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INSTREAM FLOW NEEDS FOR WATER QUALITY MANAGEMENT

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The Department of Environmental Control (DEC) was established by legislative action with passage of the Nebraska Environmental Protection Act in 1971. This legislation gave broad powers to the department directing the development of comprehensive programs for the prevention, control, and abatement of new or existing pollution of the air, waters, and land of the state. This authority is further spelled out by statute with regard to development of control programs, water quality standards, and wastewater treatment criteria.

The water pollution abatement programs administered by DEC are based primarily on two basic sets of regulations, Water Quality Standards and National Pollutant Discharge Elimination System (NPDES) Rules and Regulations. The primary purpose of the Water Quality Standards is to protect the public health and welfare. These standards are applicable to all waters of the state, flowing or impounded. The general criteria in the standards cover aesthetic conditions; suspended, colloidal, or settleable solids; oil and grease; and chlorides. The general criteria are applied statewide regardless of the water body.

In addition to the general criteria, the standards contain specific numeric criteria. These criteria are established on a segment-by-segment basis in each of the thirteen river basins in Nebraska. Limits are established for dissolved oxygen, conductivity, total dissolved solids, and ammonia and fecal coliforms, dependent upon the assigned beneficial use of a given segment in a basin. These limits are based on background data from stream monitoring and Environmental Protection Agency (EPA) approved water quality criteria. Limits are established in a manner which protects high quality streams by establishing more rigid limits, while streams of lesser quality have lower but still protective limits as dictated by the EPA-established criteria.

The Rules and Regulations established pursuant to the NPDES set up effluent limitations for a wide range of municipal and industrial discharges. The limits established under the NPDES system are based on current treatment technology and

have as a goal zero discharge of pollutants by 1985. In Nebraska the majority of NPDES permits issued to dischargers have been based on these technology-based effluent limits. These limits do not take into consideration the water quality of the receiving stream; however, the department has required more stringent effluent limitations based on water quality standards where the effluent limits are not adequate to protect instream water quality.

Effluent limitations based on water quality standards bring a completely new set of problems into play when the wastewater facilities are designed. Treatment technology has practical limits with respect to pollutant removal capabilities. Treatment above and beyond 95 percent removal often becomes quite difficult to maintain and results in a considerable increase in cost for construction, operation, and maintenance. Capital expenditures for municipal treatment systems in Nebraska in the past ten years exceeded \$177 million. These costs could be much higher if facilities are required to provide more advanced treatment due to instream water quality problems.

In these cases, when wastewater facilities must meet more stringent effluent limitations, the underlying problem is often related to water availability in the receiving stream. Lower than normal flows result in a decrease in the assimilative capacity of the receiving water, thereby resulting in real or potential water quality problems. For some facilities the solution to the problem is construction of a complete retention lagoon system. This, of course, meets the goal of zero discharge of pollutants; however, it also eliminates a source of water to the stream. In some cases, adequately treated wastewater provides a benefit by augmenting flow. For this reason the department recommends that, where possible, maximum recycling and recovery of water and wastewater components should be our ultimate goal, rather than zero pollutant discharge. In this regard, complete retention facilities can be developed which utilize the wastewater resource through irrigation or other methods, rather than relying solely on evaporation for treatment.

The need for advanced treatment due to instream conditions is not restricted to municipal discharges. Industrial effluent limitations are in general more stringent than the municipal limitations, due to the different categories of pollutants discharged.

The wastewater facility at the Spencer Food Plant in Schuyler, Nebraska, is a good example of a water quality program to provide advanced treatment because of low instream flows. Spencer Foods is a beef processing plant with a daily kill capacity of about 2,500 head. Wastewater treatment consists of three parallel anaerobic lagoons, a mechanically aerated activated sludge system, and two large series-operated polishing lagoons. The facility has an average discharge of 2.0 MGD. The discharge flows to Shonka Ditch, then to Lost Creek. The water flows in Shonka Ditch and Lost Creek are regulated by discharges from the Loup Power Canal. Flows in Lost Creek vary from 1.4 cfs to over 100 cfs throughout the year. The annual mean discharge is approximately 23 cfs or 14.8 MGD.

Technology-based effluent limitations on ammonia discharge for meat processing facilities are calculated on the number and pounds of beef killed per day. These limits would allow for a daily maximum ammonia discharge of 320 pounds (145 kg) for the Spencer Food Plant. This effluent limitation was not totally adequate in providing for protection of instream water quality in Lost Creek.

In order to assure compliance with Nebraska Water Quality Standards, a more stringent effluent limitation was necessary. The limitation would be affected by the daily kill and also the receiving water flow. It was determined that the applicable Water Quality Standards should be met at that point in Lost Creek where it is crossed by the Highway 15 bridge. This would provide for the mixing zone required in Water Quality Standards applications.

The NPDES permit for this facility now contains the following formula to be used in determining the maximum pounds per day of discharge limitation for the Spencer Food Plant:

$$Y = 5.38 \cdot V \cdot X \quad \text{Where}$$

Y = The allowable pounds of ammonia per day

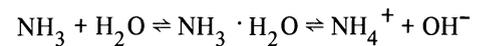
V = Allowable concentration of total ammonia for a specific temperature and pH in Lost Creek*

X = Flow in Lost Creek in cubic feet per second at the Highway 15 bridge

*Based on Thurston's *Aqueous Ammonia Equilibrium Calculations*.

The above-referenced formula provides a method calculating an effluent limit for the discharge pipe that will protect the water quality in Lost Creek as specified in the Nebraska Water Quality Standards.

Thurston's equations are an important part of the calculations necessary in applying the NPDES permit formula. The equation allows calculations of the allowable total ammonia concentration in an aqueous solution of specified pH and temperature which will result in an un-ionized ammonia concentration of less than 0.025 mg/l. The toxicity of an aqueous solution of ammonia is attributed to the un-ionized ammonia. Ammonia solutions have a chemical equilibrium, in which un-ionized ammonia exists in equilibrium with the ammonium ion and the hydroxide ion. The equilibrium can be expressed as follows:



The concentration of NH_3 and, therefore, the toxicity of an aqueous ammonia solution, is dependent upon a number of factors in addition to total ammonia concentration. However, temperature and pH are the most important factors.

To assure permit limit compliance, NPDES monitoring for this facility requires not only effluent sampling but also sampling in Lost Creek at the Highway 15 bridge. Daily discharge limitations are dependent upon instream water quality considerations rather than solely on technology-based limits. The temperature, pH, and flow in Lost Creek do not dictate the effluent limitations. In this manner DEC and the permittee are capable of maintaining the un-ionized ammonia below the 0.025 mg/l water quality criterion established by the United States Environmental Protection Agency.

Meeting these more stringent requirements requires considerable expenditure of time to assure that proper operational and maintenance practices are followed. Two situations become extremely important in regard to effluent quality for this facility: cold weather and instream flows in Lost Creek. The nitrification process within the treatment plant does not do an adequate job of ammonia removal until cold weather, at which time the process stops. When this happens, the plant's discharge is shut off, and wastewater is stored in lagoons until such time as nitrification commences again with warmer water.

The other major problem over which the facility has no control is instream flows in Lost Creek and Shonka Ditch. Decreased flows result in lowering the assimilative capacity of the stream. Should this happen when the storage capacity of the facility is exceeded and discharging becomes necessary, instream water quality may suffer, resulting in potential legal action against the dischargers.

With these considerations in mind, we can see that the

treatment facility must cope with numerous potential restrictions in providing an acceptable effluent. Effluent limitations based on water quality standards could be placed on other facilities should instream flows be reduced. Modifications to stream channels, groundwater withdrawal, surface water diversion, seasonal flow changes, nonpoint and point source discharges all contribute to the water usage/water quality problem and must be addressed in established pollution control programs.

It seems evident that water quantity and water quality programs are dependent upon each other and must be administered in a complementary fashion if we are to meet the state's water pollution abatement goals. A greater emphasis on a combined approach may be forthcoming as the state develops a more complete water policy. The state legislature has established a work group to review existing water planning and policy and to make recommendations on any needed modification or addition to existing policy.

This work group is to develop management policies that are in the best interests of the people of the state. Among the problems to be discussed are the questions involving water usage and the environmental and economic needs of the state. It is obvious that the problems facing the state in this respect are complex. Future developments in water policy and planning strategies will be extremely important to all municipal and industrial discharges in the state. Problems similar to those related herein may be eliminated in the future through a sound water planning program.