CHEMICAL EFFLUENTS TECHNOLOGY WASTE DISPOSAL INVESTIGATIONS

JULY-DECEMBER, 1963 --

THE MOVEMENT OF CONTAMINATED GROUND WATER FROM THE 200 AREAS TO THE COLUMBIA RIVER

By

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INTRODUCTION

The Chemical Effluents Technology Operation performs research to investigate the chemical and physical aspects of environmental contamination resulting from the disposal of plant effluents or from potential process incidents. This is a semiannual report, published to give the latest information on the status of contamination in the ground water arising from waste disposal operations in the 200 Areas. The preceding report in this series is HW-78951.

This report differs somewhat from previous ones in that in addition to summarizing the present status of ground-water contamination, it also presents current information relative to the travel time of radiocontaminants, Ru^{106} and H^3 in particular, between the 200 Areas and the Columbia River.

The results of the continuing ground-water monitoring program have provided one basis for assessing the safeness of waste management practices in the Chemical Processing Department. Earlier estimates of ground-water travel time from the 200 Areas to the Columbia River were based on a limited amount of monitoring data, pumping tests and tracer studies[1-6]. As more of these observations were made, refinements in the travel time estimates were also made. Current estimates of travel time are based primarily on the appearance time of

gross beta-emitters (Ru^{106}- Rh^{106}) and fission product tritium in monitoring wells located at various distances from liquid waste disposal sites. Tritium monitoring of the regional ground water was initiated relatively recently, 1961; therefore, less information is available relating to the progressive development of tritium contamination patterns than for the gross beta patterns. Monitoring results from several opportunely-located wells and the comparative results of laboratory soil column tests do provide, however, a fairly firm basis for determining the relative movement rates of these two radionuclides in soil-water systems.

The object of this report is twofold: 1) information is presented relating to the data and methods used in arriving at reliable radionuclide travel time estimates from the 200 Areas, 200 East Area in particular, to the Columbia River; and 2) the estimates are used, together with waste inventory and ground-water monitoring results, to forecast the rate at which tritium and ruthenium may enter the river. Such information has application in the radiological evaluation of waste disposal practices in the 200 Areas.

SUMMARY

The history and current status of low and intermediate-level liquid waste disposal practices in the 200 Areas, and the ground-water monitoring results, continue to attest to the safety and practicality of current and projected ground disposal operations.

An average travel time of from 7-8 years is estimated for Ru^{106} contamination in the ground water to move from the Purex Plant site southeast to the

Columbia River. A period of time only slightly less, 6-7 years, is indicated for tritium following the same path. These travel periods will result in less than one percent of the ruthenium and about 70 percent of the tritium entering the ground water beneath Purex Plant cribs reaching the Columbia River.

Tritium concentrations in wells adjacent to the river may soon be more than an order of magnitude greater than the present background concentration in river water. Ruthenium-106 concentrations in these wells will be detectable but, due to decay and quantity discharged, will be several orders of magnitude below the recommended exposure limit for the population at large. Neither radionuclide will affect measurably the exposure to downstream water users.

Due to the less permeable sediments beneath 200 West Area, radiocontaminants discharged to the Redox Plant ground disposal facilities will move appreciably slower toward the river; a travel time of about 20 years is indicated. However, the limited amount of radionuclide migration data in that case makes the travel time estimate less certain than is the case for 200 East Area. Even with this uncertainty, it is not likely that 200 West Area will contribute any ruthenium and no more than a small fraction (in comparison with that from 200 East Area) of the tritium to the river.

Although the bulk of the activity is expected to enter the river north of the 300 Area, the indicated presence of a thin, confined aquifer (an Upper Beverly Member) above the uppermost continuous basalt flow presents a potential path for lesser amounts of diluted wastes to enter the river at other

locations. Studies are in progress to attempt to delineate the discharge point(s) of that aquifer.

DISCUSSION

River Entry Locations

Figure 1 is a map of the plant area and vicinity showing locations (boundaries) where the continuous basalt flow beneath the region is at an elevation higher than the "free" ground-water elevation. Wastes are confined to flow within this area, and must enter the Columbia River above Wallula Gap to leave the region.

Figure 2 is a geologic cross section (northwest-southeast) through the plume of contaminated ground water emanating from 200 East Area. Quite evident is the increasing depth to basalt in going from 200 East Area toward the river. Also noticeable on this cross section are the confined interbed (Upper Beverly Member) and near the river the overlying thin basalt member, (Saddle Mountain Flow No. 2). Geologic data indicate that the entrance or "open end" of the interbed may be in the vicinity of 200 East Area; however, exact locations with respect to Purex waste cribs have not yet been determined. The Upper Beverly Member is on top of the basalt boundary flow shown in Figure 1. At a location several miles west of the river, and within the indicated contaminated ground-water area, the confining structure is Saddle Mountain Flow No. 2. That flow also lies on top of the boundary basalt surface; therefore, wastes entering the confined Upper Beverly Member must also be discharged to the Columbia River within the confines of the basalt-bounded area. An evaluation of

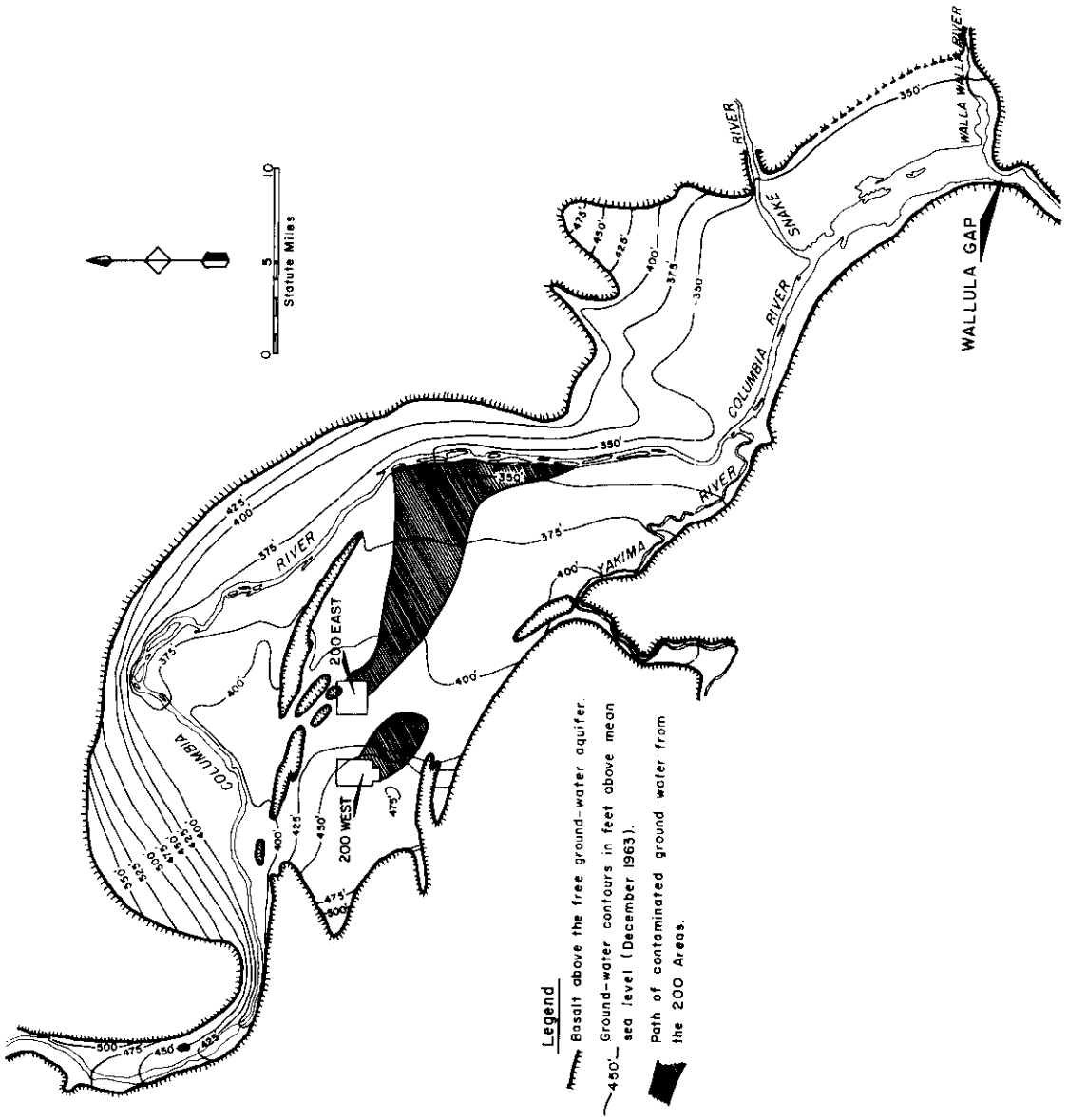

FIGURE 1
Extent of the Project Ground-Water Flow System

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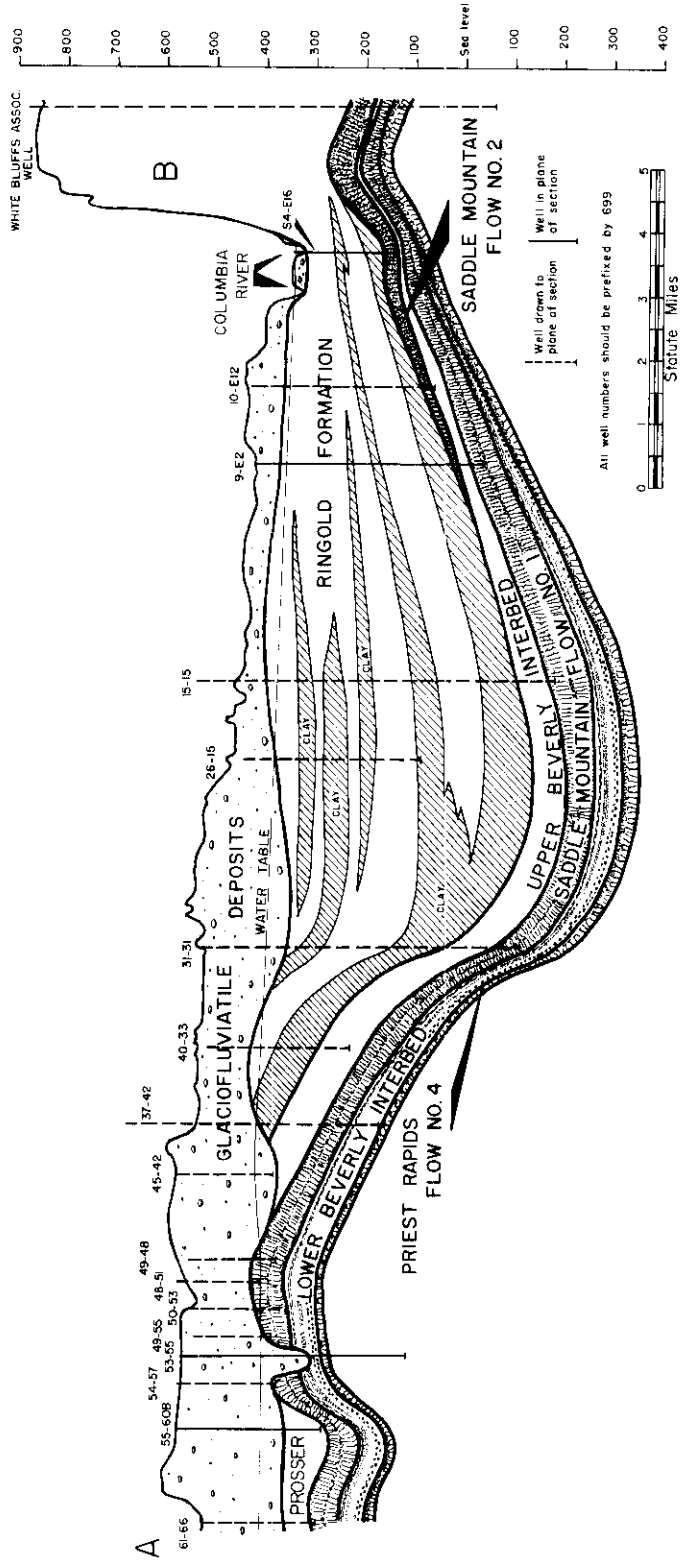

FIGURE 2
Geologic Cross Section -- 200 Areas to the Columbia River
(Line A-B on Figures 4&5)

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radioanalytical results of samples from two wells near the river indicates that the travel time (Purex Plant to River) in the interbed may be only slightly greater (several months) than that of the free ground water. The division of waste between the free ground water and confined aquifers is difficult to estimate since only a few wells penetrate into the latter zone—more wells are planned. Based on the relatively high radionuclide concentrations noted in the larger number of wells which penetrate only the free ground-water aquifer, most of the activity which has entered the regional ground water can be accounted for in the free ground water which discharges into the river at locations shown on Figure 1.

Travel Time Estimates

Travel time estimates for ruthenium are based primarily on the appearance time of the radionuclide in monitoring wells located between 200 East Area and the river. Figure 3 shows time correlations between the discharge of gross beta activity (not including tritium) from Purex and its appearance in three typical wells. The wells noted, 34-39, 20-20 and 20-E12 are respectively 2, 6.5 and 11 miles southeast of the Purex Plant. The 1960 and 1963 peaks in the curve for well 34-39 probably correspond to the 1957 and 1960-61 peaks respectively in the waste discharge curve. The 1962 peak in the well 20-20 curve probably corresponds to the 1957 peak on the discharge curve. On these bases, it is predicted that the largest peak on the Purex Plant waste discharge curve, late 1962, will be evident in well 34-39 in 1965 and in well 20-20 in 1967.

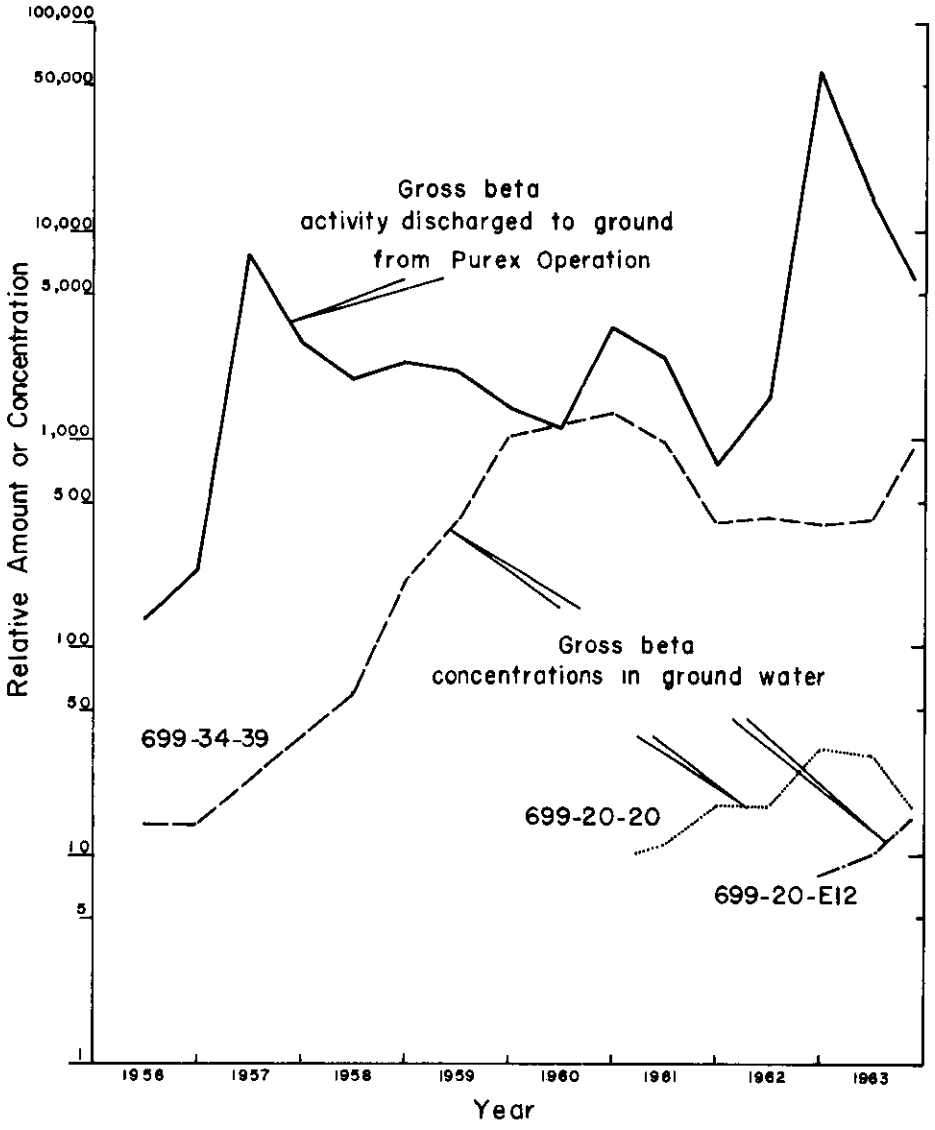

FIGURE 3

Relation Between Gross Beta Activity in Outlying Wells
With Relative Amount Discharged to Ground at the Purex Plant

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The appearance of ruthenium and tritium in wells 20-E12 and 10-E12, both located about 1 mile from the river, was noted during the past year. In the case of these and several other wells located closer to the river than to the Purex Plant, the appearance of radionuclides is somewhat sporadic. This is very likely attributable to several causes: concentrations are quite low at this time (near the routine detection limits) and fluctuations in river level result in the seasonal entry of river water into several of the wells (low but positive concentrations of Cr^{51} as well as H^3 and Ru^{106} were detected in one recent sample).

Travel time estimates for tritium also are based on the time of appearance of tritium in monitoring well samples. In late 1961, when ground-water samples were first analyzed for tritium, concentrations well above the detection limit were noted in wells located halfway between 200 East Area and the river. Wells 20-20 (Figure 3) and 26-15 contained tritium concentrations of about 2.5×10^{-4} μc/cc at the same time that gross beta concentrations were beginning to increase noticeably. The estimated 6-7 years travel time is based also on the results of a series of laboratory soil column tests comparing ruthenium and tritium sorption characteristics with actual ground-water samples as influent[7]. Breakthrough curves for the two radionuclides were essentially identical in column tests employing sand, sand - 10% silt, and sand - 20% silt. In a pure silt column, however, the breakthrough of Ru^{106} lagged the breakthrough of H^3 by about 25 percent.

The estimated travel time for radionuclides to move from 200 West Area

to the river is considerably in excess of that required for Ru^{106} to decay to concentrations well below the current routine detection limit, 8×10^{-8} μc/cc, and also below any limit which would make it of concern in the river. Figure 4 shows that the gross beta-emitter (Ru^{106}) contamination is not now beyond the downward-projected boundaries of 200 West Area. Over the past several years the areal extent of the ruthenium contamination beneath 200 West Area has been steadily decreasing. The decrease is the result of a large reduction in the amount of activity contained in Redox process condensate waste, and the decay of 1-year Ru^{106} in the slow-moving ground water beneath the area. The extent to which tritium has migrated from 200 West Area, about 5 miles southeast, is shown in Figure 5. This movement through the low permeability Ringold sediments has occurred over a 12-year period. If the present rate of movement is continued, it will be about 3-5 years before 200 West Area tritium enters the permeable sediments and joins the 200 East Area contamination plume. From there an additional 2-3 years will elapse before it reaches the river. The addition of that tritium to the plume will likely not be detectable in wells that now show significant concentrations of tritium from the Purex Plant.

The amount of ruthenium and tritium which will reach the river is a function of the amount which entered the ground water beneath disposal facilities and the travel time (representing radioactive decay) for the radionuclides to migrate to the river.

Figure 6 outlines the general path that ruthenium and tritium follow in moving from 200 East Area to the River. The sources of these two radionuclides

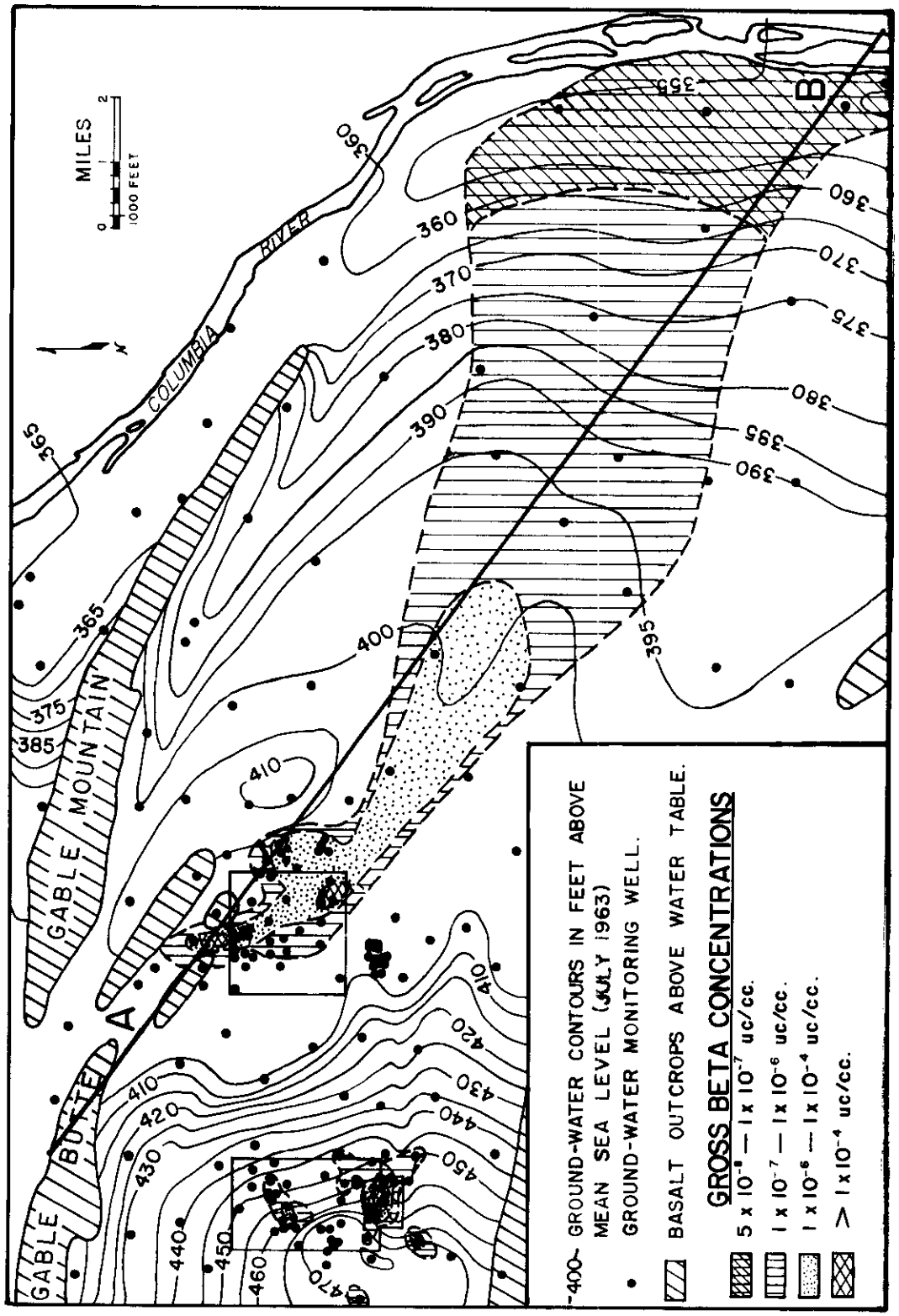

FIGURE 4

Extent of Ground Water Gross Beta Contamination July - December, 1963

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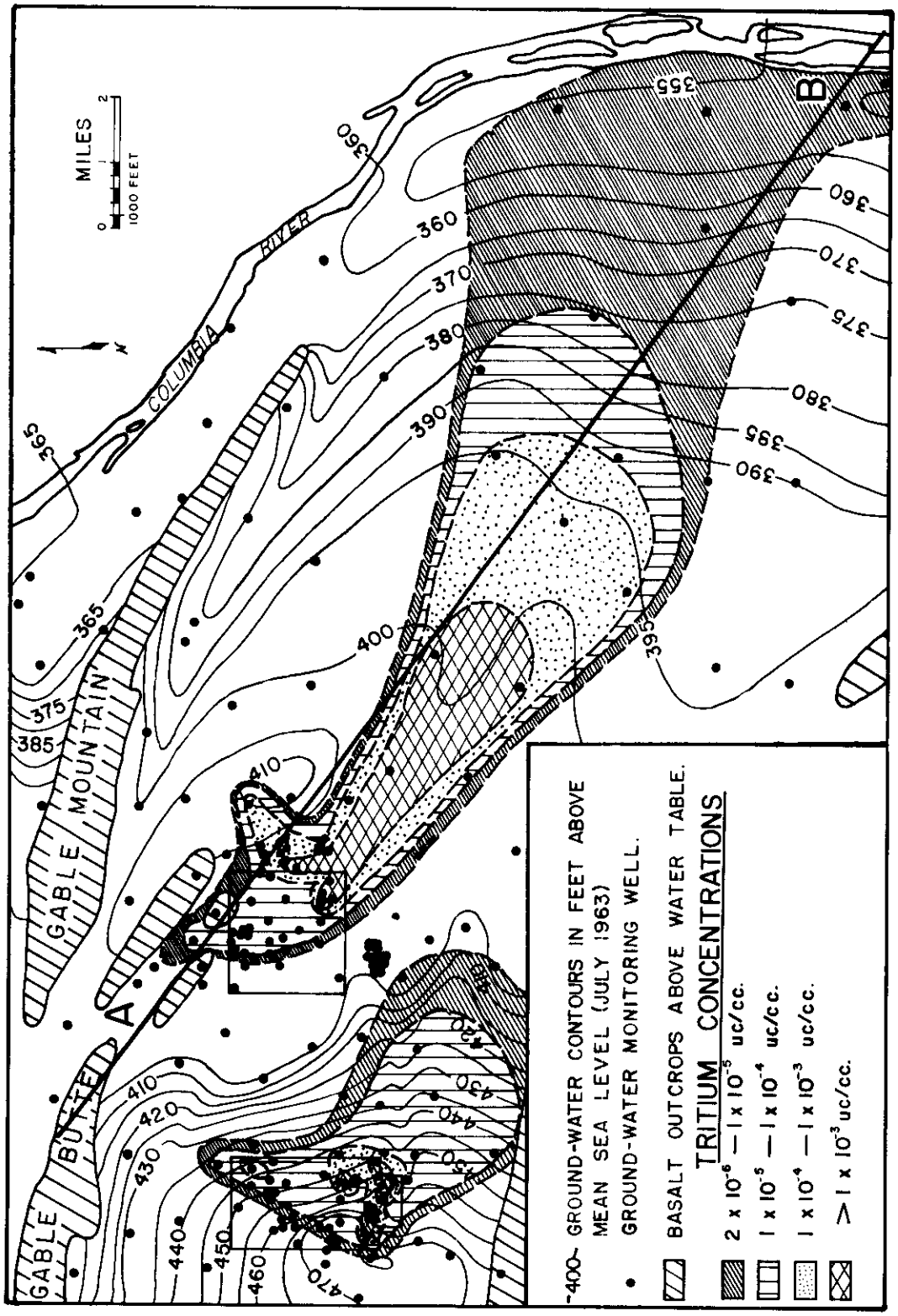

FIGURE 5

Extent of Ground Water Tritium Contamination July - December, 1963

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are essentially identical (emanating from the Purex process condensate and tank farm condensate cribs) with the exception that a significant amount of the tritium, about 20 percent of that discharged, is associated with the vacuum acid fractionator overheads which enter the B-swamp by way of the Chemical Sewer. The path is divided into average yearly increments based on estimates of travel time between the various wells. The quantities of Ru^{106} and H^{3} contained in each of the yearly-increment volumes were calculated, and those values were corrected for radioactive decay over the appropriate period of time required to migrate from each location to the river. In general, fair agreement was noted between the quantities of radionuclides so determined and the yearly waste disposal inventory data reported for the Purex Plant.

It is estimated that less than 100 curies of Ru^{106}/year will reach riverbank locations over the next 7-8 years, and that the yearly rate of fission product tritium addition to the river should not increase the present tritium background concentration in river water by more than 50 percent.

There are definite uncertainties associated with current estimates which likely constitute the major questionable considerations: 1) the uniformity of radionuclide distribution in each zone, particularly variations with depth; 2) the relatively sparse monitoring well coverage at some locations; and 3) possible inaccuracies in flow system interpretation. An attempt was made to reduce the degree of uncertainty to a minimum by also considering the waste disposal inventory data reported routinely by the separations plants, and to stay on the conservative side when significant anomalies were evident.

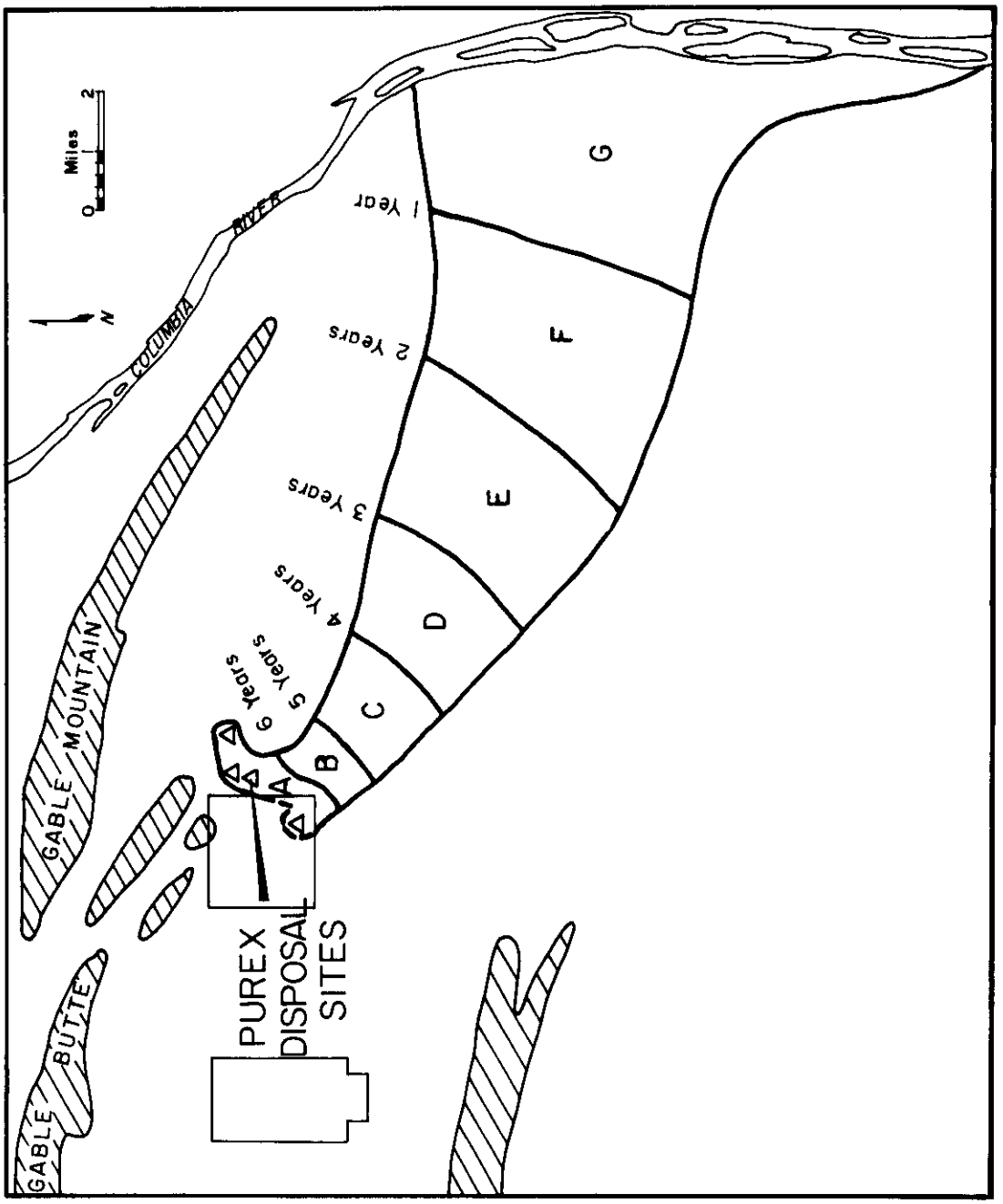

FIGURE 6
Indicated Travel Time Increments for Tritium and Ru^{106}
Between the Purex Plant and the Columbia River

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The travel time and radionuclide distribution estimates will be refined as additional information becomes available from the installation of new wells, depth samples obtained from piezometers installed in existing wells, research on radionuclide migration rates, and the ground-water mathematical model.

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