fluent forecast in 1980 is estimated at more than 100,000 cu m (80,000 acre-ft) per year, and 175,000 cu m (140,000 acre-ft) in the year 2000.

The sewage-reclamation recharge project was conceived to solve both environmental hazards and water-resources management problems and consists of 2 phases, sewage reclamation and recharge of the reclaimed sewage.

The project provides for treatment of the sewage in a series of oxidation ponds and pumping to nearby spreading grounds after detention in the terminal pond. Recharge operations will begin in 1973 with the recharge of 7,500 cu m/year; the scope of these operations is to be stepped up gradually to reach 50,000 cu m by 1980. The spreading grounds cover an area of 250 acres and are about 0.7 mi from the oxidation ponds.

The area occupied by the spreading grounds consists of sand dunes, overlying, for the most part, calcareous sandstones. These formations constitute the main aquifer of the region. The reclaimed sewage will be spread alternately to allow the grounds to be dried and cultivated between recharge operations in order to remove the surficial crust and increase infiltration. It is estimated that the rate of percolation will be about 6 in./day.

An array of 30 production wells—drilled for the specific purpose of exploiting the recharged water—surrounds the spreading grounds at a distance of 0.3 mi from its perimeter. The quality of the recharged water is satisfactory from the content of nitrogen compounds (less than 10 ppm), phosphates (less than 1 ppm), and bacteria and virus. As an additional precaution, the water will be held in the subsurface for a period of 400 days, during which it will undergo natural filtration and mixing with existing groundwater. Furthermore, the recharge operations will allow regulation of supply and demand according to existing conditions.

Following its subsurface movement and mixing, the reclaimed water will be pumped and conveyed to the National Water Carrier for transfer to the southern area of the country for supplementing irrigation requirements.

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Hydrogeologic and Economic Factors in Decision Making Under Uncertainty for Normative Subsurface Disposal of Fluid Wastes, Northern Williston Basin, Saskatchewan, Canada

The normative subsurface waste-disposal condition of no hazard to population, coupled with optimum allocation of drilling funds, can be achieved best through search for primary and alternative disposal formations by evaluation of hydrogeologic data on a basinwide scale. Any decision to drill a disposal well in Saskatchewan is made under considerable uncertainty, which is a reflection of the present reconnaissance level of subsurface information.

Subsurface disposal of fluid wastes in the Williston basin region is largely restricted to sandstone and carbonate aquifers (Cambrian through Lower Cretaceous) of the Saskatchewan-Manitoba tectonic shelf: (1) oil-field brines (at rates of the order of 15 gpm); (2) waste brines from exploitation of Devonian potash deposits (up to 750 gpm); (3) waste brines from solution mining of LPG-storage caverns in Devonian halite (up to 300 gpm); (4) refinery sour water and spent caustic (up to 20 gpm); and (5) chlor-alkali-plant wastes (up to 15 gpm), partly associated with previously injected herbicide wastes.

Hydrogeologic constraints on development of subsurface waste-disposal systems, not related to reservoir quality of disposal formations but likely to influence waste migration, are (1) proximity of the outcrop belt on the north and east, (2) pre-Cretaceous valley systems controlling development of fluvial channels up to the present, (3) sinks formed through localized solution of Paleozoic halite, and (4) positive basement features and related overlying structures.

Estimated ultimate capital investments for existing Saskatchewan injection systems range from $20,000 to $100,000 in the oil fields, to more than $300,000 for some potash-brine disposal wells, and are determined largely by depth of disposal formation, drilling technique, and well design. Potash-brine disposal wells in the vicinity of shaft mines include the most costly and refined systems, and involve directional drilling to formations below the potash unit and mud programs employing fluids compatible with evaporite minerals.

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Role of Bacteria in Decomposition of Injected Liquid Waste at Wilmington, North Carolina

In 1968, Hercules Chemical, Inc., Wilmington, North Carolina, began injecting organic waste through wells into a saline-disposal zone at depths of 850–1,000 ft. The waste, which is a by-product of dimethyl terephthalate used in the production of synthetic fiber, is composed of water, with a pH of about 4.0, containing approximately 15,000 ppm acetic acid, 5,000 ppm formic acid, and 500 ppm methanol.

The movement and composition of the transformed waste have been monitored by a network of 14 observation wells drilled to various depths. The waste-water analysis and monitoring were performed by the U.S. Geological Survey.

In June 1972, waste was detected in observation well 14. The microbial population was periodically sampled as the dissolved organic carbon fraction increased. The dissolved organic content increased to 112 mg/l, and then rapidly decreased to 20 mg/l. This sudden decrease in dissolved organic carbon was accompanied by the appearance of gas composed of approximately 60% methane. Each time a decrease in dissolved organic carbon occurred, gas was found and an increase in the total microbial population was measured.

Methane gas production is the result of microbial activity. The injected waste contains adequate carbon and energy substrates for the strictly anaerobic, methane-producing bacteria which have been isolated from well 14. In addition to the methane-producing bacteria, other bacteria have been isolated and identified. Microorganisms such as *Agrobacterium*, *Pseudomonas* (especially species *fluorescens*), *Proteus*, *Bacillus*, *Arthrobacter*, *Aerobacter*, *Corynebacterium*, and *Staphylococcus* have been observed. The total microbial population was found to be 25×10^6 organisms per milliliter in well 14 and 30×10^8 organisms per milliliter in the unpolluted aquifer. The source of these bacteria is the natural aquifer, inasmuch as the injected waste is sterile. The waste alone does not support a microbial population for it contains no nitrogen. Such nitrogen substrate is apparently supplied by the natural water in the aquifer.