302/RC/87/09/01

MEMORANDUM FOR: Ronald L. Ballard, Chief
Technical Review Branch
Division of High-Level Waste Management

FROM: Donald L. Chery, Section Leader,
Hydrology Section
Technical Review Branch
Division of High-Level Waste Management

SUBJECT: INTERSECTION OF A DIKE WITH WASTE CANISTERS

Richard Codell of the Hydrology Section has performed a brief study at the request of John Trapp, to estimate the number of possible intersections between a linear intrusive dike in a field of waste canisters. The dike was assumed to be 815 meters in length and one meter wide. The canisters had an average spacing of about 16.5 meters and had an effective diameter for the purposes of the calculation of one meter. A Monte Carlo simulation of either randomly placed or regularly placed canisters indicated that there would be about 6±2.5 intersections. Two computer programs are available for repeating the analyses with other criteria. Please contact R. Codell (x7-4558) if you have any questions.

ORIGINAL SIGNED BY

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Intersection of Waste Canisters with a Dike

by Richard Codell, Hydrology Section

Introduction

One unanticipated event which could lead to the failure of waste canisters is the penetration of the repository by a magmatic intrusion (dike). An example of such an intrusion in a typical repository has been studied by means of computer simulation in order to reveal the potential number of canisters which could be affected. This example is presented below.

Statement of Problem

A circular area with a radius of 1250 meters has 18,000 spent fuel canisters uniformly dispersed arealy as shown in Fig. 1. The radius of the canister and backfill is assumed to be one meter. A linear dike of width one meter and length 815 meters may have any orientation as long as both ends of the dike are totally within the circle. The object of the exercise is to find the number of canisters which come in contact with the dike. Two cases are considered. In the first case, the canisters are assumed to be placed on a regular square grid. The area of the large circle is 4.91E6 m², which works out to a distance between canisters of 16.51 meters. In the second case, the dike is linear, but the canisters are dispersed randomly with an average density of one canister per 273 m². The second case can also be construed to represent an irregular dike in a regular field of canisters.

Solution

Regular canister spacing

Since the dike is contained within the large circle, the only variables would be the orientation of the dike and its relative position with respect to the axes of the grid. Its closeness to the edge of the large circle is irrelevant. The problem therefore is reduced to that shown in Fig. 2, where the distance between the canister circles (1 meter) and the dike must be determined. The dike is uniquely specified by its length (815 m), its width (1 m), its intersection with the vertical axis $x = 0$ and its orientation θ with respect to the horizontal axis. The domain of the problem is all points within the rectangle of length $L \cos \theta$ and width $L \sin \theta$. The canister circles will overlap the dike if the distance between the center of the canister and the center of the dike is less than or equal to one meter. This distance is determined by the formula:

$$d = \frac{|-ax + y - b|}{\sqrt{a^2 + 1}}$$

where a = the slope of the dike tan R, and b is the intersection of the center line of the dike with the axis x = 0. For each realization, the distance d between the points and the centerline of the dike is calculated.

A large number of realizations of the dike is generated in a Monte Carlo fashion. For each realization, the intercept b is chosen to be a uniform random number between 0 and 16.51 meters, and the angle θ is chosen to be a uniform random number between 0 and 90 degrees.

Randomly spaced canisters

In this case, only one orientation of the dike needs to be considered. A diagonal line with b = 0 and θ=45 degrees was chosen for computational convenience. An array of randomly positioned canisters is generated for each realization. the x and y positions of each canister in the domain is chosen as a uniform random number.

Results

Uniformly spaced canisters

The minimum number of intersections can be shown directly to be zero. Furthermore, if the dike is perfectly aligned along one of the lines on which the canisters are placed there will be 49 intersections. If it is perfectly aligned with the diagonal there will be about 33 intersections. The results of the Monte Carlo simulation with 1,000 lines is presented in Fig. 3 as the cumulative probability that the number of intersections will not be exceeded. The minimum, median and maximum number of intersections from the 1000 realizations is 0, 6 and 49 respectively. The mean is 5.9 with a standard deviation of ± 2.6 (although there is definite skewing).

Randomly spaced canisters

The cumulative probability that the number of intersections will be exceeded is presented in Fig.3 for the case of a random canister field. Since there is not a particular orientation for which there is likely to be a large number of intersections of the random field with the line, the extremes at both the high and low end of the probability curve for this case are less pronounced. The minimum, median and maximum number of intersections for the 1000 realizations is 1, 6 and 16 respectively. The mean is 6.6 with a standard deviation of ±2.5, and the distribution is less skewed.

Conclusions

The estimate of the number of intersections for a typical repository has been made for the cases of a linear dike and either a regularly spaced of randomly spaced field of canisters. The analyses demonstrate robustly that the number of intersections for this example is about 6 ±2.5 over a wide range of orientations and positions of the dike within the canister field. While the maximum number of intersections can approach 49 for the stated conditions and a regularly spaced field of canisters, the probability of this eventuality is very low.

Computer Codes

A floppy disk of the compiled codes for personal computers is available for studying other configurations. The results presented here were run on the NRC MV-8000 computer, so there are likely to be minor differences because of differences in the random number generators.

Program RLINE1 is for regularly spaced canisters, while program RLINE2 is for the randomly spaced case. Both programs require the following data:

NLINES = number of realizations of the dike

ALEN = length of the dike, meters

DX = average distance between canisters, meters

TOL = distance between center of dike and center of canister for contact to occur, meters.

The output of the programs is (1) the number of intersections ranked from the lowest to the highest for the NLINES realization, and (2) the statistics of the number of intersections (mean, average deviation, standard deviation, skew and kurtosis).

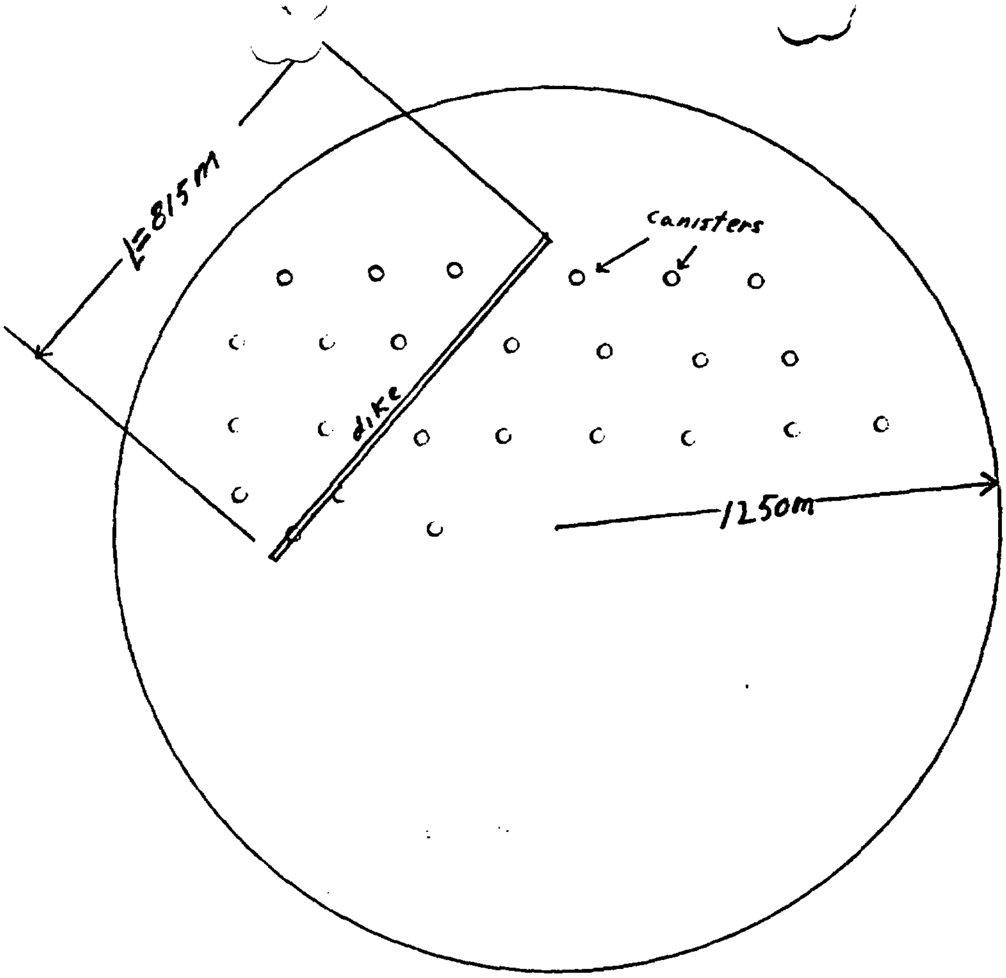

Figure 1 - Dike in a field of canisters (not to scale)

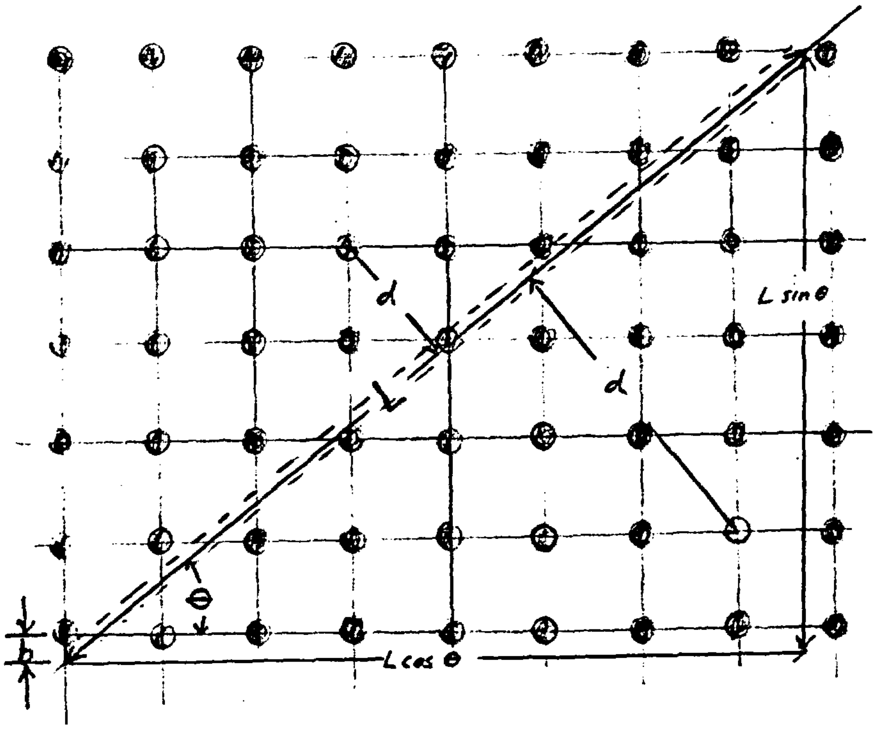

Figure 2 - Problem domain for regular canister placement
(not to scale)

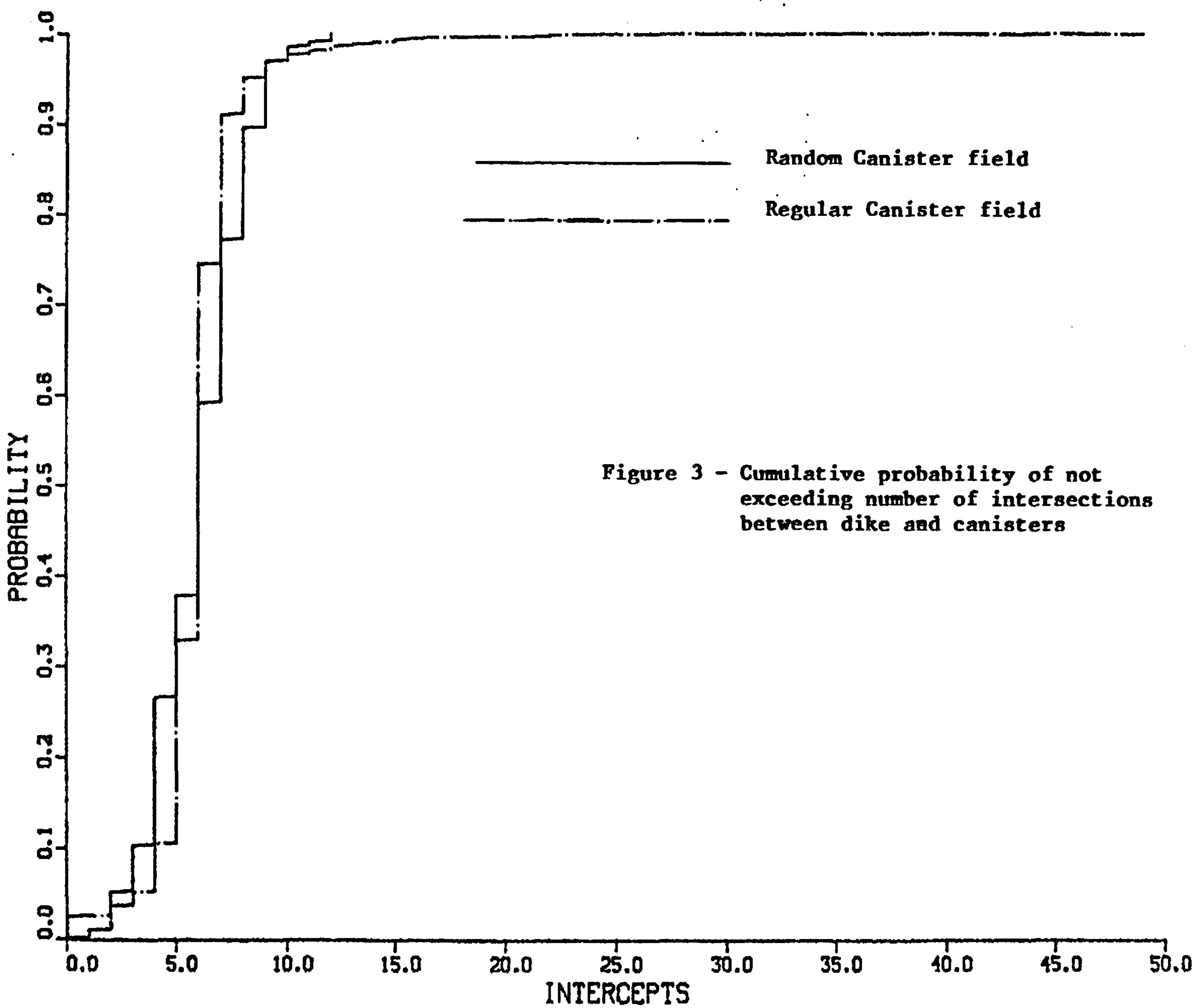

Figure 3 - Cumulative probability of not exceeding number of intersections between dike and canisters

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