using the 5-tube MPN method for total and fecal coliform, according to Standard Methods (1976). Both the total coliform and fecal coliform standards are applicable in the Tillamook Bay Drainage Basin. The Health Division uses a total coliform standard for shellfish growing waters, as does the FDA (see Table 1). In 1980 the Department changed from the total coliform standard to the fecal coliform standard for shellfish-growing waters (see Table 1). The change was made to better measure the effects of fecal sources.

**SUMMARY OF 208 SURVEY SAMPLING CHARACTERISTICS**

Field surveys were designed to coincide with four particular weather and soil conditions:

1. Heavy rainfall when soils were saturated. This occurred December 1979.
2. Rainfall after a period of dry weather when soils were unsaturated. This occurred March 1980.
3. No rainfall during summer low river flows and unsaturated soils. This occurred July 1980.
4. First "freshet" storm after October 1, when soils become saturated and overland runoff increases. This occurred October 1980.

Each of the four field surveys is summarized in Table 2. Each survey consisted of several individual sampling runs. The table shows daily rainfall and mean daily Wilson River flow for each individual run, while the bay bacterial water quality data are summarized for each survey as a whole. Ranges of median values for fecal coliform are included for each survey to show the extent of bacterial input associated with each climatic condition. Coliform ranges for followup sampling in March 1980 reflect actual values, as do salinity and temperature data. Salinity is displayed as a range for each end of the oyster lease. The north end data represent stations 7, 13, and 11. The south end represents stations 6, '14, and 2 (see Fig. 1). Ranges of salinity and temperature are included to show how specific climatic and runoff conditions can influence these physical parameters which in turn influence oyster pumping. Most importantly, the number of oysters collected and the number that exceeded the meat standard are included. An evaluation of sewage treatment plant operation is also included. Not included for lack of space is a generalized statement of water quality in each of the rivers for each survey.

In brief, the water quality in the lower part of the basin generally exceeded the bacterial water standard whenever a rainfall event took place, because of the ready access that animal wastes had to the water courses (Ore. Dep. Environ. Qual., 1981b). The next section covers the conclusions that were drawn from these field surveys.

**CONCLUSIONS DRAWN FROM 208 FIELD SURVEYS**

The field surveys provided further evidence to confirm two basic hypotheses, held by most observers who had previously studied the bay about what was occurring in the Tillamook basin. First, the total and fecal coliform standards for the shellfish-growing waters were exceeded periodically or even constantly during the wet weather months, October through April. Second, the data showed that the major source of this fecal contamination was input from improper waste practices at dairy operations. This source represented approximately 70 percent of all fecal coliform input to the rivers and thus into the bay (Ore. Dep. Environ. Qual., 1981b).

The extentiveness of the data collected, however, allowed many more detailed inferences than these to be made. In addition to the estimate that 70 percent of all fecal coliform input to the rivers was from dairy animal wastes, the data permitted estimating that improperly functioning on-site sewage systems were responsible for 15 to 20 percent of the fecal coliform input. The remaining 5 to 10 percent was attributable to natural, background levels from numerous sources such as the wild animal population (Ore. Dep. Environ. Qual., 1981b). Although the sewage treatment plants operated within their permit levels during all the surveys, the data gained from the surveys increased the ability to assess the immediate and disastrous effects malfunctions can have on water quality.

The data also helped provide a more detailed under-

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**Table 1.—Federal Food and Drug Administration and State of Oregon shellfish growing water and market oyster meat standards applicable to estuarine and fresh waters in the Tillamook Bay drainage basin.**

<table>
<thead>
<tr>
<th>Agency</th>
<th>Marketed oyster meats</th>
<th>Estuarine shellfish growing waters</th>
<th>Freshwater and non shellfish growing estuarine waters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and Drug Administration (FDA)</td>
<td>For 100 grams oyster meat: total coliform 60,000 fecal coliform 230 standard plate count 500,000</td>
<td>For 100 milliliters of sample: median of 70 total coliform; 10% of samples not greater than 230 per 100 milliliters</td>
<td>No Standard</td>
</tr>
<tr>
<td>Oregon State Health Division (OSHD)</td>
<td>Same as FDA</td>
<td>Same as FDA</td>
<td>No Standard</td>
</tr>
<tr>
<td>Department of Environmental Quality (DEQ)</td>
<td>No Standard</td>
<td>For 100 milliliters of sample: median of 14 fecal coliform; 10% of samples not greater than 43 per 100 milliliters</td>
<td>For 100 milliliters of sample: log mean of 200 fecal coliform for 5 samples in 30 days; 10% of samples not greater than 400 for period</td>
</tr>
</tbody>
</table>

standing of the potential disease transmission pathways by which a pathogen might be transported to the shellfish-growing waters. The data showed, however, that a constant straight line correlation between the amount of pollution in the bay and the level of contamination in the shellfish meats did not necessarily exist. While this could be expected given the complexity of the physical and biological systems being studied, it complicated the development of a management plan for the water quality in the bay. The next sections describe how this plan was developed.

**DEVELOPMENT OF THE FECAL WASTES MANAGEMENT PLAN**

With the completion of the field surveys and the identification of the sources of the bay's fecal contaminants, two tasks lay ahead. One was to develop a plan to reduce

![Figure 2.-Average seasonal salinities (parts per thousand) in Tillamook Bay from samples taken near the bottom at high tide.](image)
fecal inputs at their source; the other to create a set of
criteria to decide when the bay should or should not be
open to shellfish harvesting. As this paper focuses on the
latter task, only a brief synopsis of the waste plan will be
included here. (For a more complete account, see Ore. 
Dep. Environ. Qual., 1981c.)

The Tillamook Bay Drainage Basin Fecal Wastes Man­
agement Plan was developed by the Department of Envi­
nmental Quality and the Tillamook Advisory Commit­
tees. The plan addresses the identified fecal sources with
a course of action to correct their fecal input to the bay.
Major components of this plan include:
1. A notification procedure was developed for all sew­
age treatment plant malfunctions. Warning equipment
was also installed.

2. Best management practices (BMP's) were devel­
oped by the Tillamook Soil and Water Conservation Dis­
trict. These BMP's addressed improper or nonexisting ani­
mal waste management practices.
3. On-site sewage problem areas were identified and
those areas requiring further investigation and correction
were prioritized.
4. Commitment was obtained from all involved parties
to execute their identified plans for fecal input correction.
5. The need for annual recertification and reevaluation
of the plan was agreed upon.

All parties recognized that the fruits of the Fecal Waste
Management Plan, in terms of improved water quality for
shellfish growing, were 5 to 10 years away. Since com­
plete closure of Tillamook Bay was not an attractive option

Table 2.—Summary of 208 water quality data for Tillamook Bay collected during selected rainfall and soil saturation conditions.

<table>
<thead>
<tr>
<th>Date of survey</th>
<th>Daily rainfall</th>
<th>Daily mean Wilson R. flow</th>
<th>Fecal coliform WQ std,for shellfish waters, beds north/ south (ppth)</th>
<th>Range of salinities over 7 sites (range)</th>
<th>Range of temperature over beds (centigrade)</th>
<th>Oyster meat quality, 2 sites no. of samples/ no. exceeded</th>
<th>Sewage treatment plants</th>
<th>Soil saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1979</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79/12/02</td>
<td>1.62</td>
<td>4560</td>
<td>exceeded 5 to 27/7</td>
<td></td>
<td></td>
<td>1/0, several meet samples permit saturated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79/12/03</td>
<td>0.15</td>
<td>2560</td>
<td>for 3 to 20</td>
<td></td>
<td></td>
<td>see below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79/12/04</td>
<td>2.54</td>
<td>5830</td>
<td>entire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79/12/05</td>
<td>0.05</td>
<td>3440</td>
<td>survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79/12/06</td>
<td>0.18</td>
<td>2200</td>
<td>((30 to 2400)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79/12/07</td>
<td>-0.05</td>
<td>1630</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/10</td>
<td>0.36</td>
<td>729</td>
<td>exceeded 7 to 23/7</td>
<td></td>
<td></td>
<td>7/2 meet unsaturated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/11</td>
<td>0.78</td>
<td>845</td>
<td>for 0 to 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/12</td>
<td>0.94</td>
<td>1010</td>
<td>entire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/13</td>
<td>0.81</td>
<td>1540</td>
<td>survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/14</td>
<td>0.61</td>
<td>1570</td>
<td>(4 to 1100)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/15</td>
<td>-3.4</td>
<td>1460</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/16</td>
<td>0.03</td>
<td>1320</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80/03/17</td>
<td>0.99</td>
<td>1510</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Followup sampling* Flow and rain data only
| 80/03/18*      | 0.49           | 1970                      | exceeded 20/4.5                                               |                                           |                                         | 2/0 not sampled saturated                                  |                        |               |
| 80/03/19*      | 0.43           | 1860                      | (9 to 240)                                                   |                                           |                                         |                                                               |                        |               |
| 80/03/20*      | 0.00           | 2050                      | exceeded 17/6.5                                               |                                           |                                         |                                                               |                        |               |
| 80/03/21*      | 0.01           | 2020                      | (15 to 150)                                                  |                                           |                                         |                                                               |                        |               |
| 80/03/22*      | 0.90           | 1760                      |                                                             |                                           |                                         |                                                               |                        |               |
| 80/03/23*      | 0.18           | 1610                      |                                                             |                                           |                                         |                                                               |                        |               |
| 80/03/24*      | 0.03           | 1410                      |                                                             |                                           |                                         |                                                               |                        |               |
| 80/03/25*      | 0.00           | 1250                      | meet 18/9                                                     |                                           |                                         |                                                               |                        |               |
| 80/03/26*      | 0.45           | 1220                      | (3 to 23)                                                    |                                           |                                         |                                                               |                        |               |
| 80/03/27*      | 0.11           | 1190                      | 4 of 7 exceeded 9/5                                           |                                           |                                         |                                                               |                        |               |

July 1980
| 80/07/28       | 0.00           | 93                        | meet 26 to 32/7                                               |                                           |                                         |                                                               |                        |               |
| 80/02/29       | 0.00           | 90                        | for 27 to 30                                                  |                                           |                                         |                                                               |                        |               |
| 80/07/30       | 0.00           | 88                        | survey (3 to 43)                                              |                                           |                                         |                                                               |                        |               |

October 1980
| 80/10/25       | 0.14           | 95                        | 4 of 7 exceeded 20 to 27/7                                    |                                           |                                         |                                                               |                        |               |
| 80/10/26       | 0.89           | 250                       | (3 to 240)                                                   |                                           |                                         |                                                               |                        |               |
| 80/10/27       | 0.00           | 200                       |                                                             |                                           |                                         |                                                               |                        |               |
| 80/10/28       | 0.00           | 169                       |                                                             |                                           |                                         |                                                               |                        |               |
| 80/10/29       | 0.00           | 120                       |                                                             |                                           |                                         |                                                               |                        |               |

CFS = cubic feet per second ppth = parts per thousand

Glendening, 1985
while corrective actions were taken, the final task of the study was to develop the criteria for temporary bay closures.

RATIONAL FOR THE BAY CLOSURE PLAN

Development of the bay closure plan involved two courses of action. First, the results of the 208 studies together with other research data were examined to determine when oysters were most likely to be contaminated. These analyses formed the basis for developing scenarios projecting the probability of oyster contamination, given different seasonal conditions. Second, these scenarios were discussed with the shellfish committees consisting of oystermen, university experts, and the State Health Division. Proposed Criteria for the Temporary Closure of Tillamook Bay to Shellfish Harvest (Ore. Dep. Environ. Qual., 1981d) fully discusses the plan that resulted from these consultations.

ANALYSIS OF FACTORS CONTRIBUTING TO OYSTER CONTAMINATION

Preliminary analysis

Initial analysis focused on determining if a correlation existed between physical parameters and bacterial densities. If a strong correlation could be established, it would serve as an immediate gauge of when to close the bay to shellfish harvesting. Correlations were sought for fecal coliform versus salinity and versus river flow (the Wilson River and for bay stations 12, 6, and 14, using data from 1970 to 1979). No clear correlation was apparent during that period.

Table 3.—Risk assessment of oyster meat contamination for various physical, biological and climatic conditions.

<table>
<thead>
<tr>
<th></th>
<th>Average rainfall</th>
<th>Average river flow</th>
<th>Soil saturation</th>
<th>Bay water quality</th>
<th>Salinity over shellfish beds (high tide)</th>
<th>Temp. over shellfish beds</th>
<th>Oyster pumping activity</th>
<th>Oyster harvest</th>
<th>Risk of contaminated oysters</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>18.6 cm 7.3 in</td>
<td>low to moderate</td>
<td>unsaturated (filling)</td>
<td>meets std. except for fresher rainfalls</td>
<td>27 to 31 ppth</td>
<td>11 to 13°C</td>
<td>active</td>
<td>yes</td>
<td>low to high (rainfall events)</td>
</tr>
<tr>
<td>November</td>
<td>35.1 cm 13.8 in</td>
<td>moderate to high</td>
<td>unsaturated to saturated</td>
<td>exceeds stds.</td>
<td>27 to 31 ppth</td>
<td>11 to 13°C</td>
<td>reduced to very limited</td>
<td>peak harvest</td>
<td>high to moderate</td>
</tr>
<tr>
<td>December</td>
<td>42.4 cm 16.7 in</td>
<td>high to very high</td>
<td>saturated</td>
<td>greatly exceeds stds.</td>
<td>10 to 23 ppth</td>
<td>8 to 9°C</td>
<td>very limited</td>
<td>peak harvest</td>
<td>moderate to low</td>
</tr>
<tr>
<td>January</td>
<td>40.1 cm 15.8 in</td>
<td>high to very high</td>
<td>saturated</td>
<td>greatly exceeds stds.</td>
<td>10 to 23 ppth</td>
<td>8 to 9°C</td>
<td>very limited</td>
<td>peak harvest</td>
<td>moderate to low</td>
</tr>
<tr>
<td>February</td>
<td>23.3 cm 9.2 in</td>
<td>high</td>
<td>saturated</td>
<td>exceeds stds.</td>
<td>10 to 23 ppth</td>
<td>8 to 9°C</td>
<td>very limited</td>
<td>yes</td>
<td>low</td>
</tr>
<tr>
<td>March</td>
<td>26.7 cm 10.5 in</td>
<td>high to moderate</td>
<td>saturated</td>
<td>exceeds stds.</td>
<td>6 to 26 ppth</td>
<td>9.5 to 10.5°C</td>
<td>reduced to limited</td>
<td>yes</td>
<td>low</td>
</tr>
<tr>
<td>April</td>
<td>16.6 cm 6.5 in</td>
<td>moderate</td>
<td>saturated</td>
<td>exceeds to meets stds.</td>
<td>6 to 26 ppth</td>
<td>9.5 to 10.5°C</td>
<td>reduced</td>
<td>yes</td>
<td>low</td>
</tr>
<tr>
<td>May</td>
<td>9.4 cm 3.7 in</td>
<td>moderate to low</td>
<td>saturated to unsaturated (draining)</td>
<td>exceeds to meets stds.</td>
<td>6 to 26 ppth</td>
<td>9.5 to 10.5°C</td>
<td>active</td>
<td>yes</td>
<td>low to moderate (rainfall event)</td>
</tr>
<tr>
<td>June</td>
<td>7.7 cm 3.0 in</td>
<td>low</td>
<td>unsaturated (draining)</td>
<td>meets stds.</td>
<td>22 to 31 ppth</td>
<td>12.5 to 16.5°C</td>
<td>active (potential spawn)</td>
<td>reduced</td>
<td>low to moderate (rainfall event)</td>
</tr>
<tr>
<td>July</td>
<td>3.5 cm 1.4 in</td>
<td>low</td>
<td>unsaturated</td>
<td>meets stds.</td>
<td>22 to 31 ppth</td>
<td>12.5 to 16.5°C</td>
<td>very active</td>
<td>yes</td>
<td>low</td>
</tr>
<tr>
<td>August</td>
<td>4.6 cm 1.8 in</td>
<td>low</td>
<td>unsaturated</td>
<td>meets stds.</td>
<td>22 to 31 ppth</td>
<td>12.5 to 16.5°C</td>
<td>very active</td>
<td>yes</td>
<td>low</td>
</tr>
<tr>
<td>September</td>
<td>9.9 cm 3.9 in</td>
<td>low</td>
<td>unsaturated</td>
<td>meets stds.</td>
<td>27 to 31 ppth</td>
<td>12.5 to 16.5°C</td>
<td>very active</td>
<td>no</td>
<td>low to high (rainfall event)</td>
</tr>
</tbody>
</table>

ppth = parts per thousand  C = centigrade

Glendening, 1985

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the wet weather period for these physical parameters and bacteria densities. The same analysis was tried using data gathered during the 208 study, and the results were the same.

These analyses suggested that any effort to explain the coliform densities in the bay must take into account multiple factors including: (1) amounts of freshwater input and its bacterial loading reflecting recent rainfall intensities and soil saturations; and (2) the varying tidal stages and movements of salinity gradients up and down the bay, which seasonally change the dilution rate of freshwater. The complex interaction of these and possibly other variables made modelling these interactions extremely difficult. The ability to obtain the measurements necessary to use such a model also was beyond reach. The focus of the analysis thus shifted to evaluating those situations that might produce the highest risk of contaminated oysters.

**Analysis of oyster behavior**

Review of the bacterial data analyses on the oyster meats had shown that the meats did not always exceed the bacterial standard even when the ambient water quality exceeded the standard for shellfish-growing waters (see Table 2). Factors other than ambient water quality affect oyster meat bacterial quality. Therefore, to better understand oyster meat quality, the conditions that affect oyster feeding/pumping activity were investigated.

Research has shown that three conditions influence oyster pumping activity: temperature, salinity, and turbidity (U.S. Health Educ. Welf., 1966). Any one of these conditions can cause oysters to substantially decrease or cease pumping. Oysters will decrease or cease pumping when: (1) water temperature is 10°C or less; (2) salinities are 10 parts per thousand or less; or (3) turbidity is more than 20 Jackson Turbidity Units (JTU). All three of these conditions occur during periods of high freshwater inflow during the winter months. During this time oysters pump only small volumes of water just to keep themselves oxygenated.

Oysters will most actively pump when: (1) salinities are 25 parts per thousand or greater; (2) temperatures are 15°C or greater; and (3) turbidity is below 20 JTU. These conditions occur from April through October, during low freshwater inflow when salinities range from 20 to 50 parts per thousand, and temperatures from 12° to 17°C. Water quality in the bay is generally good during this period because of low stream inflows, which implies low runoff and thus low bacteria densities.

**Bay salinity and temperature**

Since the review of oyster behavior had shown that these were important factors, bay salinities, temperature data, and freshwater inflow were reviewed for each of the four field surveys and analyzed against oyster meat bacteria data and bay bacteria data. The aim was to determine how important these conditions were in accounting for the level of bacteria in the meat. The same analysis was also performed on three other studies (U.S. Health Educ. Welf., 1974, 1976, 1978) that had collected oyster meat samples. The conclusion was reached that these factors were indeed essential to determining the probable degree of oyster contamination.

The two studies conducted by the FDA in 1977 and 1974 illustrate very well the issues of concern here (U.S. Health Educ. Welf., 1974, 1978). The 1977 study shows how factors combine to make a period of presumably high contamination less so. The 1974 study illustrates the opposite—how high contamination risks can exist even when ambient bacterial readings are low.

In December 1977, the FDA conducted a survey on Tillamook Bay during a major winter storm. Bacterial water quality in the shellfish-growing water ranged from a fecal coliform median of 4,600 to 6,300 per 100 ml. Salinities ranged from a median of 10 to 16 parts per thousand. Temperatures ranged from 9° to 10°C. Forty-four oyster samples were collected from the bay. Of these, 17 exceeded the bacterial meat standard and 11 were at the limit of the standard, 230 fecal coliform MPN/100 grams. Of the 17 that exceeded the standard, nine had values in the 300's, four had values in the 400's; and four had a value 500 or greater. Even though the oyster meat samples did exceed the market standard, they did not reflect the extent of bacterial densities that occurred over the oyster beds. In its report the FDA stated, "The environment was adverse for the oyster because of the low salinity values, the high turbidity of the water, and the presence of the sediment. Their inability to pump, with the near absence of concentration of pollutants and resulting lower than expected fecal coliform counts, made the oysters an unreliable indicator of pollution." (U.S. Health Educ. Welf., 1978)

In November 1974 the FDA conducted a survey on Tillamook Bay shortly after the first "freshet" rainfall event of the water year and continued sampling into and through the second "freshet." (The Department of Environmental Quality 208 survey conducted in October 1980 had similar climatic conditions.) While during the survey the shellfish-growing waters did meet standards, it was conjectured that the bay had received a large bacterial load as a result of this first "freshet." Salinities over the oyster growing area were in the range for pumping activity of 19 to 23 parts per thousand. Temperatures were 9° to 10°C. Of the 12 oyster samples collected, 10 exceeded the meat standard, and 9 of the 10 had fecal coliform values that ranged from 4,700 to 92,000 MPN. The risk to public health from consuming raw contaminated oysters in this situation was high, and the data showed that oysters have a high probability of becoming contaminated when a bacterial load is introduced to the bay, and salinities are within the optimum range for active pumping (U.S. Health Educ. Welfare, 1974). (The sampling done in October 1980, when conditions for active oyster pumping also existed in the bay, further supports this hypothesis. Three of the six meat samples were either at the limit of or exceeded the meat standard.)

**REVISED METHOD OF ASSESSING THE RISKS OF OYSTER CONTAMINATION**

By reviewing all the relevant data, conclusions were made about the risks associated with the harvesting of shellfish under various seasonal conditions. These principal conclusions are as follows:

1. Rainfall conditions exist October through April and cause large inflows of freshwater, which carry with them large bacterial loadings to the bay. Shellfish-growing waters in Tillamook Bay exceed the bacterial standard under these conditions.

2. During periods of high inflow, salinities and temperatures are below the optimum for active shellfish pumping.

3. Shellfish meats do not reflect bacteria concentrations in proportion to the water quality because they are not actively pumping.

4. Tillamook Bay meets the shellfish-growing water standard under conditions of very little or no rainfall. This occurs May through October.

5. During periods of low inflow and optimum salinities and temperatures, oysters will actively pump.

6. Shellfish meats can exceed the meat standard if salinities and temperatures are optimum for pumping; and a large bacterial load is introduced to the bay as a result of a rainfall event. This can occur even though the bay waters
meet the shellfish-growing water standard.

These conditions were used to project the likely risk of oyster contaminations at different times of the year under various conditions. For example, by using these premises and varying the expected rainfall amounts (1.0, 1.5, or 2.0 inches) together with the corresponding expected river flows (based on historical data), it was possible to project the risk in harvesting. Table 3 was created for this paper to portray, in summary form, the types of criteria used to assess risks for a hypothetical water year.

TILLAMOOK BAY SHELLFISH MANAGEMENT PLAN

The conclusions and assessments of risk that were drawn from the water quality studies were discussed with the Shellfish Committees for use as criteria in constructing a bay closure plan. A consensus was reached that any plan would have to insure that the risk of contaminated oysters was low. Concern was also expressed about what each proposed criteria would mean in terms of the number and length of possible bay closures. Important input was also made at this time about how the impact of different fecal sources was to be considered in devising the plan. The committees recommended that the plan address itself to specific events such as major rainfalls or sewage treatment plant malfunctions. During these discussions a consensus was also agreed upon that, according to the best available evidence and expert opinion, a 5-day purging period for the oysters after a period of probable contamination would give the best margin of safety. With the committees’ assistance, a management plan was developed. The plan was submitted to the State Health Division and, with minor modifications, adopted. The plan as executed by the Oregon State Health Division is as follows:

1. Close the bay when a sewage treatment plant bypass or malfunction occurs. Closure would be variable depending on the magnitude of the problem.
2. Close the bay for 5 days when the Wilson River’s flow reaches 8,500 cubic feet per second (cfs) for 12 hours or more. This situation represents the river’s flow at flood stage and will cause flooding of fecal sources low in the basin.
3. Close the bay for 5 days when the Wilson River’s flow doubles between April 1 and August 31.
4. Close the bay for 5 days when the Wilson River’s flow reaches 500 cfs or greater from Sept. 1 to Dec. 1 for the first “freshet” of the water year.
5. Close the bay for 5 days for the second rainfall event between Sept. 1 and Dec. 1 that increases the Wilson River’s flow to 1,500 cfs or greater.

MANAGEMENT PLAN EXECUTION AND ASSESSMENT

The Tillamook Bay Management Plan has been in effect since October 1981. In 1981, it resulted in three bay closures, two in the fall and one during the winter because of high river flows. In 1982, a higher than normal rainfall year, it resulted in nine closures, two in the fall, four in the winter resulting from high river flows, and three caused by sewage treatment plant malfunctions. In 1983, it resulted in three closures, one in the fall and two in the winter because of high river flows. In 1984, it resulted in two closures in the fall only. And in 1985, no closures to date have occurred because of a drier than normal winter.

In discussion with Health Division staff the management plan has been viewed as a good starting point for controlling the harvest and sale of fecally-contaminated shellfish. However, review of the oyster meat data collected in conjunction with bay closures indicates that 5-day closure after “freshet” rainfall events is not a sufficient length of time to allow oysters to purge themselves (Chaceran, 1985).

A followup nonpoint source study of the Tillamook Bay Drainage Basin has been scheduled by the Department for 1985 and 1986. The planned surveys will be smaller in scope but are intended to gather data for use in assessing the effects of animal waste BMP’s that were put in place using Rural Clean Water Act funding. Each survey will coincide with specific rainfall events, and river, bay and oyster meat bacteriological samples will be taken. To better assess oyster purification abilities, bay and oyster meat sampling will be continued for 7 to 10 days beyond each rainfall event. This information will allow the Tillamook Bay Shellfish Management Plan to be fine-tuned.

CONCLUSIONS

Total and fecal coliform water quality standards can indicate sources of fecal pollution in fresh and estuarine waters. In the absence of better data, they are often used as indicators of shellfish pollution. However, a complex relationship exists between densities of coliforms in shellfish-growing waters and the densities of coliforms in shellfish meats. Shellfish management plans should investigate these complex relationships and use them to develop closure criteria for shellfish harvesting based on the probability of high coliform densities in shellfish meats. Further research is needed to establish an indicator directly related to the incidence of disease. To this end, recently proposed EPA bacterial water quality criteria for fresh and marine water contact recreational waters attempt to establish a more direct relationship to the incidence of disease. It is hoped that the FDA will investigate and establish bacterial criteria that are more directly related to the incidence of disease for use in shellfish-growing waters.

REFERENCES

EVALUATION OF NONPOINT SOURCE IMPACTS ON WATER QUALITY FROM FOREST PRACTICES IN IDAHO: RELATION TO WATER QUALITY STANDARDS

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Division of Environment
Boise, Idaho

ABSTRACT
An interdisciplinary task force was appointed by the Board of Health and Welfare to determine the impacts of forest operations on protected uses and make recommendations on water quality standards. Twenty-five forest operations were inspected by the Task Force in 1984 for compliance with the Idaho Forest Practices Act (FPA) and their potential for impacting salmonid fish habitat. Seven of the 25 operations were considered a major impact or hazard to salmonid habitat due to direct delivery of sediment associated with roads or skid trails. At the remaining sites impacts on protected uses were prevented either by site conditions—low geologic hazard, streams with no protected uses—or by good practices. U.S. Forest Service timber sales met or exceeded the Forest Practices Act. Noncompliance on State and private lands was associated primarily with reuse of existing roads near stream channels, failure to identify and use appropriate logging systems in hazardous geologic conditions, and lack of timely installation of erosion control measures.

INTRODUCTION
In 1980, the Idaho Water Quality Standards (Idaho Dep. Health Welfare, 1980) were revised to include specific language for control of nonpoint source pollution, including silviculture. The Forest Practices Act Rules and Regulations (Idaho Dep. Lands, 1979) administered by the Idaho Department of Lands were identified as best management practices (BMP’s) for silviculture. The Antidegradation Policy was deleted during this revision, but language that requires protection of designated uses was retained.

In 1982 the Idaho Division of Environment commented unfavorably on a timber sale environmental assessment report prepared by the U.S. Forest Service. The Division of Environment held that the potential reduction in fisheries, as estimated in the environmental assessment, would violate the standard protecting beneficial uses. The predicted impact was based on the cumulative effects of sediment on fisheries habitat. The Forest Service replied that strict interpretation of this standard would set a precedent that could severely curtail timber harvest opportunities in the national forests—with consequential impacts on the State economy.

The Forest Service petitioned the Board of Health and Welfare to change the standards relating to injury of protected uses. Additional conflicting petitions were submitted by environmental and industry groups, and public hearings on these petitions were held. As a result of the hearings, the Board of Health and Welfare adopted a compromise position in revising the standards. At the same time, the Board directed the Division of Environment to establish an interdisciplinary task force to study the problems of nonpoint source pollution from forest practices.

The Board established the task force to provide a technically sound answer to questions that arose during public debate regarding the water quality standards:

1. Do BMP’s provide adequate water quality protection for protected uses defined in the Water Quality Standards?
2. Are current forest practices affecting water quality (protected uses) and to what extent?
3. Are the existing regulatory controls for silvicultural operations adequate to prevent water quality impacts?

METHODS
Eight task force members were selected to represent the major agencies and interest groups involved in the issue of nonpoint source pollution on forested lands and to provide technical expertise in the following fields: silviculture, hydrology, geology/soil science, forest road construction, fishery biology, and water quality. Agencies and interest groups represented included: Idaho Department of Health and Welfare—Division of Environment, Idaho Department of Lands, Idaho Fish and Game Department, Idaho Conservation League, American Fisheries Society, Idaho Forest Industry Council, and both Forest Service regions in Idaho.

The task force made onsite evaluations of 25 silvicultural operations in 1984. Sampling design incorporated consideration of geographic location, geologic land type, logging methods, proximity to streams, and the need to examine forest operations after the first runoff season. Site selection was stratified based on ownership categories. Forty-five percent of the timber volume in Idaho is harvested from 10 national forests, 45 percent from private industrial and nonindustrial forests, and 10 percent from State school endowment lands. The 25 evaluations were divided approximately by timber volume to include 10 Forest Service timber sales, 10 private operations, and 5 State timber sales. Sites were selected randomly from a list of candidate operations. Although 25 sites do not comprise a statistically valid sample of forest operations in Idaho, observed trends of compliance with practices, of impacts on streams, and of administrative procedures used by land management agencies are considered to be representative.

Site evaluation was based on compliance with proposed revisions of the Idaho Forest Practices Act Rules and Regulations (FPA). These revisions resulted from a section 208 project (Braun, 1979), and include 19 individual rules for timber harvesting and 30 rules for road design, construction, and maintenance. The proposed rules clarify vague wording in the current rules, but do not differ substantially in intent. Therefore, ratings of compliance with the proposed rules also apply to the current rules.

A task force consensus rated each applicable rule subjectively for compliance with the rule for water quality impact using a rating system from 1 to 5, with 1 being a low rating and 5 as superior rating.

Analysis of water quality impacts was based primarily on the effects of sedimentation on fisheries habitat. A site was rated by observation of direct sediment delivery to streams and the potential for continuing impacts from the
site. Observation of cobble embeddedness estimated the existing status of sediment impacts in the drainage.

RESULTS
Compliance with the proposed rules varied by land ownership category (Fig. 1). Forest Service administered lands had a high compliance rate. Only 5 percent of the individual ratings (n = 371) were judged as a minor departure from the intent of the rule. Noncompliance ratings were higher on State and private lands. On State lands, 21 percent of the individual ratings were considered a minor departure, and 12 percent a major departure. On private lands 10 percent were judged a minor departure, and 8 percent a major departure.

State Lands
Administrative procedures and management practices used by the Idaho Department of Land did not provide an adequate level of water quality protection. Three of the five inspected timber sales resulted in major impacts or potential hazards to fisheries habitat (Table 1). Recurring practices that caused water quality impacts or potential hazards were associated with roads and skid trails. Reuse of existing roads located too close to stream channels, poor road construction and maintenance practices, and incomplete stabilization of cut and fill slopes before the runoff season were among the hazardous practices. Ground skidding occurred during wet weather and on steep erosive slopes. Skid trails on some sites paralleled tributary channels so that erosion control was ineffective in preventing sediment delivery.

United States Forest Service
Seven of the 10 sites inspected met or exceeded the FPA rules. Minor departures from a limited number of rules were noted in three sales. A minor water quality impact occurred at only one site when poor road drainage practices at a stream crossing and a culvert installation created a fish-passage barrier.

Overall administration of forest practices by the Forest Service helps prevent water quality impacts. Roads are planned, constructed, and maintained to appropriate standards. Erosion control practices are extensive and up to date. Logging systems that minimize soil and stream disturbance are applied in sensitive land types. Extensive planning and consideration of environmental effects are major positive factors in achieving water quality protection.

Figure 1.—Comparison of compliance with proposed Forest Practices Act Rules at 10 U.S. Forest Service, 10 private, and 5 State silvicultural operations. The percentage is based on ratings of individual rules at a site, then summed for the sites within the land management category.

not evident in other land ownerships. The costs associated with Forest Service administration of timber sales is much higher than under State or private ownerships.

Private Operations
Protection of water quality values was considered adequate at 6 of the 10 sites (Table 1). This was due, in part, to the low hazard land types and minimal stream values in some of these operations, as well as to the forest practices conducted. At each of the remaining four sites, a major departure from the FPA rules resulted in a major impact (one site) or potential major hazard (three sites) to fisheries habitat.

Recurring reasons for violation of the FPA rules included inadequate planning in location and design of roads, reuse of existing roads and skid trails located close to stream channels, inadequate road drainage and stream crossing structures, and erosion control practices not completed before the runoff season.

Existing Stream Conditions
Cobble embeddedness was used as an indicator of the existing substrate condition with respect to cumulative effects of watershed activities. Of the 25 sites inspected, 14 were near a Class I stream, that is, a stream that could be used by resident or adfluvial trout. Of these 14 streams, obvious cobble embeddedness was observed in 9 (Table 2): At these nine sites (60 percent of Class I streams), sediment delivery from past or ongoing activities may have already caused sustained damage to the fishery habitat.

DISCUSSION
The current controversy in Idaho is over the impact of logging on a watershed basis, that is, over the additive effects of nonpoint source sediment produced on a sensitive protected use. Specifically, the issue has focused on plans for building roads in unroaded areas (usually considered de facto wilderness by conservation groups) in the Idaho batholith. These watersheds are generally high hazard lands that historically supported runs of salmon and steelhead trout. Restoring these anadromous salmonid runs is considered a high priority by the public in Idaho.

The risk that a site presents to continuing impacts depends on a number of site-specific factors together with the way in which the operation is administered. Key site-specific considerations are the geologic erosion hazard, the stream's capability to support protected uses, and the stream energy in regard to transporting sediment out of a critical habitat.

Cumulative impacts change habitat conditions at a critical stream reach by the addition of individual impacts over space and time; recovery does not occur before the next individual practice. The issue of cumulative impacts of forest practices has received a great deal of attention. The Washington Forest Practices Board has recently completed a summary of the literature (Geppart et al. 1984). Cumulative effects can only be quantified by costly and time-consuming monitoring after the fact, or by predicting the impact through modeling.

The task force speculated on the cumulative impact potential of the inspected operations independently from the existing watershed conditions, because we were interested in the implication for recommendations on future management. Sixteen sites were considered low risks, six moderate risks, and three high risks for contributing to cumulative watershed impacts (Table 2). If proposed BMP's were fully complied with, the task force believed these risks would be substantially lowered. Four sites would still pose moderate risks for cumulative effects de-
Table 1.—Summary of compliance with proposed Forest Practice Act Rules and water quality impact rating at 25 silvicultural operations in Idaho, 1984.

<table>
<thead>
<tr>
<th>Stream Class1</th>
<th>Site</th>
<th>Compliance with proposed rules</th>
<th>Water quality impact rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idaho Department of Lands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Lightning Point</td>
<td>Major departure</td>
<td>Severe hazard</td>
</tr>
<tr>
<td>I</td>
<td>Trapper Creek</td>
<td>Major departure</td>
<td>Major hazard</td>
</tr>
<tr>
<td>I</td>
<td>Willow Creek</td>
<td>Major departure</td>
<td>Major hazard</td>
</tr>
<tr>
<td>II</td>
<td>Crazy Creek</td>
<td>Minor departure</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>II</td>
<td>Killarney Lake</td>
<td>Minor departure</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>United States Forest Service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Bryan Creek</td>
<td>Exceeds requirements</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Camp Eleven</td>
<td>Exceeds requirements</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Cedar Creek</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Decorah</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>II</td>
<td>M.F. Weiser River</td>
<td>Minor departure</td>
<td>Minor hazard</td>
</tr>
<tr>
<td>II</td>
<td>Bonaparte</td>
<td>Minor departure</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>II</td>
<td>Deer Creek</td>
<td>Exceeds requirements</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>II</td>
<td>Olson Tunnel</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>II</td>
<td>Spring/Done Creek</td>
<td>Exceeds requirements</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>II</td>
<td>Tollgate</td>
<td>Minor departure</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>Private Operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Bellgrove Creek</td>
<td>Minor departure</td>
<td>Major hazard</td>
</tr>
<tr>
<td>I</td>
<td>French Creek</td>
<td>Major departure</td>
<td>Major hazard</td>
</tr>
<tr>
<td>I</td>
<td>'Gold Fork Creek</td>
<td>Major departure</td>
<td>Major hazard</td>
</tr>
<tr>
<td>I</td>
<td>N.F. Grouse Creek</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Mica Creek</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Thomas Creek</td>
<td>Gross neglect</td>
<td>Major hazard</td>
</tr>
<tr>
<td>I</td>
<td>Laffinwell</td>
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<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Little Meadow Creek</td>
<td>Minor departure</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Little Mud Creek</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
<tr>
<td>I</td>
<td>Little Salmon Creek</td>
<td>In compliance</td>
<td>Adequate protection</td>
</tr>
</tbody>
</table>

1Stream Class:  I—Important for spawning, rearing, or migration of fish.
II—Not used by fish; principal value is downstream influence on class I streams.

Table 2.—Geology, land type hazard, and sediment impacts at 25 silvicultural operations in Idaho, 1984.

<table>
<thead>
<tr>
<th>Site</th>
<th>Geology</th>
<th>Land type hazard</th>
<th>Pre-Existing sediment condition1</th>
<th>Project sediment2</th>
<th>Cum. Impact potential3</th>
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<tr>
<td>Idaho Department of Lands</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightning Point</td>
<td>Mica schist</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Trapper Creek</td>
<td>Glacial outwash</td>
<td>High</td>
<td>Yes</td>
<td>No</td>
<td>Mod.</td>
</tr>
<tr>
<td>Willow Creek</td>
<td>Batholith</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Crazy Creek</td>
<td>Glacial Till</td>
<td>Low</td>
<td>N.A.</td>
<td>N.A.</td>
<td>Low</td>
</tr>
<tr>
<td>Killarney Lake</td>
<td>Hard metamorphics</td>
<td>Low</td>
<td>N.A.</td>
<td>N.A.</td>
<td>Low</td>
</tr>
<tr>
<td>United States Forest Service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bryan Creek</td>
<td>Batholith</td>
<td>High</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Camp Eleven</td>
<td>Altered granitics</td>
<td>Mod.</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Cedar Creek</td>
<td>Hard metamorphics</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Decorah</td>
<td>Hard metamorphics</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>M.F. Weiser River</td>
<td>Basalt</td>
<td>Low</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Bonaparte</td>
<td>Batholith</td>
<td>High</td>
<td>Yes</td>
<td>No</td>
<td>Mod.</td>
</tr>
<tr>
<td>Deer Creek</td>
<td>Batholith</td>
<td>High</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Olson Tunnel</td>
<td>Altered granitics</td>
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<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Spring/Done Creek</td>
<td>Glacial till</td>
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<td>No</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Tollgate</td>
<td>Batholith</td>
<td>High</td>
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<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Private Operations</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bellgrove Creek</td>
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<td>Yes</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>French Creek</td>
<td>Batholith</td>
<td>High</td>
<td>No</td>
<td>Yes</td>
<td>Mod.</td>
</tr>
<tr>
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<td>Alluvium</td>
<td>Low</td>
<td>N.A.</td>
<td>Yes</td>
<td>Mod.</td>
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<tr>
<td>N.F. Grouse Creek</td>
<td>Glacial till</td>
<td>Low</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
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<tr>
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<td>No</td>
<td>Mod.</td>
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<tr>
<td>Thomas Creek</td>
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<td>Low</td>
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<td>N.I.</td>
<td>Low</td>
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<tr>
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<td>Low</td>
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<tr>
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<td>Mod.</td>
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<td>Yes</td>
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<tr>
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<tr>
<td>Little Salmon Creek</td>
<td>Basalt</td>
<td>Low</td>
<td>No</td>
<td>N.O.</td>
<td>Low</td>
</tr>
</tbody>
</table>

1Pre-existing sediment condition: stream has been severely impacted by watershed activities as shown by observed cobble embeddedness.
2Project sediment: observed sediment delivery of damaging magnitude from the current forest operation.
3Potential for sustained damage to fishery habitat based on contribution to cumulative impacts.
spite these practices because of hazards associated with the land type.

The difference between administration of forest practices by the Forest Service and administration on State and private lands is a major consideration regarding the potential risk for cumulative impacts. Management practices based on watershed objectives under Forest Service administration are the key to this process. The ability to schedule forest practices in a watershed over space and time is critical to prevent cumulative impacts. This process reasonably assures that sustained damage to a protected use will not occur in low and moderate hazard land types on Forest Service lands. The potential for cumulative impacts is considered moderate on high hazard land types, however, because of the unknown risk associated with mass failure from roads in these areas.

On State and private lands, implementation of proposed FPA rules is expected to eliminate most problems identified during this study. However, the potential for cumulative impacts is much higher than under Forest Service administration because no mechanism addresses watershed planning and the ability to schedule forest practices in a watershed over time.

Relation to Water Quality Standards

The Federal Clean Water Act (P.L. 92-500) provides the framework and goals for nonpoint source pollution control. Water quality standards are the statutory and regulatory basis for achieving the goal of the Clean Water Act (section 101(a) and 303(c)). Section 208 set up a means to develop water pollution abatement plans for nonpoint sources, and a method to identify a reasonable set of BMP's for meeting water quality standards.

EPA has promulgated the Antidegradation Policy (U.S. Environ. Prot. Agency, 1983) based on the Clean Water Act. States are expected to include this policy in their water quality standards. Interpretation of the Antidegradation Policy in relation to nonpoint sources is unclear. Strictly interpreted, the Antidegradation Policy could be construed to prohibit any ground disturbing activity from which sediment would be delivered to a stream—regardless of the magnitude of resulting impact on protected uses.

In Idaho, the Health and Welfare Board has substituted more workable language for the Antidegradation Policy. The bottom line in these standards is protection of beneficial uses. The Forest Service has developed and continues to refine the technology by which cumulative effects of timber harvest on salmonid habitat can be predicted and monitored (Platts et al. 1983; Cline et al. 1981). The Division of Environment is working with the Forest Service to establish guidelines for the protection of beneficial uses. These guidelines will establish specific watershed objectives based on the sensitivity and importance of the fishery. This process is a practical attempt to apply the Clean Water Act to State standards and nonpoint sources of pollution.

ACKNOWLEDGEMENTS: The author is grateful for the individual efforts of the task force members and the contributions of the participating agencies: Dewey Almas and Don Jones, Idaho Department of Lands; Virgil Moore, Idaho Fish and Game Department; Doli Obie, Idaho Conservation League; Jack Griffith, American Fisheries Society; Dale McGreer, Idaho Forest Industries Council; Michael Cook, Nez Perce National Forest; and Philip Jahn, Payette National Forest.

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ILLINOIS AGRICULTURAL SOIL EROSION CONTROL STANDARDS: A USEFUL TOOL FOR NONPOINT SOURCE POLLUTION CONTROL

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ABSTRACT

Illinois’ primary nonpoint source pollutant is sediment from agricultural land. The Illinois Water Quality Management plan estimated costs of sediment pollution. The legislature and subsequently all 98 soil and water conservation districts adopted a soil erosion and sediment control program with the following provisions: (1) progressive standards aimed at reducing agricultural erosion to “tolerable” soil loss levels by the year 2000; (2) a complaint program tied to the standards; (3) a cost share program tied to complaints. State priority areas, especially lake watersheds, are addressed through a cooperative selection process and watershed work plans. Water quality goals are incorporated in watershed work plans. This approach has provided a balance between both State mandated soil conservation and water quality conservation goals. Our presentation will present examples of this approach.

BACKGROUND

To fully appreciate the usefulness of Illinois’ Agricultural Soil Conservation Standards, Illinois’ soil and water resource base and setting needs to be understood. Illinois is the Prairie State. It is a rich agricultural empire blessed with rich topsoil and a very favorable climate for crop production. Only about 170,000 acres (or 1/2 of 1 percent of cropland) is irrigated. With about a $3.3 billion share of exports, Illinois ranks as the number one agricultural export state. Of the 10.2 million acres of this cropland exceeds the tolerable soil loss or “T” discussed in this paper. About 5.5 million of these acres can be brought to “T” through conservation tillage and other practices to manage concentrated waterflows. Only .5 million acres can be treated solely with conservation tillage. On another 3.7 million acres where soil loss exceeds 2 “T”, structural practices such as terraces are necessary. Finally, about 1 million acres may need conversion to less intensive land uses such as pasture or forest crops to reduce soil loss to tolerable levels.

Illinois has about 100,000 farm operating units. Owners farm approximately 40 percent of farmland, but much is professionally managed for trusts and investors.

CONSERVATION DISTRICTS

Illinois has 98 Soil and Water Conservation Districts (SWCD) generally set up on county boundary lines. The State Water Quality Management Plan assigned districts the primary responsibility for reducing nonpoint source sediment pollution. Districts develop rapport and working partnerships with land operators through (1) resource information and education; (2) technical assistance, (3) incentives, (4) recognition, and (5) evaluation based on mutually developed goals.

Districts work cooperatively with many other conservation agencies to achieve their natural resource management objectives, but primary support comes from the Illinois Department of Agriculture and the U.S. Department of Agriculture (Fig. 1). The Soil Conservation Service pro-
Figure 1.—Soil and Water Conservation District (SWCD) and Association of Illinois Soil and Water Conservation District (AISWCD) Organizational Chart.

Figure 2.—Illinois watershed selection and implementation process.
provides technical assistance. The Agricultural Stabilization and Conservation Service (ASCS) provides farmer incentives, and the Cooperative Extension Service develops educational programs. District employees provide technical assistance, information programs, and demonstrations. By next year we hope to have about 200 SWCD employees: at least one resource conservationist and a secretary in each SWCD office.

District directors are direct links to the most important part of the system—land operators. Illinois district directors contribute over a million dollars in time each year. Since districts do not have taxing authority, directors are frequently searching out funds. As in other States, districts have organized themselves into councils and a State association, which helps develop a consensus on regional and State conservation issues. The association emphasizes an action program of assisting SWCD's to develop local watershed projects. Over 30 local watershed projects with a variety of funding mechanisms are now operating. Many projects have local funds. A State watershed selection committee reviews projects for possible applications of State or Federal funds (Fig. 2). All projects are geared to meet the SWCD soil erosion standards in specific watersheds above affected waterbodies.

The districts' arrangements with numerous agencies and organizations are complex, but in Illinois the soil erosion control standards help to unite the conservation family and give it direction and a measurable goal. SWCD's have significantly improved water quality and reduced sediment through targeting lake watersheds.

**ILLINOIS SOIL AND WATER CONSERVATION DISTRICTS SOIL EROSION AND SEDIMENT CONTROL STANDARDS**

Goals were adopted and endorsed on the State level through the water quality management planning process.

![Figure 4.-Complaint process](image)

**WATER QUALITY CRITERIA AND STANDARDS**

Figure 3.—Schedule for Illinois Soil and Water Conservation Districts' Soil Erosion and Sedimentation Control Program and Standards.

(Fig. 3). The State goal is to reduce the average annual erosion rate on agricultural land to or below the "tolerable" soil loss or "T" for that soil type by the year 2000. "T" is based on maintaining long term agricultural productivity. Normally 3 to 5 tons of soil/acre/year, on certain fragile soils it is only 1 ton/acre/year. Average soil loss is measured by the Universal Soil Loss Equation (USLE). The standards are progressively more stringent. Till 1988 soil loss should be under 4 "T." To comply after 1988, the goal will be 2 "T": on slopes greater than 5 percent and "T" on less than 5 percent slopes. By 1994 soil loss should be under 1.5 "T." Farm conservation planning is aimed at the year 2000 goal of being at or under "T."

As mandated, all 98 SWCD's adopted the state guidelines as their standards by the 1983 deadline. Sixteen districts adopted more stringent standards. Wisconsin, Minnesota, Ohio, and Indiana are considering similar standards or already have them.

A complaint program was adopted with the district standards for offsite problems caused by agricultural soil erosion (Fig. 4). Anyone can file a complaint. The SWCD notifies the land operator, investigates to determine compliance with the standard and assists the land operator to
develop a schedule of compliance and implement it. If a violation goes unattended for a year, the district and the Illinois Department of Agriculture can conduct hearings. If there is still a violation the case may be referred to the Illinois Pollution Control Board. The combined forces of reason, public opinion, and cost sharing have resulted in no outstanding violations. Of 73 complaints filed to date, 47 were found out of compliance with the district standards. In all cases the landowners entered into a compliance schedule.

A State cost share program for addressing complaints started with a modest $50,000 in FY 1984 and remained the same in FY 1985. Some friendly complaints were filed to help secure cost sharing. Road commissioners also filed a number of complaints. The complaint fund will probably be doubled in FY 1986 and a $4 million "Build Illinois" cost share program for structural conservation practices will probably be enacted. This program was based partly on the success of and interest generated by the complaint program, but primarily on the districts’ documentation of their needs to meet their standards.

**USEFULNESS OF STANDARDS**

To understand the usefulness of the soil erosion control standards, three levels must be considered: the landowner or local level, the county office, and the State offices.

First, if the land operators did not judge the standards useful they would likely fail. Farmers must make a profit. A soil erosion standard based on productivity encourages the land operator to maintain his land’s productivity and profitability. Saving soil is in the land operator’s best interest.

The land operator also knows that a conservationist was present and actually measured slope and calculated the USLE, which gives these standards more credibility. Using an Illinois Extension publication, #1200, the land operator can measure and verify his own soil loss. The standards and compliance schedules also provide a reasonable period for land users to develop management skills in new soil saving methods such as conservation tillage.

For those landowners affected by sedimentation, the standards and complaint program is a reasonable process for solving a problem beyond their control. Many complaints have been filed by neighboring farmers. The complaints and their documentation emphasize the offsite benefits and the public role in finding and funding solutions. An example of a cooperative program for reducing soil loss to tolerable levels above a lake watershed is found in Jo Daviess County. The Apple Canyon Lake Homeowners Association worked cooperatively with landowners, the Jo Daviess District, and USDA agencies and provided $25,000 to help install conservation practices above the lake.

At the county office level, soil erosion standards are extremely useful. District evaluations, staffing, work plans, and priority area designations are based on the districts’ standards. The documentation of their needs to meet "T" by 2000 was crucial in the development of the Build Illinois program.

The soil erosion standards provide a definable goal to county level soil conservationists when assisting land operators with conservation planning. Conservationists also document their work based on meeting their district’s standards. With a productivity based standard they also have a more marketable program and a higher potential for land user’s acceptance.

County and State level information programs have successfully built an understanding and popularity of "T" information programs virtually always mention the county standards. Agribusiness frequently mention soil conservation standards in promoting their products and services. "T farming is for our kids" is a popular bumper sticker. Many other "T by 2000" promotional items have been produced by districts.

County and State educational programs emphasize the Universal Soil Loss Equation, conservation tillage, and maintaining production while practicing conservation farming. Numerous slide, newsletter, and news column presentations reference the standards.

Lake watershed projects’ land treatment goals are typically based on reaching "T" standards. To reduce sedimentation to desired levels in some lakes, standards less than "T" sediment retention structures, or shoreline erosion practices may be needed. At the State level, the standards are integrated with the reporting and allocation systems. The Illinois Department of Agriculture allocates State funds for conservation districts based on staff productivity in meeting "T" goals, land not meeting "T", and other factors. State training programs for SWCD directors and annual conferences aim at meeting "T" goals. State cost share funds allocations are based in part on land with soil losses greater than "T". All State agencies were ordered by Governor Thompson to bring soil loss to these standards on land they control.

For the Illinois Environmental Protection Agency, the agricultural soil erosion control standards foster cooperation with the agricultural community. The standards have helped put a greater emphasis on critical area treatment and have helped direct Federal funds to water quality problem areas. The standards have helped various State groups to come together through participation in each other’s decisionmaking processes.

Federal agencies, too, utilize the "T" goal. All SCS conservation planning is based on meeting "T" goals. ASCS utilizes "T" goal data in allocating funds and setting priorities for special projects.

"T" standards and specifically the "T by 2000" goals have permeated the entire soil and water conservation and nonpoint source water quality programs in Illinois. Everyone benefits from clean water, navigable waterways, and the maintenance of productive farmland. Agencies have designed their programs to help SWCD meet their standards. Excellent cooperation and hard work by the conservation family have helped districts increase the probability of meeting their soil erosion standards.

**ON THE HORIZON**

Anticipating problems and adjusting programs to meet them are basic tenets of management. The easiest problems, however, have already been solved. The widespread adoption of conservation tillage has helped a great deal. The bulk of the additional reductions in soil conservation will require construction practices and difficult land use conversions. Districts and the Illinois Department of Agriculture have a plan but completing it will require about $1 billion for enduring conservation practices, 200 additional technical staff, and 70 additional educational staff. That plan’s achievement will depend on citizens recognition of benefits.

Another key concern is the documentation of improved water quality. Since the "T by 2000" agricultural standard is now well established, the Illinois Environmental Protection Agency will be reemphasizing water quality rather than soil loss.

As farmers bring their farms closer to "T," it will be increasingly more difficult to sell farmers on conservation practices. A 5 ton/acre soil loss amounts to only about 0.03 inch of topsoil evenly spread over the field. This is
almost invisible even to the farmer. Farmers can see the gullies and rills associated with 4 "T" fields, but considera-
ibly more education and promotion will be needed to get to the much less visible "T" level.

Finally, flexibility to changing market conditions and technologies is required. Research efforts must be aimed at improving water quality and maintaining soil productivity while improving farm profitability.
GROUND WATER QUALITY STANDARDS

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ABSTRACT

Contaminated ground water is difficult, if not impossible to restore. Water quality standards do not protect this resource, but they should serve as the basis for a program preventing contamination. In Nebraska, where ground water use as a drinking water supply is even higher than the national average, standards and regulations are being revised to support each other as part of a more comprehensive water protection program. New standards are being written, where needed, under a Standards Implementation Strategy that identifies existing gaps in data needed to draw up better standards.

In discussing the approach we use in Nebraska to refine ground water quality standards, I will not examine criteria for contaminants or the rationales behind them. Instead I will focus on institutional arrangements and policies we are using to protect ground water.

Obviously ground water is an extremely important resource throughout the United States. It is reported that ground water constitutes more than 96 percent of all fresh water in the United States. It supplies 50 percent of the U.S. population with drinking water. It is used by 95 percent of the rural population as a potable supply. Principal uses of ground water are irrigation, public drinking water, and industry.

Statistics for Nebraska show an even greater reliance on ground water. Only two communities within the State rely solely on surface water instead of ground water as a drinking water source. Nebraska ranks third nationally in total ground water use, behind California and Texas, and trails only California in ground water used for agricultural purposes. On a per capita basis, this ranking is even higher.

We have relied upon ground water for generations with little thought to the possibility of exhausting the supply or contaminating this resource. Many people have believed that ground water is a nearly pristine resource insulated from contamination.

We are becoming more aware, almost on a daily basis, of ground water contamination and resulting use impairments. For instance, on the national level, reportedly 8,000 private, public, and industrial wells have been closed or in some way affected by contamination.

In Nebraska, we are aware of 136 ground water contamination sites, most of which have been identified by our Department of Health in its monitoring of municipal wells. Synthetic organic compounds (SOC's) have been detected in 10 public drinking water supplies. Nitrate–nitrogen levels have been identified to excess of maximum contaminant levels (10 ppm) in 86 public water supplies and numerous private wells. Thirty-seven communities within Nebraska have taken corrective action to alleviate nitrate problems, involving in most cases relocating the water supply at considerable expense.

Sources of contamination in Nebraska are similar to those identified nationally. Among the most likely sources in Nebraska are agricultural chemicals (pesticides and fertilizers), waste treatment sites and waste disposal sites, chemical and fuel storage facilities, improperly constructed or abandoned water wells and test holes, industrial facilities, and accidents along transportation corridors.

Most of the sources I have just listed would by definition fall into the point source category. However, the most widespread contaminant in the State is nitrate–nitrogen. Nitrates can originate from both point and nonpoint sources. However, in several large areas throughout Nebraska nitrates appear to come primarily from nonpoint sources (agriculture-related activities).

Although we in Nebraska certainly do not claim to have all of the answers, through the past 4 years the Department of Environmental Control, other agencies, and consultants have dedicated a great deal of thought and effort to the issue of ground water quality protection and the development of our strategy.

The goal of ground water quality standards, as we perceive it, is to protect ground water quality for actual and attainable uses. This protection should be prevention-oriented. Contaminated ground water is difficult, in some cases impossible, to restore to original baseline conditions. Add to this the economic constraints to restoration, and it becomes apparent that prevention is the best option if existing quality is to be maintained for future generations.

Standards, in and of themselves, do not provide any protection to the resource; however, they should serve as the foundation on which preventive programming is based. For this reason we believe strong, well-defined, and comprehensive ground water standards are the hub for developing effective pollution prevention programs.

Nebraska has had standards for ground water quality in effect since 1978. They have remained unaltered since then and, quite frankly, have not been used to the extent necessary to protect aquifers. The lack of use does not reflect lack of initiative by our Department, but rather the very general and nondescriptive manner in which the standards are written. The existing standards were a good first step and have allowed for some protection and enforcement in cases where gaps existed among program authorities.

Basically, our existing standards consist of an antidegradation policy. Uses for aquifers have not been identified, and the specific criteria stated within the standards are based upon human health. These standards contain both general criteria and numeric criteria along with a reporting requirement. The list of constituents for which specific criteria have been established is not particularly comprehensive.

We are presently involved in reviewing the standards and intend to complete these revisions by the end of this calendar year. We now believe that this will involve a major renovation of existing standards.

Three primary objectives that have been developed to guide our efforts reflect our philosophy toward the use of standards in protecting ground water quality. The objectives determine standards as:

1. A guide for program development (that is, reflect sensitive areas and serve as a basis for program regulations and permit limits);
2. A mechanism for identifying problems, triggering enforcement action, and prioritizing planning activities; and
3. The yardstick for measuring cleanup needs and restoration levels.

Our philosophy in developing new standards to meet these objectives focuses on two premises. First, if standards are to guide program development, the criteria established within them should apply to the programs and must be easily translated into program specifications (for example, permit limits, monitoring requirements, and so on). Secondly, standards should be enforceable in and of themselves, although the most effective enforcement will result when standards are used to trigger regulatory activities in programs involving fuel and chemical storage, underground injection, chemigation, pesticide management, municipal and industrial lagoons, septic tanks, solid waste disposal sites, and agricultural management practices, to name a few.

Many of the program areas already have regulations in place. However, within the past 4 years we have identified numerous program deficiencies within and between existing State and Federal programs. We are proposing modification in several areas of deficiency and new program development in others. We believe it is paramount, as a first step, to establish well-defined standards to guide these program modifications and developments.

Some specific areas of the standards that will be developed on a statewide basis include:
1. Ground water area delineations based upon existing and potential uses.
2. Use designation for each ground water, including classes within some use designations (for example, drinking water).
3. Maximum contamination levels for probable contaminants.
4. Triggering or trend criteria on the most probable contaminants: planning, monitoring and compliance activities will be initiated.
5. Reporting and liability clause.
7. Implementation mechanism for the antidegradation clause (Continuing Planning Process (CPP) document).
8. Narrative criteria for less probable or new contaminants.
9. Implementation mechanism for transfer from narrative criteria to numeric criteria (CPP document).
10. Restoration policy and a protocol for cleanup and restoration decisions (CPP document).

The fact that we do not have ground water quality data from many areas of Nebraska and also lack data on environmental fates and chronic health effects limits a comprehensive and well-defined coverage of many components of the standards. With this understanding, we will therefore be identifying data gaps and developing a standards implementation strategy concurrent with our revision activities. This strategy will plot a course for establishing the data necessary to further refine standards. We anticipate this will be a multiyear implementation schedule.

Obviously, protecting our ground water is a major concern in Nebraska. Our approach to standards is to make them a more useful tool in preventing ground water contamination.