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RADIOLOGICAL IMPACT OF HANFORD
WASTE DISPOSAL ON GROUNDWATER QUALITY

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ABSTRACT

Since the startup of the Hanford plant over 25 years ago, large volumes of liquids containing low concentrations of radioactivity have been discharged to ground disposal sites in the Chemical Separations Areas. These disposal sites are located on a plateau in the Hanford project interior, about 12-15 miles up-gradient from the nearest domestic water source. An extensive groundwater surveillance program has been maintained since the startup of the Hanford plant.

It is the purpose of this paper to describe the groundwater monitoring program and to show the impact of radioactive waste disposal on the groundwater beneath the Hanford plant. Gross beta activity (primarily $^{106}\text{Ru-Rh}$) concentrations in the groundwater during the last five years are reviewed. It will be seen that in recent years, the geographical distribution of this activity has become fairly stationary and that after many years of discharging liquid effluents to ground, the gross beta activity concentrations are decreasing.

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INTRODUCTION

An extensive groundwater surveillance program has been conducted at Hanford since plant startup more than 25 years ago. One of the objectives of this program is to monitor the movement of liquids containing low concentrations of radioactivity through the soil beneath the Hanford plant. A major portion of the surveillance program consists of the collection and analysis of water samples from numerous wells which have been drilled for this purpose. A fair portion of the sampling effort is devoted to wells adjacent to disposal sites on the Chemical Separations Area plateau. These disposal sites receive carefully controlled discharges of liquids containing low concentrations of radioactivity and utilize the favorable ion exchange capacity of the tall soil column beneath them. ~~In addition,~~ there are no domestic water supplies closer than 12 miles to the disposal sites. This paper describes groundwater surveillance techniques and the impact of radioactive waste disposal on the groundwater beneath the Hanford plant.

GROUNDWATER SURVEILLANCE TECHNIQUES

Over 1300 wells have been constructed on the Hanford project area. Some of the wells were constructed originally to provide sanitary water for outlying installations (such as U. S. Army facilities); others were drilled to permit surveillance of groundwater in the vicinity of waste disposal facilities, and still others were drilled to obtain data for a geologic survey of the region. The distribution of wells on the Hanford project is shown in Figure 1. About 200 to 300 of these wells are used for routine surveillance of radionuclide

migration in the groundwater flow system. Most of the wells appearing in Figure 1 have steel casing and are 8 inches in diameter. The notation "well to basalt" indicates a well which has been drilled down to the basalt bedrock which lies beneath the unconsolidated and semi-consolidated sediments. The notation "well with piezometers" indicates those wells in which several smaller diameter tubes have been sealed at different depths below the regional water table for the purpose of obtaining water samples.

In order to keep abreast of the status of the groundwater, samples are collected on a frequency which varies from monthly to quarterly, depending on the location of the well with respect to the groundwater flow system. Most wells are sampled by lowering a small stainless steel cage containing a one-liter glass jar into the well, a technique termed "bailing." Some wells containing piezometer tubes are also sampled by bailing; however, this is accomplished with a smaller diameter sampling apparatus. Other piezometer tubes are sampled by the "air-lift" method; that is, compressed air is injected into the piezometer tube (near the bottom), forcing the water out of the top of the tube.

Routine maintenance of the groundwater monitoring wells is required. Some wells require the removal of accumulated sand and silt, while others require added perforations in the well casing, especially in areas where the water table elevation has fluctuated significantly with time. Such changes in the water table elevation could result in a well containing relatively stagnant water or perhaps no water at all. In deep wells which penetrate more than one aquifer, piezometer tubes are placed in the well and are sealed in a manner that will permit sampling a specific aquifer. Considerable care and attention

is taken to assure that the tubes are isolated from each other.] One of the prime concerns in sampling, not specifically related to the well structure, is avoiding the introduction of radionuclides to the water to be sampled by the sampling apparatus itself. Several categories of bailers, based on the recent history of radionuclide concentrations, have been established so that this type of sample bias is virtually eliminated.

Samples collected by the methods just mentioned are generally analyzed for total beta, tritium, and nitrate ion concentrations. Groundwater samples collected adjacent to disposal sites are analyzed for several additional radionuclides which may be present in the water discharged to disposal site. The total beta activity is calculated as Ru-106, since radiochemical analyses have shown that this radionuclide accounts for a major fraction of the radioactivity detected by a total beta analysis. Periodic analyses have shown that Ru-106 (and its daughter, Rh-106) account for 60 to 90 percent of the radioactivity measured in a total beta analysis, ~~with the remainder due to Te-99 and Co-60.~~ ^{and} Ruthenium-106 also has the lowest Concentration Guide of the radionuclides present. The more radiotoxic nuclides, such as Sr-90 and Cs-137, ~~The remainder of the beta activity is due to Te-99 and Co-60.~~ are tightly held by soil minerals and have only been detected in the groundwater intermittently in the immediate vicinity of a few disposal sites.

ANALYSIS OF GROUNDWATER SURVEILLANCE DATA

In the analysis of groundwater surveillance data, Ru-106 concentrations for each well are studied immediately after they are furnished by the laboratory and are then averaged on a six-month basis. The average concentrations are

then compared with the Concentration Guide (formerly called the Maximum Permissible Concentration) as ^{listed in} defined by the Atomic Energy Commission ~~(AEC)~~ ⁽¹⁾ ~~Health~~ ^{and Safety} Manual for Ru-106 (10 pCi/ml). It is recognized that these guides are intended only for drinking water, and at present no groundwater from zones having detectable Ru-106 concentrations serves as a drinking water supply. The Concentration Guides, however, do provide a rapid, meaningful method of evaluating the potential significance of many water-borne radionuclides. After the data are expressed as a percent of the Concentration Guide, they are plotted as shown in Figure 2.

Ruthenium-106 concentration data are shown here for the period from July--December 1970⁽²⁾ for levels corresponding to 2--10, 10--100, and >100 percent of the Concentration Guide. Two zones of detectable Ru-106 concentrations can be distinguished; both of which represent effluents from the Chemical Separations Areas. The larger of the two plumes (defined by concentration contours) originating from the Chemical Separations Areas--the one bounded by the large rectangle--is the subject of the remainder of this presentation.

Changes in the ruthenium-106 concentration contours with time are shown in Figure 3. The boundary of the concentration contour for each year corresponds to 2 percent of the Concentration Guide. The particular years shown here were selected for specific reasons. The year 1961⁽³⁾ represents a period when the plume was in its early growth stage. The year 1967⁽⁴⁾ represents the maximum geographical spread of the Ru-106 concentration contour, while 1970⁽²⁾ represents the current definition of this contour.

The boundaries shown in this figure are not meant to indicate that no radioactivity is present outside them. It is possible that some radionuclides may in fact reach the Columbia River, but because of dilution by the natural groundwater flow and because of decay due to the long transit time through the soil, the concentrations in the groundwater and in the river are too low to be measured by the sophisticated radiochemical techniques in routine use.

The current data suggest that the concentration contour is receding, and indeed this appears to be the case. To illustrate this point, let us look at the behavior with time of the Ru-106 concentrations in three wells on the approximate centerline of the contour--34-39A, 31-31, and 26-15.

Figure 4 shows a history of the radioactivity discharged to ground disposal sites and the concentrations in three wells down-gradient from these sites. The data shown in the upper half of this figure apply to 200-East Area disposal sites which were in active use during the past 15 years. The numbers in parentheses shown in the lower half of this figure following the well numbers are the distances in miles from each well to the disposal site area.

Several comparisons might be made between the radioactivity discharged to ground and the concentrations in the three wells in order to visualize the radionuclide travel times for portions of the groundwater flow network. The peak concentrations observed in 1959 in wells 34-39A and 31-31 and in 1962-63 in well 26-15 probably correspond to the peak in the discharge curve in 1957. Similarly, the peak concentrations observed in 1964 in wells 34-39A and 31-31 and in 1967 in well 26-15 probably correspond to the peak in the discharge curve in 1962.

Sophisticated mathematical modelling of Hanford's groundwater flow ^{system}~~network~~, incorporating digital computer solution, has been done in recent years. (5, 6).

The groundwater sampling program has provided both input parameter and verification data for this model. Travel time estimates obtained by use of the digital model correlate well with the radionuclide behavioral characteristics shown in the previous two figures.

CONCLUSIONS

In conclusion, we have seen that after many years of discharging effluents to ground, ruthenium-106 has migrated from the disposal sites, but this migration has not reached the Columbia River ^{in detectable concentrations} and is, in fact, diminishing at the present time.

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WELL LOCATIONS

HANFORD PROJECT

CHANGES IN $^{106}\text{Ru-Rh}$ PLUME WITH TIME

GROUND WATER CONCENTRATIONS VS. RADIOACTIVITY DISCHARGED