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GROUND WATER MONITORING

Use of Tritium as a Tracer

J. H. Horton and D. I. Ross 36844

December 1959

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Introduction

An accurate and cheap method of monitoring ground water is needed if ground disposal of liquid radioactive waste is to be economical and safe. Such monitoring should require a limited number of wells, since the installation of wells, the collection of water samples, and the analysis of water samples are all expensive. Yet the monitoring program must be adequate to insure the detection of the most rapid movement of radioactivity.

In areas such as the Savannah River Plant where the soil is nonuniform, it is difficult to fulfill these requirements because of the tortuous paths which ground water may follow. Accurate tracing of ground water from the disposal areas, far in advance of the hazardous radioactive materials, could greatly reduce the monitoring program. A few monitoring wells in the zone of most rapid water movement would then be sufficient for determining the useful life of the disposal area.

This report presents the results of a study to determine the usefulness of tritium as an aid in tracing ground water near radioactive-waste ground disposal areas. The seepage basins in routine use by H Area were selected for the study.

Period Covered: The study described in this report was conducted during the period from October 1958 to January 1959.

Summary

Ground water from the H-Area seepage basins was readily traced by use of tritium. Water from the basins was readily detected in a nearby stream and in the ground water between the basins and the stream. The comparative tritium concentrations in the ground water showed that the most rapid movement of water from the basins was confined to a zone about 50 feet wide. Monitoring wells installed in this zone of most rapid ground water movement should be adequate for determining the useful life of the seepage basins.

Discussion

Requirements of a Good Tracer

Many materials have been used as tracers for ground water, but most of them have not been completely satisfactory.[1,2] The ideal tracer would have the following characteristics:[2,3]

- It should be readily determinable quantitatively in low concentrations.
- It should be entirely absent, or present in only very small amounts, in the normal ground water.
- It must not react with materials in the test environment to form a precipitate.
- It must not be absorbed by the porous medium.
- It must be cheap and readily available.
- The test environment must not influence it so as to impair the precision of detection.

Kaufman and Orlab[3] have tested several materials in soil columns to determine which of them would most satisfactorily meet the requirements of a good tracer. The materials tested included various salts and radioactive materials. Chlorides moved more rapidly through the soil than did any other material. Of the radioactive materials, tritium was by far the best; it moved approximately 90 percent as fast as did the chlorides. Despite this slight retention by soil, it appears that tritium will serve as a satisfactory ground water tracer. Tritium has these added advantages:

- It has a relatively long half life (12 years).
- The recent development of a commercially available liquid scintillation counter[4] has made it possible to readily detect tritium in concentrations as low as 10 $\mu\mu c/\ell$. This concentration is less than 0.5% of the public zone maximum permissible concentration.
- Studies at the Savannah River Plant have shown that tritium is present in the liquid waste from uranium separations facilities.

Description of Seepage Basins

Basin Design. A diagram of the seepage basins used in the study is shown in figure 1. The liquid waste is discharged to basin 1, from whence it overflows to basin 2 and finally to basin 3.

Geology of the Seepage Basin Area. A detailed description of the seepage basin area geology and hydrology has been presented by Reichert.[5] At the basins, the normal water table is 15 to 25 feet below the ground surface. Soil in the area is extremely heterogeneous and includes discontinuous layers of sand, sandy clay, clayey sand, and clay interwoven with a mesh of fissures. These fissures are filled with quite permeable material. Water has been observed seeping from one basin to another through these fissures and on two occasions has outcropped through them onto the ground surface near basin 1. The natural outcrop of the ground water in the area is a small branch of Four Mile Creek about 400 to 500 feet east of the seepage basins. A narrow swampy area borders the branch directly downhill from the seepage basins, and several very small tributaries of the branch originate in the swamp. The ground water gradient between the seepage basins and the branch is quite steep, averaging 3 feet per 100 feet. The flow rate of the branch varies greatly, depending on the rate at which water is discharged from H Area into the two area effluents which flow into the stream.

History of the Seepage Basins. Use of the seepage basins began during July 1955; thus they had been in service for approximately three and one-half years at the time of this study. During this time, very low level high volume radioactive waste was discharged to the basins.

The rate of water loss from the basins has generally decreased. During the first year of operation, the total loss by seepage and evaporation was sufficiently high so that there was no overflow from basin 1 to basin 2. During that period the pH of the liquid waste was generally 3 or less. Since September 1956, NaOH has frequently been added to the liquid waste to neutralize the acidity. The Na caused the basin soil to swell,[6] thereby sealing the fissures described above, and almost immediately the water began to overflow into basin 2. For about 18 months previous to the study, all three basins contained liquid waste.

Tritium Tracer Study

To test the feasibility of using the tritium present in the seepage basin waste as an aid in tracing water movement from the basins, an extensive study was conducted from October 1958 to January 1959. The study was carried out in two phases:

- Detection of the outcrop of seepage basin water in Four Mile Creek.
- Detection of the zone of most rapid movement of seepage basin water between the basins and Four Mile Creek.

A preliminary study indicated that tritium from the seepage basins could be readily detected in Four Mile Creek and that the largest quantities were outcropping downstream of the intersection of the two H-Area effluents in the branch which flows east of the basins (see figure 1). On October 31, November 3, and November 4, 1958, water samples were collected from 15 locations on this branch (locations 1 through 3 and 10 through 21, figure 1). The concentration of tritium in these water samples showed that entry of tritium from the seepage basins into the stream began between locations 3 and 10.

Sampling at closer intervals between locations 3 and 10 (see locations 4 through 9, figure 1) showed that the first entry of significant amounts of tritium was about 50 feet downstream from location 3. The average concentration of tritium in the stream water at each sample location is shown in figure 2.

The slope of the curve in figure 2 is indicative of the rate at which seepage basin water outcrops into the stream between the various sample locations. Significant outcropping appeared to occur between all sample locations except 10 and 11, 15 through 17, and 20 and 21. The most rapid rate of outcropping was between locations 3 and 5. A comparison of concentration increases shows that approximately 20 percent of the tritium flowing past location 21 entered the stream between locations 3 and 5, a distance of about 75 feet.

Ground water outcropping into Four Mile Creek between locations 3 and 5 flowed from the small swampy area bordering the creek. The swamp extends from a short distance above location 1 to below location 10, a distance of about 950 feet, and is approximately 100 feet wide. Several small streams of water drain from the swamp into the creek. Extensive sampling and analysis of water from the swamp revealed tritium concentrations many times as high as in Four Mile Creek. Comparison of tritium concentrations in Four Mile Creek above and below the small swamp streams showed little or no change attributable to the streams. This indicates that subsurface seepage accounts for the movement of a large portion of the seepage basin water across the swamp.

To determine the pattern of ground water movement from the seepage basins into the swamp, the tritium content of ground water from 74 test wells spaced about 12-1/2 feet apart and a few feet uphill from the swamp was determined. The locations of these wells are shown in figure 1. Along the line of wells, the ground water was never greater than 3 feet below the surface. The tritium concentration in the well water varied greatly, as shown in figure 3. The results showed that the movement of ground water from the seepage basins was quite irregular. The most rapid rate of ground water movement appeared between wells 37 and 41, a distance of about 50 feet.

Below the swamp, the stream bed of Four Mile Creek is quite deep due to recent erosion by the discharge of water from H Area. In places the stream bed is as much as five feet deep, as compared to about one foot in the vicinity of the swamp. Very slow seepage of ground water, with an occasional trickle, could be observed on the bank of the creek over its entire length. Because of the difficulty of collecting samples of ground water in this region, sampling was limited to three samples collected from seepage along the creek bank between locations 6 and 9 and two samples from test wells.

Conclusions

This study has shown that tritium present in liquid waste from uranium chemical separations facilities can be used to trace the movement of ground water from seepage basins which receive the waste. Similar studies prior to the installation of permanent ground water monitoring wells should reduce the number of wells required and insure that the wells are properly located.

In actual practice, the zone of the most rapid ground water movement must be determined in the vicinity of the seepage basins by collection of water samples from uncased test wells. The wells located in the zone of most rapid ground water movement would then be selected for casing and used as permanent monitoring wells.

Application of the techniques used in this study must necessarily vary according to the conditions under which they are used. Tritium could be readily added to liquid waste in which it is absent or in which the concentration is not adequate. The required concentration of tritium in the liquid waste will be determined by: (1) the amount by which the seepage basin water is diluted by the ground water, and (2) the flow rate of the stream into which the ground water outcrops.

It also appears that some precautions are necessary. In cases where the distance to the nearest flowing stream is great and the ground water is near the surface, the tritium may be dissipated to the atmosphere by transpiration from vegetation and by capillary movement to the ground surface. Under such conditions it would be inadvisable to wait for the tritium to outcrop into the stream. Also, even after tritium is detected in the nearest flowing stream it is possible for the zone of most rapid water movement to shift as the result of the effects upon the soil of chemicals in the waste. Therefore, the zone of maximum outcropping of seepage basin water into the flowing stream should be routinely confirmed.

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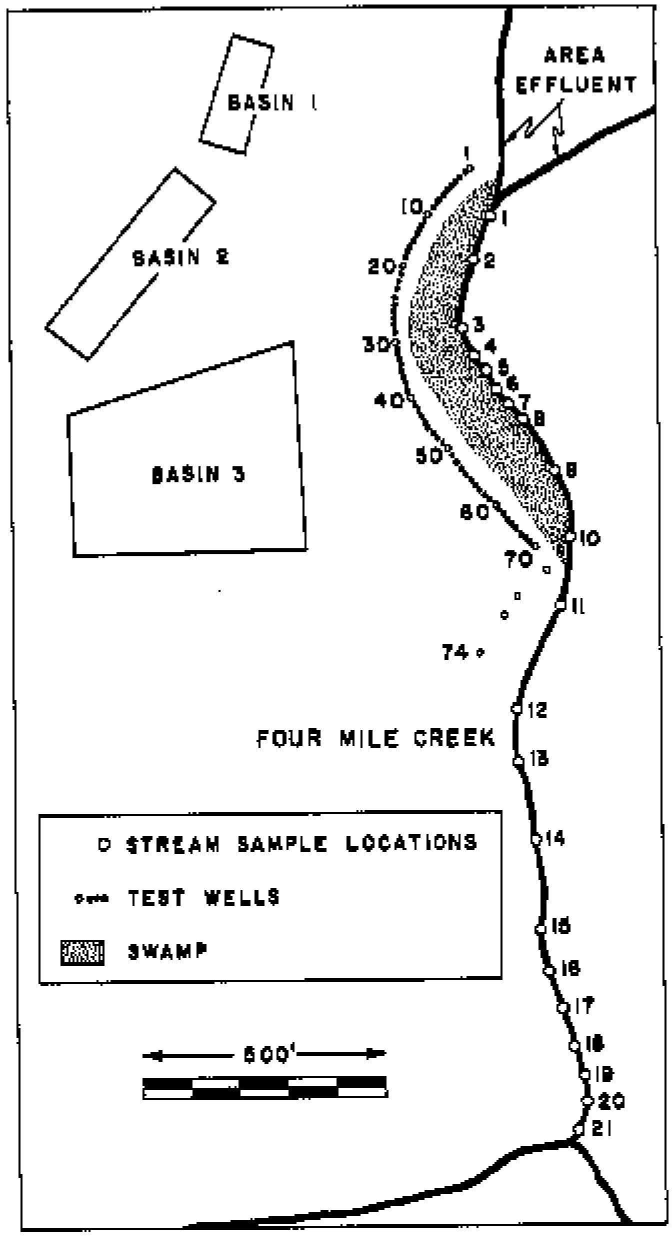

FIGURE 1. SEEPAGE BASINS AND SAMPLE LOCATIONS

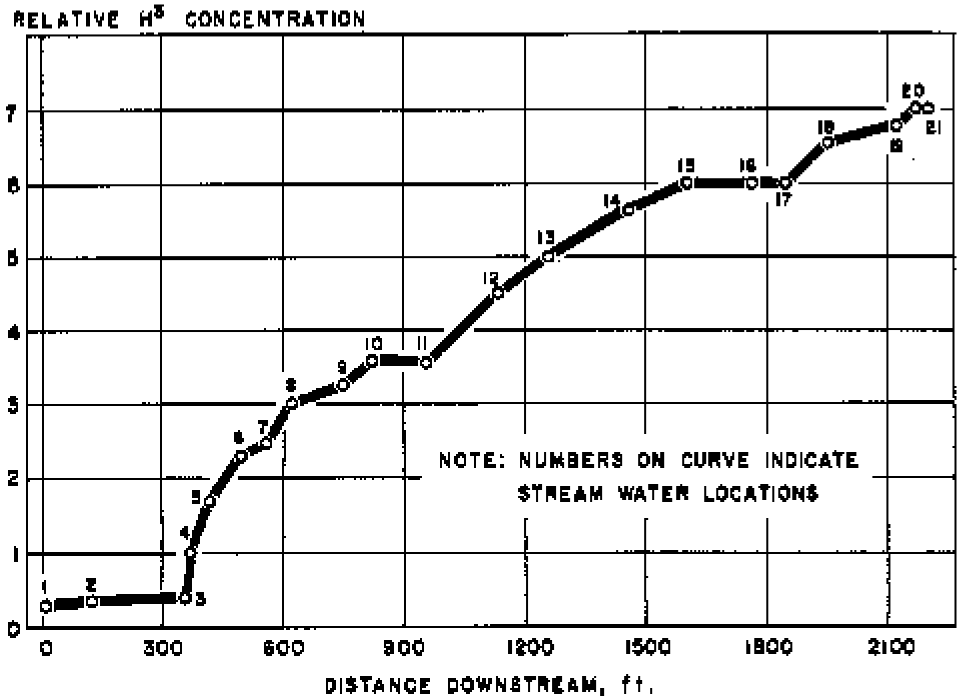

FIGURE 2. TRITIUM IN FOUR MILE CREEK WATER

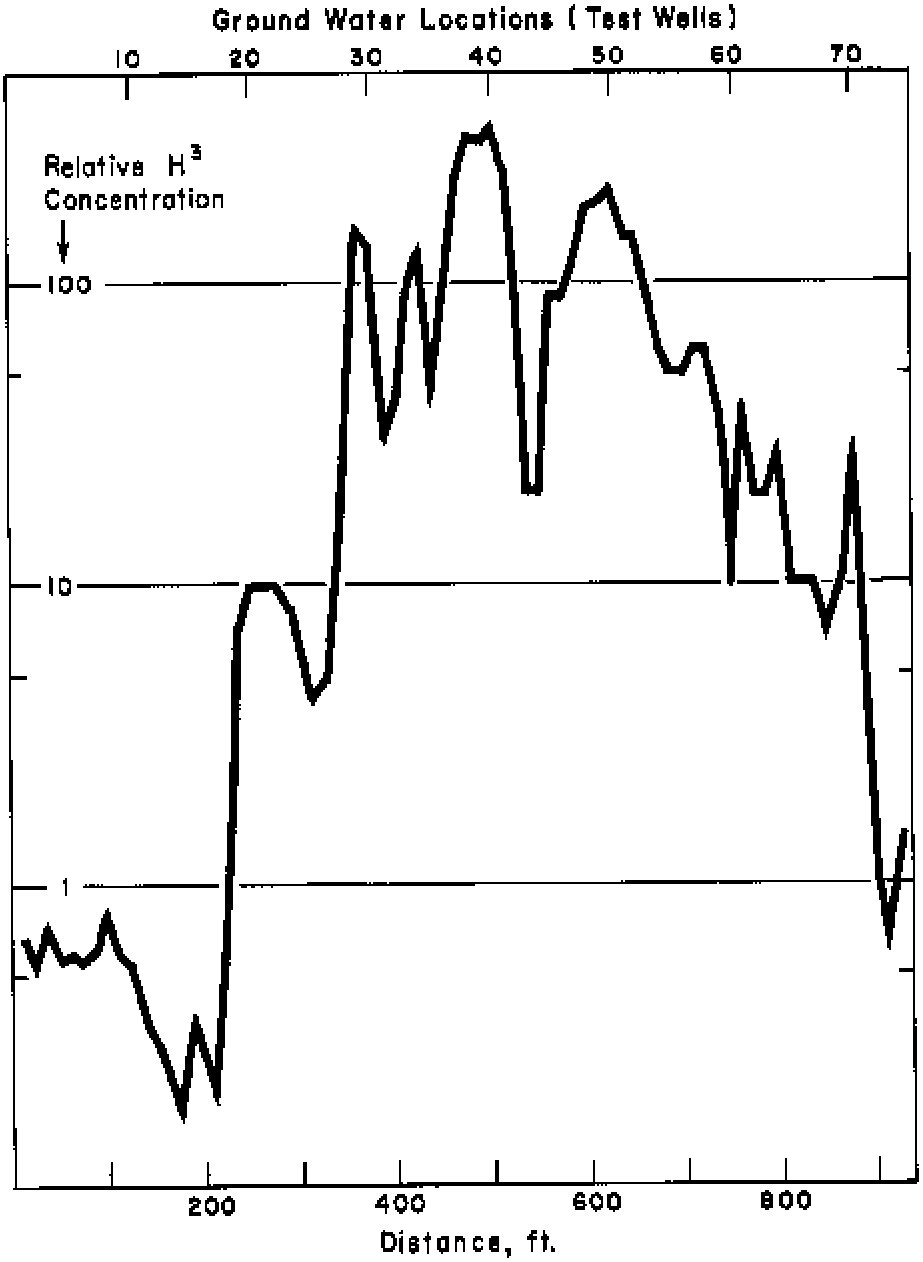

FIGURE 3. TRITIUM IN THE GROUND WATER
(Test Wells 1 through 74)