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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT CALCULATION COVER SHEET		1. QA: QA Page: 1 Of: 26

2. Calculation Title

Number of Waste Packages Hit by Igneous Intrusion

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ACRONYMS

CDF	Cumulative Distribution Function
CRWMS	Civilian Radioactive Waste Management System
DTN	Data Tracking Number
EDA	Enhanced Design Analysis
M&O	Management and Operation
PDF	Probability Distribution Function
PHVA	Probabilistic Volcanic Hazard Analysis
SR	Site Recommendation
TBV	To be Verified
TSPA	Total Systems Performance Assessment

1. PURPOSE

In broad terms, the purpose of this calculation is to support the analyses of the contribution of igneous activity to Yucca Mountain Repository Total System Performance Assessments. Igneous activity is a disruptive event that is included in the Total System Performance Assessment-Site Recommendation analyses. Two igneous-activity scenarios are analyzed here (Figure I-1). The Volcanic Eruption scenario is direct release of radioactive waste to the accessible environment because of a volcanic eruption. The Igneous Intrusion Groundwater Release scenario considers the *in situ* damage to waste packages that occurs if they are encapsulated or otherwise affected by magma as a result of an igneous intrusion. An igneous intrusion is defined as magmatic activity that does not reach the earth's surface. Magma that does reach the surface from igneous activity is an eruption (or extrusive activity).

The objective of the calculation is to develop a probabilistic measure of the number of waste packages that could be affected (either damaged or dispersed) by the two scenarios. For the Volcanic Eruption Scenario, the number of waste packages destroyed by a volcanic eruption is the calculated number of waste packages contained within an eruptive conduit of a specified diameter, given that a dike has intersected the drift, and that the conduit is located at a drift. For the Igneous Intrusion Groundwater Release Scenario the number of waste packages destroyed by an igneous intrusion (dike) that intersects the repository, but does not result in an eruption reflects the calculated number of waste packages that have been destroyed in-situ by magma.

All key components related to the basic conceptual model used in this calculation are based on data and interpretations in the Probabilistic Volcanic Hazards Analysis (PVHA) report (CRWMS M&O 1996; CRWMS M&O 1999a - PA-NEP-99347.T) and the repository layout in, *Input Transmittal for Repository Design Information to Support Total System Performance Assessment – Site Recommendation* (CRWMS M&O 1999b - PA-EBS-99277.T) with drift orientation azimuth angle of 108° and *Repository Subsurface Design Information to Support TSPA-SR* (CRWMS M&O 2000a - PA-SSR-99218.Tc) with drift orientation of 72°. The PVHA report (CRWMS M&O 1996) provides the framework for three analysis and model reports that provide probability distributions that are used as input for this calculation. These analysis/model reports include *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000b), *Dike Propagation Near Drifts*, (CRWMS M&O 2000c); and, *Characterize Eruptive Processes at Yucca Mountain, Nevada* (CRWMS M&O 2000d). This calculation provides outputs to *Igneous Consequence Modeling for the TSPA-SR* (CRWMS M&O 2000e). The work is being performed according to procedure AP-3.12Q, Rev. 0/ICN 0, *Calculations*. The development plan for this work is documented in (CRWMS M&O 1999c and CRWMS M&O 2000f). The QAP-2.0 evaluation for the activity is documented in (CRWMS M&O 1999d).

2. METHOD

This calculation utilizes a conceptual model for an igneous intrusion that intersects the repository footprint (described below), simplifying assumptions related to the impact of igneous intrusions on waste packages (see Section 3), and input parameters from analysis/model reports (see Section 5). In this calculation, the inputs are sorted and used in hand calculations to determine the number of waste packages destroyed due to an igneous event that intrudes into the repository. The hand calculations are done using accepted EXCEL spreadsheet functions (see Section 4).

The conceptual model used as the basis for this calculation summarizes information from CRWMS M&O 1996, CRWMS M&O 1999b, CRWMS M&O 2000a, CRWMS M&O 2000b, and CRWMS M&O 2000d. Elements of this conceptual model include:

Current Vs example

- An igneous event occurs in the Yucca Mountain region. An event is defined as an ascending basaltic dike(s) that reaches the repository elevation and intersects the repository footprint. If the dike(s) continues to the surface, then a volcanic eruption occurs. If the dike does not continue to the surface, then the event is termed an igneous intrusion.
- The intrusion process assumed is that a vertical tabular dike propagates up to the level of a horizontal planar network of parallel, equally spaced repository drifts. Above the drifts, eruptive conduits may form somewhere along the dike. These conduits are circular in cross section and develop from the surface downward. At the surface, the conduit is referred to as a vent. For each eruptive vent there is assumed to be one and only one conduit. Conduits connect the earth's surface with dikes at repository level.
- A dike(s) is described by its length inside the repository footprint, its azimuth angle (orientation of the dike relative to the drifts), its width, the number of eruptive centers (or as used in this calculation "conduits") on the dike(s), the diameter of conduits, and the number of dikes in a swarm. CRWMS M&O 1999a - PA-NEP-99347.T provides information on dike length, azimuth angle, and number of conduits on a dike. CRWMS M&O 2000d provides information on dike width, conduit diameter, and number of dikes in a swarm.
- The probability of occurrence for a dike intersecting the repository footprint was initially developed in the PVHA (see, for example (CRWMS M&O 1996, Figure 4-32a)). This probability has been updated because the repository shape and size are now different from that used in the PVHA elicitations. The new probabilities have been developed from the original PVHA interpretations and are provided in CRWMS M&O 1999a - PA-NEP-99347-T.
- The repository layout (CRWMS M&O 1999b - PA-EBS-99277.T, Item 1.1; CRWMS M&O 2000a - PA-SSR-99218.Tc) provides information on the number of drifts that could be crossed by a dike with a given azimuth angle and length inside the repository. The intersection of the repository by a dike is described by simple geometric relationships between a vertical tabular dike that intersects a horizontal planar network of parallel, equally spaced repository drifts
- The points of intersection of a dike with the repository footprint define the locations where waste packages are affected by the magma *in situ*. The number of packages impacted by magma in the drifts is a function of the dike length, azimuth, width, and number of dikes in a swarm. A geometric argument is used to calculate the number of packages directly hit by this mechanism.

- As is established in the CRWMS M&O 2000b (Section 6.3.2.1), intrusive dikes that ascend to within few hundred meters of the earth's surface may continue to the surface and erupt. Based on the PVHA work, dikes that intrude the repository will most likely extend outside the repository footprint as well. The location(s) and number of conduits (eruptive vents) along the dike are variable (CRWMS M&O 2000b, Section 5), and are considered to be random variables in this calculation.

- There are several styles of eruptions that have previously occurred in the Yucca Mountain region (CRWMS M&O 2000b, Section 6.2; CRWMS M&O 2000d, Section 6.3). A relatively violent eruption of long duration would have the greatest potential for interacting with relatively more waste packages and dispersing volcanic ash contaminated with radioactive waste over relatively large distances. Volcanologists characterize such highly dispersive eruptions as "violent strombolian" (CRWMS M&O 2000d, Section 6.5.1).

- CRWMS M&O 2000b (Section 6.5) defines five alternative assessments for the number and spatial distribution of eruptive centers (conduits) associated with a volcanic event. Each of these alternatives is expressed as a conditional probability distribution function (PDF). The relative likelihoods assigned to each conditional PDF are discussed and justified in CRWMS M&O 2000b (Section 6.5). The five alternative models for the number of eruptive centers (conduits) on a dike include:

    1. **Model IUD-UC:** Independent, uniformly distributed conduit locations, with distribution for total number of conduits not correlated with dike length;

    2. **Model IUD-C:** Independent, uniformly distributed conduit locations, with distribution for total number of conduits correlated with dike length; (e.g. lower probability for short dikes and higher probability for long dikes);

    3. **Model USRD-UC**: Uniformly spaced dike segments, random location of conduit within each segment, distribution for total number of conduits not correlated with dike length;

    4. **Model USRD-C:** Uniformly spaced dike segments, random location of conduit within each segment, distribution for total number of conduits correlated with dike length; and

    5. **Model USRD-FD**: Uniformly spaced dike segments, random location of conduit within each segment, distribution for total number of conduits based on spacing of 2.5 km between eruptive centers.

- When eruptive conduit(s) occur inside the repository footprint, then all those waste packages circumscribed by the eruptive conduit are assumed to be destroyed. It is these packages from which the waste can be entrained and dispersed at the land surface, if the eruption is a "violent strombolian.

- In this calculation the number of waste packages that an eruptive conduit could impact or damage considers three key factors; the conduit diameter, the dike width, and the dike azimuth angle.
- Other factors that are not considered because they are beyond the scope of this analysis include; fragmentation depth (the depth at which trapped gases exsolve from the liquid magma) of the ascending magma; eruption duration; magma chemical and physical properties; and the interaction of the dike with the repository drift network.

3. ASSUMPTIONS

This section identifies assumptions that are essential for this calculation. The discussion of each assumption includes four elements: (1) a statement of the assumption; (2) the rationale for the assumption; (3) a statement on the need for further confirmation, if any, of the assumption (i.e. the "to be verified" (TBV) status); and (4) a statement where the assumption is used in the calculation.

3.1 DIKE LENGTH, AZIMUTH ANGLE AND NUMBER OF ERUPTIVE CONDUITS ON A DIKE

Assumption: It is assumed that the simulation output file CCSM-PCB provided by CRWMS M&O 1999a - PA-NEP-99347.T is the most representative for igneous intrusive events in the Yucca Mountain region. File CCSM-PCB contains the conditional distributions for dike length, dike azimuth, and number of eruptive centers, appropriate for the mean frequency of intersection of both the primary block and the contingency block.
Rationale: In CRWMS M&O 1999a - PA-NEP-99347.T six simulations files were reported reflecting the uncertainties inherent in the PVHA calculation and repository design. The six files are CCSM-PB.out, CC05-PB.out, CC95-PB.out, CCSM-PCB.out, CC05-PCB.out, and CC95-PCB.out. File CCSM-PB contains the conditional joint probability distributions for dike length, dike azimuth, and number of eruptive centers within the repository footprint, appropriate for the mean frequency of intersection of the primary repository block. Files CC05-PB and CC95-PB contain the conditional distributions for dike length, dike azimuth, and number of eruptive centers, appropriate for the 5th and 95th-percentile of the distribution for frequency of intersection, respectively. File CCSM-PCB contains the conditional distributions for dike length, dike azimuth, and number of eruptive centers, appropriate for the mean frequency of intersection of both the primary block and the contingency block. Files CC05-PCB and CC95-PCB contain the conditional distributions for dike length, dike azimuth, and number of eruptive centers, appropriate for the 5th and 95th-percentile of the distribution for frequency of intersection, respectively. Only the CCSM-PCB output file is used in this calculation because it is expected to bound the effects of possible design changes.
Confirmation Status: No additional work is planned to verify this assumption. All output data from this simulation is expected to bound the effects of possible design changes.
Use within the Calculation: The parameters associated with this are used in Sections 5.1.2 and 5.1.3

3.2 DIKE WIDTH, NUMBER OF DIKES IN A SWARM, AND CONDUIT DIAMETER

Assumption: It is assumed that the PDF's for dike width, number of dikes in a swarm, and conduit diameter provided in CRWMS M&O 2000d are representative for igneous events in the Yucca Mountain region.
Rationale: This assumption is considered to be reasonable and is based on the expert elicitations documented in the *Probabilistic Volcanic Hazards Analysis Report* (CRWMS M&O 1996).
Confirmation Status: No additional work is planned to verify this assumption. These PDF's are considered to be bounding.
Use within the Calculation: The parameters associated with this assumption are used in Sections 5.1.2 and 5.1.3.

3.3 MINIMUM CONDUIT DIAMETER

Assumption: It is assumed that the minimum conduit diameter used for this calculation is 15 m.
Rationale: This assumption is based on setting the maximum conduit diameter established in CRWMS M&O 2000d of 150 m to coincide with a CDF probability of 0.9999. This results in a minimum CDF probability of 0.0000 for a conduit diameter of 15 m.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is conservative.
Use within the Calculation: The parameters associated with this assumption are used in Sections 5.1.2.

3.4 DIKE INTERSECTION WITH THE REPOSITORY

Assumption: It is assumed that the point of intersection of a dike with the repository occurs at the widest part of the repository. A simple geometric model is used with a vertical tabular dike intersecting a horizontal planar network of parallel, equally spaced repository drifts.
Rationale: This assumption is conservative and maximizes the dike length inside the repository.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is conservative.
Use within the Calculation: The parameter associated with this assumption is used in Sections 5.1.2 and 5.1.3.

3.5 DISTANCE MAGMA WILL FLOW AWAY FROM AN INTERSECTING DIKE WITHIN A DRIFT FOR REPOSITORY DESIGN THAT INCLUDES BACKFILL

Assumption: It is assumed that the distance magma will flow away from an intersecting dike within a drift that has been backfilled is 15 meters on each side of the dike. This assumption results in an individual effective dike width of 30m + the width of the dike. This total effective dike width results in three waste packages on both sides of a dike to be included in the calculation for number of dikes hit under the Igneous Intrusion Groundwater Release scenario.
Rationale: This value is within the range provided in CRWMS M&O 2000c and is considered reasonable for a repository design that includes backfill.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is considered to be reasonable.

Use within the Calculation: The parameter associated with this assumption is used in Section 5.1.3.

3.6 DIKE SWARMS

Assumption: All dikes in a swarm are assumed to have the same length and width.
Rationale: This assumption is a simplification.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is a reasonable simplification to facilitate the calculation.
Use within the Calculation: The parameter associated with this assumption is used in Section 5.1.3.

3.7 DIKE SPACING WHEN MULTIPLE DIKES INTERSECT A DRIFT

Assumption: When multiple dikes intersect a drift, it is assumed that the dike spacing is 30 meters.
Rationale: This assumption is a simplification. When coupled with Assumption 3.4, this assumption results in one combined dike with a total width equal to the sum of effective dike widths for each dike in the swarm
Confirmation Status: No additional work is planned to verify this assumption. This assumption is a reasonable simplification to facilitate the calculation.
Use within the Calculation: The parameter associated with this assumption is used in Section 5.1.3.

3.8 WHEN ONE CONDUIT INTERSECTS ONE DRIFT

Assumption: When one conduit intersects a drift, the conduit is assumed to be centered within that drift and all waste packages within the conduit diameter are assumed to be destroyed.
Rationale: This assumption is a simplification that maximizes the number of waste packages hit by a single conduit that intersects a drift.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is conservative in that it maximizes the number of waste packages hit for any conduit that intersects a drift.
Use within the Calculation: The parameters associated with this assumption are used in Sections 5.1.2.

3.9 WHEN ONE CONDUIT INTERSECTS TWO DRIFTS

Assumption: When the diameter of one conduit is greater than 75 m and it intersects two drifts, it is assumed that the number of waste packages destroyed is twice the number of packages destroyed in the first drift.
Rationale: This assumption is a simplification that maximizes the number of waste packages hit by a single conduit that intersects two drifts.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is conservative in that it maximizes the number of waste packages hit when one conduit intersects two drifts.

Use within the Calculation: The parameters associated with this assumption are used in Sections 5.1.2.

3.10 WHEN MULTIPLE CONDUITS INTERSECT THE REPOSITORY

Assumption: When multiple conduits occur within the repository footprint, all conduits are assumed to have the same diameter and to be coincident (centered) with drifts.
Rationale: This assumption is a simplification that maximizes the number of waste packages hit by multiple conduits.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is conservative because it maximizes the number of waste packages hit when multiple conduits occur within the repository footprint.
Use within the Calculation: The parameters associated with this assumption are used in Sections 5.1.2.

3.11 WASTE PACKAGES DESTROYED WITHIN A CONDUIT

Assumption: It is assumed that only those waste packages located partially or entirely within the area of the eruptive conduit contribute to the radionuclide source term for the volcanic release scenario. The number of waste packages within an eruptive conduit is a function of conduit diameter, waste package length, and inter-package spacing.
Rationale: Although magma associated with an eruption may contact other packages along the drift, the magma moving with sufficient velocity to entrain waste in an eruption is assumed to be located only within the conduit.
Confirmation Status: No additional work is planned to verify this assumption. This assumption is considered reasonable.
Use within the Calculation: The parameters associated with this assumption are used in Sections 5.1.2.

4. USE OF COMPUTER SOFTWARE AND MODELS

This calculation is a hand calculation that uses built-in spreadsheet applications from the EXCEL 98 (Macintosh) spreadsheet program (identical to EXCEL-97 for Windows). Only EXCEL built-in functions (such as SUM, SIN, COS, ATAN, MIN, MAX, IF, OR, etc) have been used in the calculation. These built-in functions are used in EXCEL workbooks (Data Tracking Numbers (DTN) SN0001T0801500.001 and MO0004SPACAL01.001) to:

- Sort input data;
- Sample input data for use in equations 1 through 8;
- Facilitate the hand calculations specified in equations 1 through 8; and
- Develop probabilities and cumulative distribution functions (CDF's).

Sections 5.2 and 5.3 provide detailed discussions on the applications of all built-in EXCEL functions used in this calculation.

5. CALCULATION

The objective of this calculation is to develop a probabilistic measure for the number of waste packages affected (either damaged or dispersed) under the following two scenarios:

> Volcanic Eruption Scenario: Number of waste packages contained within an eruptive conduit of a specified diameter, given that a dike has intersected the drift, and that the conduit is located at a drift,
>
> Igneous Intrusion Groundwater Release Scenario: Number of waste packages in the drifts that have been contacted by magma, given that a dike has intersected the drifts.

The probability of occurrence for the Volcanic Eruption Scenario (P [conduit occurs at a drift on a dike inside the repository]) can be expressed in terms of its component probabilities as:

P [one conduit coincides with a drift] • (a)
P [conduit occurs anywhere inside the repository on a dike of length L, azimuth α] • (b)
P [dike with parameters (L,α) occurs in repository] • (c)
P [dike intersects repository footprint]. (d)

Component probabilities (b), (c), and (d) are provided in CRWMS M&O 1999a - PA-NEP-99347.T. The dike length–azimuth (L,α) data file represents the possible outcomes and their corresponding probabilities for a simulation of a dike intrusion event into the repository area. The conditional probability of this event is 1.0 Any individual (L,α) pair is only a component of the total conditional probability. To evaluate the event, the component probabilities are summed over all (L,α) pairs to give the probability that a conduit occurs at a drift.

The probability of occurrence for the Igneous Intrusion scenario (P [dike crosses n drifts]) can be expressed in terms of its component probabilities as:

P [dike with parameters (L,α) occurs in repository] • (c)
P [dike intersects repository footprint]. (d)

The component probabilities are summed over all (L,α) pairs to give the probability that a dike has intersected a drift. In the following sections, the component probabilities are described in more detail.

5.1 INPUT SOURCES

The CCSM-PCB output file of conditional probabilities (CRWMS M&O 1999a - PA-NEP-99347.T) is used as input to this calculation for dike length, azimuth angle, and number of eruptive centers (conduits) on a dike. The probabilities in this output file are conditional on the occurrence of intersections of the repository by a dike. The output file consists of over 3700 points in a parameter space for dike length and azimuth angle. The data exhaustively cover all angles from 0° (north) to 175° in 5 increments (south-southeast) and lengths from 0 km to 5.15 km in 0.05 km increments. At each length-azimuth point, the simulation has stochastically calculated the probability of occurrence. Details of the calculation are discussed in CRWMS M&O 1999a - PA-NEP-99347.T, but in essence the simulation assumes an origin for the igneous event and a dike with a given length and direction extending away from the origin. Points of origin have been used throughout the region around the repository based on the PVHA experts' interpretations. This is discussed in CRWMS M&O 2000b, Section 6.4.2.

The CCSM-PCB output data file is a single simulation of many thousands of dike intrusions into Yucca Mountain. The highest-probability points therefore represent the most likely dike lengths and directions inside the repository. Figure I-2 shows the joint PDF for dike length inside the repository and dike azimuth angle. Note that although the data file gives azimuths from 0° to 175°, they have been adjusted in the plot to run from –90° to 90° to better display the PDF. To calculate the aggregate probability of igneous activity, we must sum over all the realizations (individual probabilities) in the data file.

The repository layouts, including drift orientation, drift spacing, and drift diameters have been provided by data transmittals CRWMS M&O 1999e - PA-SSR-99218.Ta, Item 1 and CRWMS M&O 2000a - PA-SSR-99218.Tc. Two different drift orientations have been used as input to this calculation. The first drift orientation of 108° was provided by CRWMS M&O 1999e - PA-SSR-99218.Ta. The second drift orientation of 72° was provided by CRWMS M&O 2000a - PA-SSR-99218.Tc. Figure I-3 shows a representation of the layout of some of the drifts. The layout documents distinguished between a "primary block" and a slightly larger "primary + contingency block." The drift orientation for the first case has been calculated as being 108° (i.e., running primarily east west, but slightly oriented NW-SE). The orientation has been calculated from the "slope" of a horizontal line representing a drift using the northing and easting values provided in the document, and then evaluating the arctangent of that slope. The resulting value (in radians) has been converted to degrees, and the angle expressed in terms of a compass heading. For the second case, which contains a more recent design, the orientation is calculated to be 72°.

Waste-package dimensions and spacing come from SN9908T0872799.004. The value used for waste-package length is the entry "Average waste package length" in the DTN; it is the average length of all the package types to be emplaced weighted by the numbers of packages. The waste-package spacing is the DTN entry "Waste package spacing", and is that specified by Enhanced Design Alternatives (EDA) II, Design B (CRWMS M&O 1999f). Possible design changes could change this value, which would require complete recalculation of numbers of packages hit for both extrusive and intrusive events.

PDFs for dike width and eruptive conduit diameter come from CRWMS M&O 2000d, Section 6.1. Dikes are expected to propagate in swarms at repository depth (CRWMS M&O 2000d, Section 6.1). Magma that flows down drifts away from the dike can proceed until the materials in the drift obstruct it, or it solidifies. Waste packages that are so impacted by this laterally flowing magma can be destroyed, and thus can release radionuclides that may be later transported by groundwater. From CRWMS M&O 2000c (Section 7), magma is considered to flow approximately 15 m on either side of the dike through the drifts for a repository design that includes backfill. Thus, if a dike swarm has spacing of approximately 30 m or less between dikes, all the waste packages between the dikes will be contacted by the magma. The effective width of a single dike is thus the actual dike width plus 30 m. As a conservative assumption, if several parallel dikes reach a drift, a dike spacing of 30 m is assumed, (assumption 3.6) which maximizes the magma flow between the dikes through the drifts. Thus, the effective width of the swarm is the sum of the effective widths of the individual dikes. All dikes in a swarm are assumed to have the same length and width.

The dike width distribution for a single dike that is provided in CRWMS M&O 2000d, Section 6.1, has a mean of 1.5 m and a 95th percentile width of 4.5 m. The values are log-normally distributed. The parameters of a log normal distribution are the mean and the standard deviation. The log-normal distribution is fitted to the provided mean and maximum by adjusting the standard deviation until the maximum value occurs at the 0.9999 fractile of the distribution. A PDF for number of dikes in the swarm is also provided in CRWMS M&O 2000d, Section 6.1. This PDF has a mean of 3 dikes and a 95th percentile number of 10 dikes. Conduit diameter is also log-normally distributed, with a mean of 50 m and a maximum of approximately 150m, and is also provided in CRWMS M&O 2000d, Section 6.1.

5.2 CALCULATION OF NUMBER OF WASTE PACKAGES HIT UNDER THE VOLCANIC ERUPTION SCENARIO

Calculations for this scenario include:

- probability of a conduit of a given diameter intersecting one drift;
- probability of a conduit intersecting two drifts; and
- number of waste packages contained within an area circumscribed by a conduit diameter.

Conduit diameter is given by a PDF whose range is provided in CRWMS M&O 2000d, Section 6.1. The conduits are randomly located on the dike. We assume that if any part of the conduit area intersects a drift, then the packages are impacted by the intrusion in that drift. Thus, a conduit centered anywhere within a distance given by one conduit radius plus the drift diameter is considered to have intersected the drift. The probability of a conduit less than or equal to 75 m in diameter intersecting a drift is calculated using the following equation.

$$(CD+ d)/DS, \text{ for } CD \# 75 \text{ m} \qquad \text{(Eq. 1)}$$

where,

CD = conduit diameter (m)

d = drift diameter (m)

DS = drift spacing from centerline to centerline (m) (=81 m)

For conduit diameters greater than 75 m, one drift is always intersected. The probability of a conduit with a diameter greater than 75 m intersecting a second drift is calculated using the following equation.

$$(CD - (DS-d))/(DS-d), \text{ for } CD > 75 \text{ m} \qquad \text{(Eq. 2)}$$

For dike azimuths within a few degrees of the drift orientation, the dike and drift are essentially parallel. For these angles, the probability of conduit intersecting a drift is 1.0. The parallel angle used in this calculation is defined as the arctangent of the drift spacing divided by the drift length and is +/- 3.9 degrees.

For conduit diameters greater than 75 m (approximately the distance between adjacent drifts), at least one drift is always intersected by the conduit. The probability that two drifts are intersected is given by Equation 2. This is used to calculate the probability that two drifts (and thus double the number of waste packages) are intersected by the conduit.

The number of packages in a drift that are within a conduit diameter is found by using the waste-package length and inter-package spacing (given in document CRWMS M&O 1999e - PA-SSR-99218.Ta) to determine the whole and fractional packages contained within the conduit:

$$N_{pkgconduit} = \text{CEILING } [CD/(P_l+P_s)], \text{ for CD\# 75m} \qquad \text{(Eq. 3)}$$

where *CEILING* is the EXCEL spreadsheet function that rounds up its arguments. The number of packages is the quotient of conduit diameter divided by the sum of package length, P_l, and package spacing, P_s (SN9908T087299.004) (Although a conduit not centered on a drift would theoretically intersect fewer packages, this factor is ignored in the calculation as a conservatism.). For conduit diameters larger than 75 m (distance between adjacent drifts), Equation 2 is used to calculate the probability that a second drift is intersected. If this occurs, $N_{pkgconduit}$ is doubled. Note that this calculation for $N_{pkconduit}$ does not consider additional packages that would be impacted at the periphery of a large conduit.

The component probabilities that a conduit occurs at a drift on a dike inside the repository include:

- probability (a) calculated using Equation 1;
- probability (b) taken from the CCSM-PCB output file. These values are listed as conditional probabilities of numbers of eruptive centers for each (L,α) pair;
- probability (c) also comes from the CCSM-PCB output file. It is the probability values listed for the dike length–azimuth pairs; and
- probability (d) is the aggregated annual frequency of occurrence of an igneous intrusion intersecting the repository footprint, as provided by the PVHA, and modified to account for the changed repository outline (CRWMS M&O 2000b and CRWMS M&O 1999a - PA-NEP-99347.T, CRWMS M&O 2000a - PA-SSR-99218.Tc).

5.2.1 Volcanic Eruption Scenario Calculation Spreadsheets

The analysis for number of waste packages hit by an eruption is done in EXCEL workbook *PCB_Volc_Anal*.xls (see Figure I-4 for general information flow in the spreadsheets). This EXCEL workbook includes six spreadsheets that document the calculation to determine number of waste packages hit under the volcanic eruption scenario. The examples discussed in detail relate to the drift orientation of 108°. However, calculations were also conducted for 72° drift orientation.

The EXCEL spreadsheets discussed for a drift orientation of 108° in the following paragraphs are in SN0001T0801500.001. For 72°, the spreadsheets are in MO0004SPACAL01.001. The following spreadsheet discussion focuses primarily on the case for the drift orientation of 108°.

Spreadsheet No.1 - *CCSM-PCB.OUT* – This spreadsheet contains the output file data (3744 entries) from the simulation CCSM-PCB (CRWMS M&O 1999a - PA-NEP-99347.T). Table II-1 shows a portion of this spreadsheet that includes the output files for the IUD-UC and IUD-C alternative models for the distribution of eruptive centers (conduits) along the dike. The first column of the table gives the dike length (in km); the second column is azimuth angle (in degrees from north). The third column is the probability of occurrence of that length-azimuth pair in the simulation. Following that column are two groups of six columns, each group giving the probabilities for 0, 1, 2, 3, 4, or 5 conduits simulated from the IUD-UC and IUD-C alternative models.

Spreadsheet No.2 – *No Zeros* - The simulation CCSM-PCB data included many length-azimuth pairs that were zero (i.e., the simulations produced no instances where a dike had those parameters). This spreadsheet uses the EXCEL sorting function to retain only the non-zero length–azimuth probabilities and reduces the file size from 3744 entries to 1676 entries. In addition, the data have been sorted to make the azimuth the more slowly varying. Reordering the pairs allows the probabilities to be easily summed over all dike lengths for each azimuth angle.

Table II-2 in this calculation shows a portion of this spreadsheet including output files for the IUD-UC and IUD-C alternative conceptual models. It can be seen in column 3 of this table that there is a large difference in probability of occurrence between the most probable length–azimuth pairs (at 30°), and those dikes oriented along different azimuths. Of particular interest in these results are orientations near 108° (the same drift orientation for the first case considered in this calculation). These probabilities can be seen to be approximately two to three orders of magnitude lower than the maximum probabilities The bottom of the data file also shows the marginal (i.e., weighted-average) probabilities for the occurrence of 0 through 5 vents for IUD-UC and IUC-C alternative models.

Spreadsheet No. 3 - *Inp-params-vol* - This spreadsheet summarizes the other input information used in the calculation.

Table II-3 duplicates this spreadsheet for a drift orientation of 108°. (Table II-10 provides similar information for a drift orientation of 72°). The top box of this spreadsheet includes the following inputs: drift angle; drift spacing; drift diameter; waste package length; waste package spacing; the north, south, east and west coordinates outlining the primary plus contingency block of the repository footprint; the azimuth range at which dikes and drifts can be considered to be parallel; the "parallel angle" (calculated from the arctangent of the drift spacing divided by drift length); the north-south repository length; the drift length (azimuth angle 108°); and the east-west repository length. Information on waste packages is taken from SN9908T087299.004. Information on repository layout is taken from CRWMS M&O 1999e - PA-SSR-99218.Ta.

The bottom box on this spreadsheet provides the CDF look-up table for conduit diameter in meters and the probabilities that two drifts are intersected for large-diameter conduits (calculated using Equation 2).

Spreadsheet No. 4 - *Prob calcs*

This spreadsheet calculates the CDFs for the probabilities of 1 through 5 eruptive centers (conduits) to occur on a dike within the repository footprint. In addition, it calculates the number of waste packages in an eruptive conduit.

Table II-4 in this calculation shows an example of these calculations for the IUD-UC alternative model for the 108° case. (Table II-11 provides a similar example for the 72° case). The following discussion refers to this table.

Columns 1 through 3 repeat the input data – dike length, azimuth and probability – given in Table II-2. Because we wish to evaluate the probabilities of all possible dikes, the same conduit diameter is applied to every (L,α) pair in the data set. The conduit diameter is taken from the CDF look-up table in spreadsheet *Inp – params – vol* Table II-3. Because the probability distributions are presented as CDFs, using a uniform random variate over [0,1] will sample from the associated PDFs with the correct weighting. The random number used for sampling and the corresponding conduit diameter are shown at the top of column 4. Because the number of packages contained within a conduit is only a function of conduit diameter, this value is also constant for all (L,α) pairs in any one realization. The conduit diameter is used in Equation 1 to calculate the probability of intersection with a drift (shown in column 4). For conduits larger than 75 m or for conduits of any size that originates on dikes whose orientations are within the azimuth range defined by the "parallel angle" (see Table II-3), the probability of intersection is 1.0.

The number of packages hit in one drift, as calculated by Equation 3, is shown at the top of column 5. For conduit diameters less than 75 m, at most only one drift can be intersected. For larger conduits the probabilities for intersecting two drifts are calculated using Equation 2 and shown in Table II-3. These probabilities are then used in this spreadsheet by comparing the random number at the top of column 5 (labeled *Rand (drifts)*) with the probabilities in Table II-3 appropriate for the conduit diameter. Random numbers less than the probability for that conduit size, indicate that two drifts are hit. In this case, the number of packages hit is doubled. This is calculated by multiplying the results from Equation 3 by 2.

Columns 5 through 10 of the spreadsheet repeat the CCSM-PCB output file for the probabilities for 0 to 5 eruptive centers for each (L,α) pair. In columns 11 through 17, the weighted probabilities are calculated. Thus, column 12 (headed by a 1 — indicating it is the probability for one vent) is calculated as the product of: (a) the probability that one conduit intersects a dike calculated using Equation 1 (shown in column 4), (b) the probability that a conduit occurs anywhere inside the repository footprint on a dike with length L and azimuth α (given in column 3), and (c) the probability that a dike with a length/azimuth pair (L,α) (shown in column 6). The weighted probabilities for one conduit for all (L,α) pairs are then summed. The value is shown in Table II-4 at the top of column 12 as 0.115. Weighted probabilities for two through five conduits are similarly calculated and summed in columns 13 through 16. These weighted probabilities are then converted to a CDF. The CDF for one conduit is calculated by summing the weighted probabilities for one to five conduits and subtracting this value from 1.0. The CDF for two conduits is calculated by summing the weighted probabilities for two through five conduits and subtracting this value from 1.0. The CDF values for three through five conduits are similarly calculated. The CDF values are shown immediately beneath the weighted probabilities (columns 12 through 16). The numbers of vents corresponding to each CDF value are shown in the next row down. These two rows are formatted as an EXCEL lookup table using the VLOOKUP function. This calculation is repeated in this spreadsheet for all other four alternative models.

Spreadsheet No. 5 - *Simulations-vol* - The next spreadsheet in the workbook, labeled *Simulations-vol*, samples from the probability distributions in Spreadsheet No. 4 to calculate the numbers of waste packages circumscribed by one or more conduits.

We now have the probabilities for having one or more conduits intersect a drift, given the conduit diameter, and given that a dike with specified length and azimuth intersects the repository, summed over all length-azimuth values. We can randomly sample from these probability distributions to simulate the numbers of waste packages circumscribed by one or more conduits.

Table II-5 shows the first 40 of the entries (out of 2000) from this spreadsheet for a drift orientation of 108°. (Table II-12 shows the same information for the 72° case). A random number in the first column is used to sample from the lookup tables in the Spreadsheet No. 4 *Prob calcs*. This is done for each of the five alternative conceptual models for number of eruptive centers (conduits) on a dike. Every time the workbook is recalculated, a new conduit diameter is randomly picked. This in turn causes a new number of packages within the conduit to be calculated. The probability of intersection of a conduit and a drift is dependent on conduit diameter, and this is a factor in the construction of the CDF for number of conduits. Thus, a new CDF for number of conduits is constructed for every recalculation. The CDF is randomly sampled 2000 times in the spreadsheet *Simulations-vol*, and the results are compiled in the box at the top of Table II-5. CRWMS M&O 2000b (Section 6.5.2.2) provides weightings and justification for the five models for number of conduits and these are used to produce the probabilities listed at the right side of the box at the top of this spreadsheet. The weightings are shown at the bottom part of Table II-5

When the consequences for multiple conduits occurring inside the repository are calculated, all conduits are assumed to be coincident with drifts, so the total number of packages hit is the number calculated for one conduit multiplied by the number of conduits. For conduits larger than 75 m, the probability of a conduit coinciding with a drift is 1.0, so the marginal probabilities given in Table II-2 (bottom row) should be approximately the same as those found by the simulations done in the calculation shown in Table II-5. The Table II-2 values can be compared in the values tabulated in the middle part of Table II-5, Page 41. From Table II-5, the probability entries for P(0) and P(1) for IUD-UC are 0.6515 and 0.2685, respectively. From Table II-2 (bottom row) the corresponding values are 0.6286 and 0.2857 (rounded to four significant digits). It can be seen that the values are similar. The values calculated in this analysis differ from those presented in Table II-2 because they are the results of statistically sampling two different population sizes (this analysis used a population of 1000 while the data in Table II-2 are based on a much larger sample size).

Spreadsheet No. 6 - *RIP-inp-Volc* - The last spreadsheet is shown on Table II-6 and contains the output from this calculation for a drift orientation of 108° for use in the TSPA model. (Table II-13 shows the same information for the 72° case). The output parameter sets consist of the conduit diameter, the number of packages within a single conduit, and the probabilities for 0 through 5 conduits occurring at drifts. Results for representative conduit diameters across the entire range of the distribution are provided for input to the TSPA model. Probability (d) – the probability of an igneous intrusion intersecting the repository footprint – is applied when the total-system risk assessment is calculated in the TSPA analysis and thus is not included in these probabilities.

Beneath the tabulation of results for representative conduit diameters is a tabulation of summary statistics for conduits with diameters larger than 75 m. This tabulation was created using EXCEL functions. Conduit diameters greater than 75m are assumed to hit 1 drift. The probabilities do not depend on conduit diameter, so any variations are due to statistical effects. If the CRWMS M&O 2000b table is weighted, it will give numbers nearly identical to these numbers.

5.3 CALCULATION OF THE NUMBER OF WASTE PACKAGES HIT UNDER THE IGNEOUS INTRUSION GROUNDWATER EVENT SCENARIO

Calculations for this scenario include:

- maximum dike length inside the repository based on repository dimensions;
- dike length along a line perpendicular to the drifts;
- number of drifts crossed by a dike; and
- dike effective intersection length coincident with a drift.

These calculations are combined with input information identified in Section 5.1 to calculate the number of waste packages hit by a dike and its associated magma that flows along a drift.

Dike lengths provided in CRWMS M&O 2000b can be longer than the east–west extent of the repository. The limits on dike length for any azimuth angle α relative to repository dimensions is given by

$$L_r = R_{ew}/\sin(\alpha), \qquad \text{(Eq. 4)}$$

where L_r is dike length inside the repository, R_{ew} is the maximum east-west extent of the repository (value obtained from document CRWMS M&O 1999e - PA-SSR-99218.Ta).

Dike lengths in Spreadsheet No.1 – *CCSM-PCB.out* can be as much as 5.15 km. If dikes were oriented roughly East–West, then a dike length could be longer than the repository E–W dimension. Thus, it is necessary to make sure that the dike lengths used in calculations are not greater than the length of the repository. The repository length dimensions in meters are labeled "Repos N-S" and "Repos E-W" on Tables II-3, II-7, II-10, and II-14 and are based on the maximum values from CRWMS M&O 1999e – PA-SSR-99218.Ta. Because most dikes are short, and very few are oriented E-W, this calculation check turned out to be moot. This is similar for the 72° case.

The dike length along a line perpendicular to the drifts is calculated from the relation

$$D_n = L_r \sin(\beta - \alpha), \qquad \text{(Eq. 5)}$$

where D_n is the dike length along a line perpendicular to the drifts. L_r is given by Equation 4, and $(\beta-\alpha)$ is the angle between a dike with orientation from north of α, and a drift with the compass heading β. Figures I-5a and I-5b shows these relationships for the 108° drift orientation case.

The number of drifts crossed by the dike (n_D) is calculated by dividing D_n by the drift spacing (d_s) provided in document CRWMS M&O 1999e - PA-SSR-99218.Ta

$$n_D = D_n/d_s \qquad \text{(Eq. 6)}$$

A dike can intersect the drifts at various angles. The closer the angle of intersection is to the orientation of the drifts, the greater is the distance that the dike is coincident with the drift. This distance that a dike is coincident with a drift is referred to herein as the dike effective intersection length and is calculated as

$$D_p = d/\tan(\beta-\alpha) + t/\sin(\beta-\alpha), \qquad \text{(Eq. 7)}$$

where the effective intersection length coincident with a drift (D_p) is the length of the dike coinciding with the drift, d is drift diameter and t is dike thickness. Figure I-5c illustrates this relationship.

The number of waste packages impacted or damaged by magma in the drifts (but not within an eruptive conduit) is given by the number of whole and fractional packages that lie within the distance that a dike and drift are coincident times the number of drifts crossed by the dike. Combining Equations 6 and 7:

$$N_{pkgdike} = [n_D \bullet \mathrm{CEILING}[D_p/(P_l+P_s)]] \qquad \text{(Eq. 8)}$$

Note that this calculation for $N_{pkgdike}$ counts packages that may be removed by an erupting conduit.

5.3.1 Igneous Intrusion Groundwater Event Calculation Spreadsheets

This analysis (enhanced source term analysis) is done in Excel workbook *PCB-EST-Anal.xls* (SN0001T0801500.001). This EXCEL workbook includes five spreadsheets that document the entire calculation (see Figure I-4). The first three spreadsheets of this workbook are substantially the same as those used for the volcanic analysis discussed above, with the major exception that the *No_Zeroes* spreadsheet doesn't include the "number of volcanic centers" calculation.

Spreadsheet No.1 - *CCSM-PCB.OUT* – This spreadsheet contains the output file data (3744 entries) from the simulation CCSM-PCB (CRWMS M&O 2000d).

Examples of output information used in this calculation are shown in the first three columns of Table II-1. The first column of the table gives the dike length (in km); the second column is azimuth angle (in degrees from north). The third column is the probability of occurrence of that length-azimuth pair in the simulation.

Spreadsheet No.2 – *No Zeros* - The simulation CCSM-PCB data included many length-azimuth pairs that were zero (i.e., the simulations produced no instances where a dike had those parameters). This spreadsheet uses the EXCEL sorting function to retain only the non-zero length–azimuth probabilities and reduces the file size to 1676 entries. In addition, the data have been sorted to make the azimuth the more slowly varying. Reordering the pairs allows the probabilities to be easily summed over all dike lengths for each azimuth angle. This is identical to the volcanic *No Zero* spreadsheet, except that only the dike length –azimuth probabilities are included.

Spreadsheet No. 3 - *Inp-params-EST* - This spreadsheet summarizes the other input information used in the calculation

Table II-7 duplicates this spreadsheet for a drift orientation of 108° and it is very similar to Table II-3, except that the CDF's for dike width and number of dikes in the swarm are used, instead of the CDF for conduit diameter and the probability of hitting two drifts. (Table II-14 shows the same information for the 72° case). The top box of this spreadsheet includes the following inputs: drift angle; drift spacing; drift diameter; waste package length; waste package spacing; the north, south, east and west coordinates outlining the primary plus contingency block of the repository; the north-south repository length; the drift length (azimuth angle 108°); and the east-west repository length. Information on waste packages is taken from SN9908T087299.004. Information on repository layout is taken from CRWMS M&O 1999e - PA-SSR-99218.Ta.

The bottom box on this spreadsheet provides CDF look-up tables for dike width and number of dikes in the swarm.

Spreadsheet No. 4 - *Simulations-EST* - The next spreadsheet in the workbook, labeled *Simulations-EST*, samples from the CDF look-up tables in Spreadsheet No. 3 to calculate the numbers of waste packages hit by one or more dikes.

The number of waste packages that can contribute to the enhanced source term is calculated from the simulations shown in Table II-8 (labeled *Simulations-EST*) for a drift orientation of 108°. (Table II-15 presents similar information for the 72° case). This spreadsheet repeats the dike length, azimuth, and probability data from sheet *No-zeros*. Column 4 uses Equation 3 to calculate the maximum dike length that can lie within repository boundaries based on the length and azimuth angle. (These values turn out to be equal to the dike length given in column 1 of this sheet because the points of intersection of the dike and the repository boundaries are chosen to maximize dike length that occurs inside the repository.) The dike length perpendicular to the drifts, D_n, is then calculated using Equation 5. Column 6 on the spreadsheet calculates the number of drifts crossed by the dike(s) by using Equation 6. (drift spacing given in Table II-7).

The formula to calculate the number of drifts crossed uses the EXCEL CEILING function to round up the number calculated, and imposes a minimum number of 1 drift crossed. For specified length and angle, we selected the longest length in the repository for maximum damage.

At the top of column 3, the dike width distribution is sampled using the random variant shown to select a width from the CDF given in Table II-7. The number of dikes in a swarm is sampled from the random number given at the top of column 4. An effective total width of the dike swarm is calculated from the sum of the estimate of the distance that magma will flow laterally along a drift away from the dike intersection (15 m on either side of the dike for a total of 30 m) from CRWMS M&O 2000c plus the dike width times the number of dikes in the swarm. The formula uses the CEILING function. The total width of the dike swarm is listed at the top of column 5. Using the total width of the dike swarm for the term d (dike width) in Equation 7, the effective dike intersection length coincident with a drift (D_p) is calculated in column 7 for each length-azimuth pair. The calculation imposes a limit on the coincident length equal to the maximum length of a drift (shown as Drift Length Table II-7). Column 8 lists the total numbers of waste packages hit under the Igneous Intrusion Groundwater Event Scenario as calculated using Equation 8.

This value is limited by the maximum number of packages in a drift (226), as provided by the repository layout information (CRWMS M&O 1999b - PA-EBS-99277.T, Item 1).

Column 8 lists the number of packages per drift for every dike length–azimuth pair in the file. Because of the different probabilities of occurrence, these numbers of packages must be weighted by the corresponding probabilities (column 3). The weighted average number of packages hit is listed at the top of column 8 as Weighted Average Packages hit. It also uses the Excel CEILING function to round the results up.

As column 7 of the *Simulations-EST* spreadsheet shows the effective dike length varies greatly with azimuth angle. The maximum effective dike length occurs at angles 105° and 110°. The number of drifts crossed varies with dike length and azimuth.

Spreadsheet No. 5 - *RIP-inp-EST* - The last spreadsheet shown in Table II-9 contains the output from this calculation for a drift orientation of 108° for use in the TSPA model. (Table II-16 shows similar information for the 72° case). The output parameter sets consist of the number of dikes intersecting the repository, dike width, number of waste packages hit, and the combined PDF for dike width/number of dikes The *Simulations-EST* (Table II-8) spreadsheet is repeatedly recalculated to exhaustively select dike width and number of dikes. This results in different weighted average numbers of packages hit for each combination of dike width and number, which are shown in column 3 of Table II-9.

6. RESULTS

This calculation may be affected by technical product input information that requires confirmation. Any changes to the calculation that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the input information quality may be confirmed by review of the Document Input Reference System database.

The output from this calculation includes: (1) Calculation Tables for the Number of Waste Packages Hit by Igneous Intrusion [SN0001T0801500.001] (for drift azimuth angle of 108°); (2) Calculation Tables for the Number of Waste Packages Hit by Igneous Intrusion [MO00045PACAL01.001] (for drift azimuth angle of 72°); and (3) Summary of Number of Waste Packages Hit by Igneous Intrusion for 72 and 108 degree drift orientations [MO00045PAWPI01.002].

6.1 VOLCANIC ERUPTION SCENARIO

For the drift orientation of 108° case, Table II-6 lists the number of packages hit per conduit and the probabilities of 0 through 5 conduits occurring on a dike. Table II-13 shows the same information for a drift orientation of 72°. The probability is calculated as a weighted sum for all five alternative conceptual models for number of eruptive centers (conduits) on a dike. These numbers are given for all conduit diameters ranging from 15 m to 150 m. For a 15-m conduit, the probability of one conduit occurring is approximately 10 percent. For multiple conduits, each probability is less than 2 percent. For a 150-m conduit, the probability of one conduit increases to approximately 44 percent. It is 6 percent for two conduits, and less than 1 percent for greater numbers of conduits. The relative likelihoods of the conduit sizes are given by the PDF for conduit diameter, which is shown in Figure I-6. For conduit diameters greater than 75 m, there is a probability that the conduit will intersect two drifts. This probability is randomly sampled in this calculation. As Table II-6 shows, two drifts were intersected for conduits of 100, 115, 120, and 135 meters and greater. Note that the numbers of packages hit for 100, 115, 120, and 135-m conduits are double the numbers for adjoining conduit sizes. This shows that two drifts were crossed. Table II-13 shows that two drifts are intersected for conduit diameters of 100-m, 110-m, 120-m, 130-m, 135-m and greater than 145-m. Other realizations could give different instances where two drifts were intersected. The probabilities for the larger conduit diameters are fairly closely distributed (note that the sample variances are all nearly zero). There is a 49 percent chance that the conduit(s) that occur on the dike do so outside of the repository footprint, and a 43 percent chance of having one conduit occur inside the repository (which coincides with a drift). These values are quite similar to the marginal probabilities for USRD-FD model, because of its large weighting (CRWMS M&O 2000b, Section 6.5.2.2). For the purposes of the TSPA model, the mean probabilities listed at the bottom of Table II-6 and II-13 are supplied for all conduit diameters greater than 75 m. This avoids the undesirable effects of the statistical fluctuations that appear in the individual probability numbers shown in Table II-6 and Table II-13 for these diameters.

This calculation provides a spreadsheet in Attachment III labeled *T0055_output.xls* that contains the following values for the volcanic eruption scenario for drift orientation of 108°:

- The conduit-diameter CDF look-up table (Table III-1)
- The probability for one conduit to intersect two drifts (Table III-1)
- Conduit probabilities and number of packages hit as a function of conduit diameter (Table III-2)

6.2 IGNEOUS INTRUSION GROUNDWATER EVENT SCENARIO

The results for the number of waste packages contacted by magma for the igneous intrusion groundwater event scenario are detailed in the EXCEL workbook *NPackHitCDFs_Summary.xls (MO00045PAWPI01.002).* This workbook includes an exhaustive list of all combinations of dike width and number of dikes (ranging from width of 0.1 m through 8.0 m, and 1 through 45 dikes). Each width–number pair has a probability of occurrence associated with it, calculated by multiplying the separate probabilities for dike width and for number of dikes. The PDFs for these two parameters are calculated from the information given in CRWMS M&O 1999d which provides the mean, maximum, and shape of the distribution for each parameter. The CDFs associated with these PDF distributions are given in both Tables II-7 and II-14.

The hand calculations to determine the number of waste packages contacted by magma are done using spreadsheet No. 4 *Simulations EST* from EXCEL workbook *PCB_EST_Anal_.xls*. These calculations involve manually setting dike width and then calculating the number of waste packages hit for the full spectrum of possible number of dikes (1 through 45). This series of hand calculations is then repeated for each dike width (.1 m through 8.0 m). Examples of output from this workbook are shown in Tables II-9 (for drift azimuth angle 108°) and Table II-16 (for drift azimuth angle 72°).

The relative likelihoods of these dike widths and numbers of dikes are given by the PDFs in Figures I-7a and b. Numbers of packages hit range from 98 to 226 (the maximum number of packages in a drift). 450 combinations of dike width and number of dikes have been calculated, which exhaustively samples the values in both CDF look up tables included in Table II-7 (108°) and II-14 (72°). The 50th percentile value of the distribution for number of packages hit is 190 (108°) and 194 (72°). Figure I-8 shows CDF for the number of packages hit for drift azimuth angle of 108°. Figure I-9 shows the same CDF for 72°. Because there is a fixed 30-m distance added to the dike width for the area impacted by magma (CRWMS M&O 2000c), some values of packages hit never occur in this calculation. Note that probability (d) listed in Section 5.0 above has not been incorporated. This probability must be applied in the TSPA model analysis.

This calculation provides a spreadsheet in Attachment III labeled *T0055_output.xls* that contains the following values for the igneous intrusion groundwater event scenario:

- The CDF for number of packages hit – drift azimuth angle 108°. (Table III-3)
- The CDF for number of packages hit – drift azimuth angle 72°. (Table III-4)

7. INPUTS AND REFERENCES

7.1 DOCUMENTS CITED

CRWMS M&O 1996. *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada.* BA0000000-01717-2200-00082 REV 0. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971201.0221.

CRWMS M&O 1999a. *Conditional Probabilities of Igneous Dike Lengths, Azimuths, and Number of Eruption Centers for Repository Intersection.* Input Transmittal PA-NEP-99347.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991220.0140.

CRWMS M&O 1999b. *Repository Subsurface Design Information to Support Total System Performance Assessment - Site Recommendation (TSPA-SR).* Input Transmittal PA-EBS-99277.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991011.0069.

CRWMS M&O 1999c. *Number of Waste Packages Hit by Igneous Intrusion.* TDP-WIS-PA-000008 Rev 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991201.0569.

CRWMS M&O 1999d. *Conduct of Performance Assessment.* Activity Evaluation, September 30, 1999. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991028.0092.

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CRWMS M&O 2000a. *Repository Subsurface Design Information to Support TSPA-SR.* PA-SSR-99218.Tc. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000424.0690.

CRWMS M&O 2000b. *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada.* ANL-MGR-GS-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. Submit to RPC URN-0215

CRWMS M&O 2000c. *Dike Propagation Near Drifts.* ANL-WIS-MD-000015. Las Vegas, Nevada: CRWMS M&O. Submit to RPC URN-0217

CRWMS M&O 2000d. *Characterize Eruptive Processes at Yucca Mountain, Nevada.* ANL-MGR-GS-000002. Las Vegas, Nevada: CRWMS M&O . Submit to RPC URN-0016

CRWMS M&O 2000e. *Igneous Consequence Modeling for TSPA-SR.* ANL-WIS-MD-000017. Las Vegas, Nevada: CRWMS M&O . Submit to RPC URN-0014

CRWMS M&O 2000f. *Number of Waste Packages Hit by Igneous Intrusion.* Development Plan. TDP-WIS-PA-000008 Rev 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000424.0700.

7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

AP-3.12Q. *Calculations.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL. 19990702.0312.

7.3 Source Data

SN9908T0872799.004. Tabulated In-Drift Geometric and Thermal Properties Used in Drift-Scale Models for TSPA-SR (Total System Performance Assessment-Site Recommendation). Submittal date: 08/30/1999.

8. ATTACHMENTS

ATTACHMENT I FIGURES

ATTACHMENT II TABLES

ATTACHMENT III T0055_OUTPUTS.XLS

SDS 5/18/2000 for JM

ATTACHMENT I

FIGURES

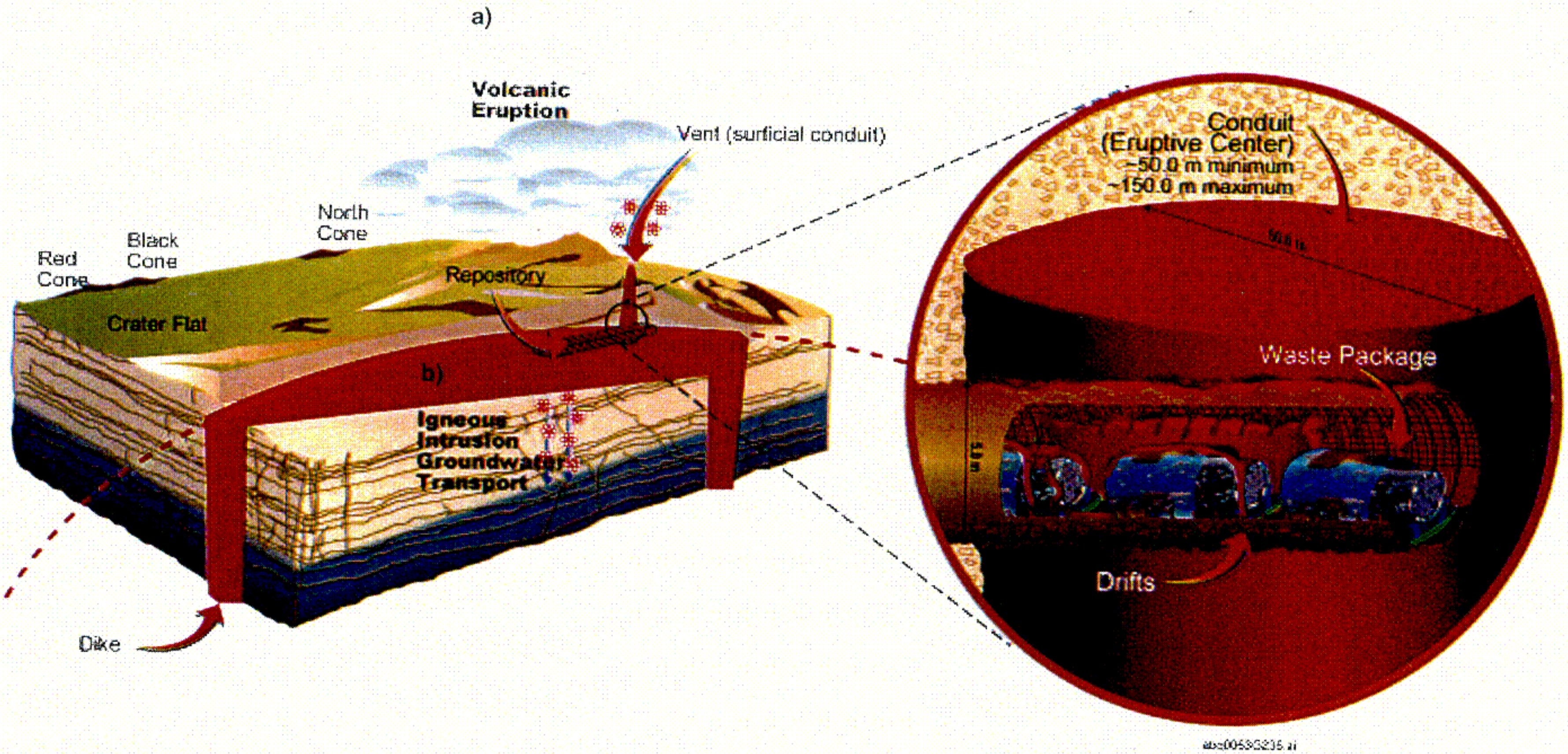

Figure I-1. Conceptual Figure of a) Volcanic Eruption and b) Igneous Intrusion Groundwater Release Scenarios

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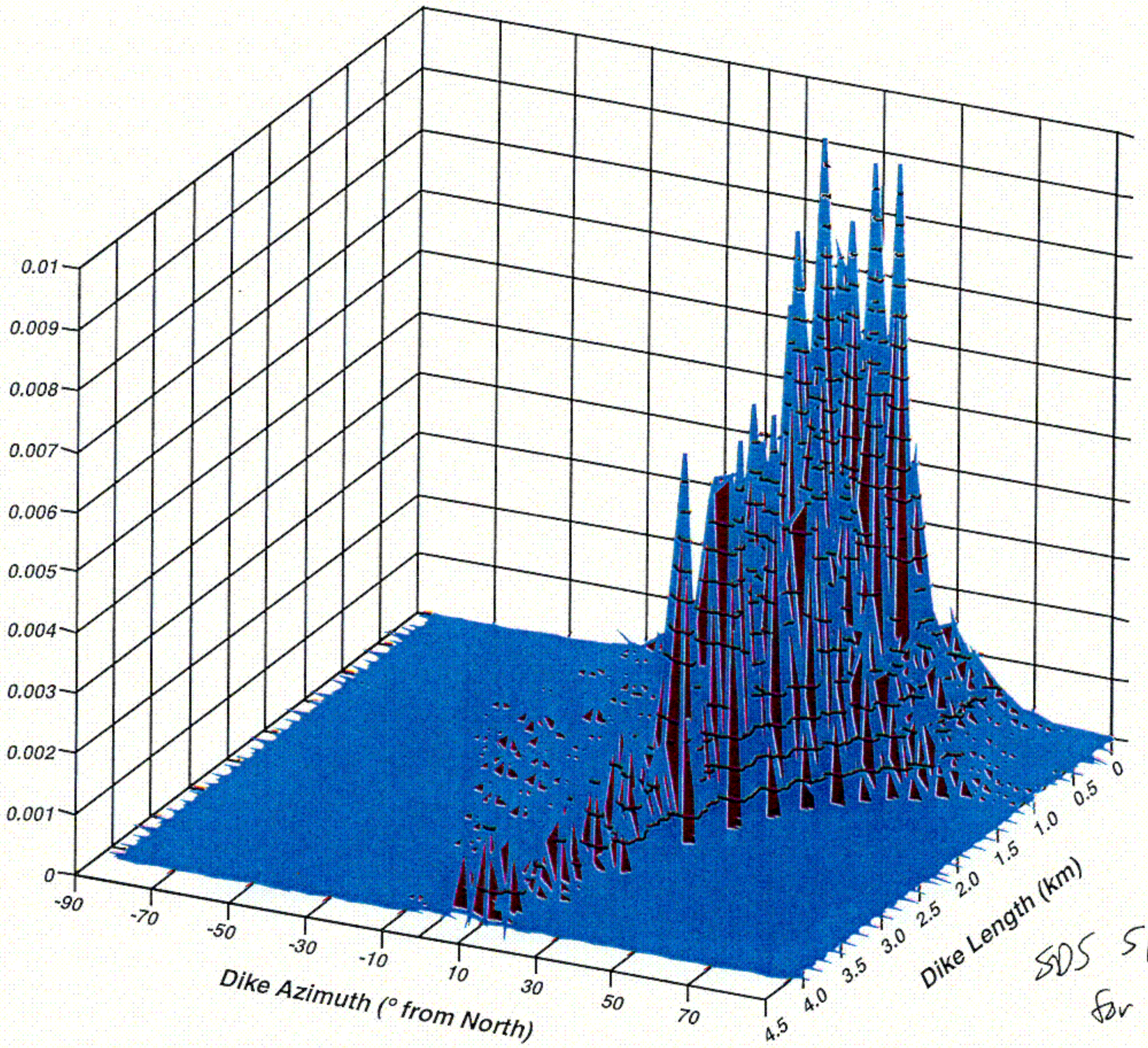

SDS 5/18/2000 for JM

Figure I-2. Joint Probability Distribution for Dike Length and Azimuth Angle (after CRWMS M&O 1999a - PA-NEP-99347.T)

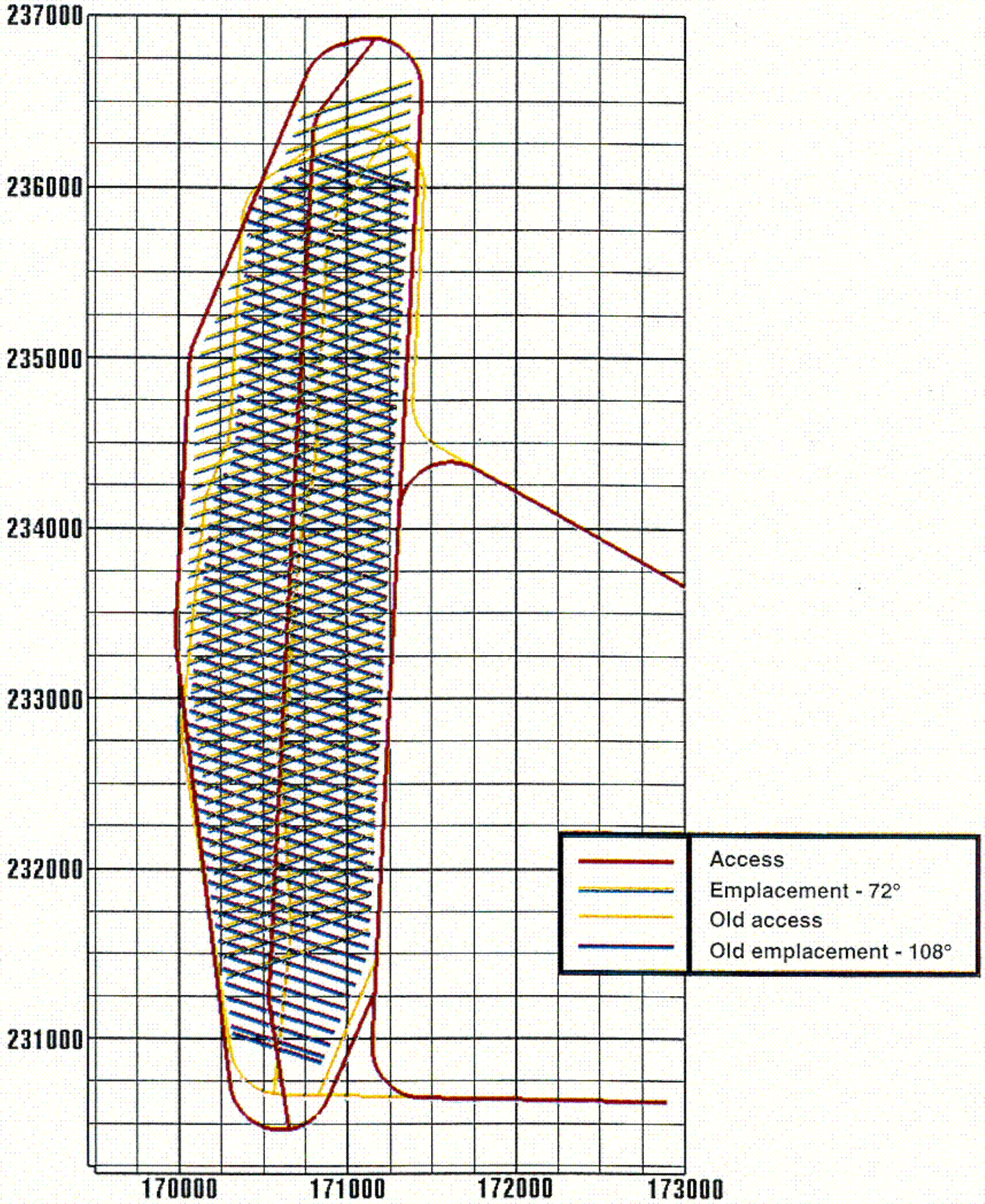

Figure I-3. Schematic of Repository Layout (after CRWMS M&O 1999e - PA-SSR-99218.Ta)

C03

SDS 5/18/2000 for JM

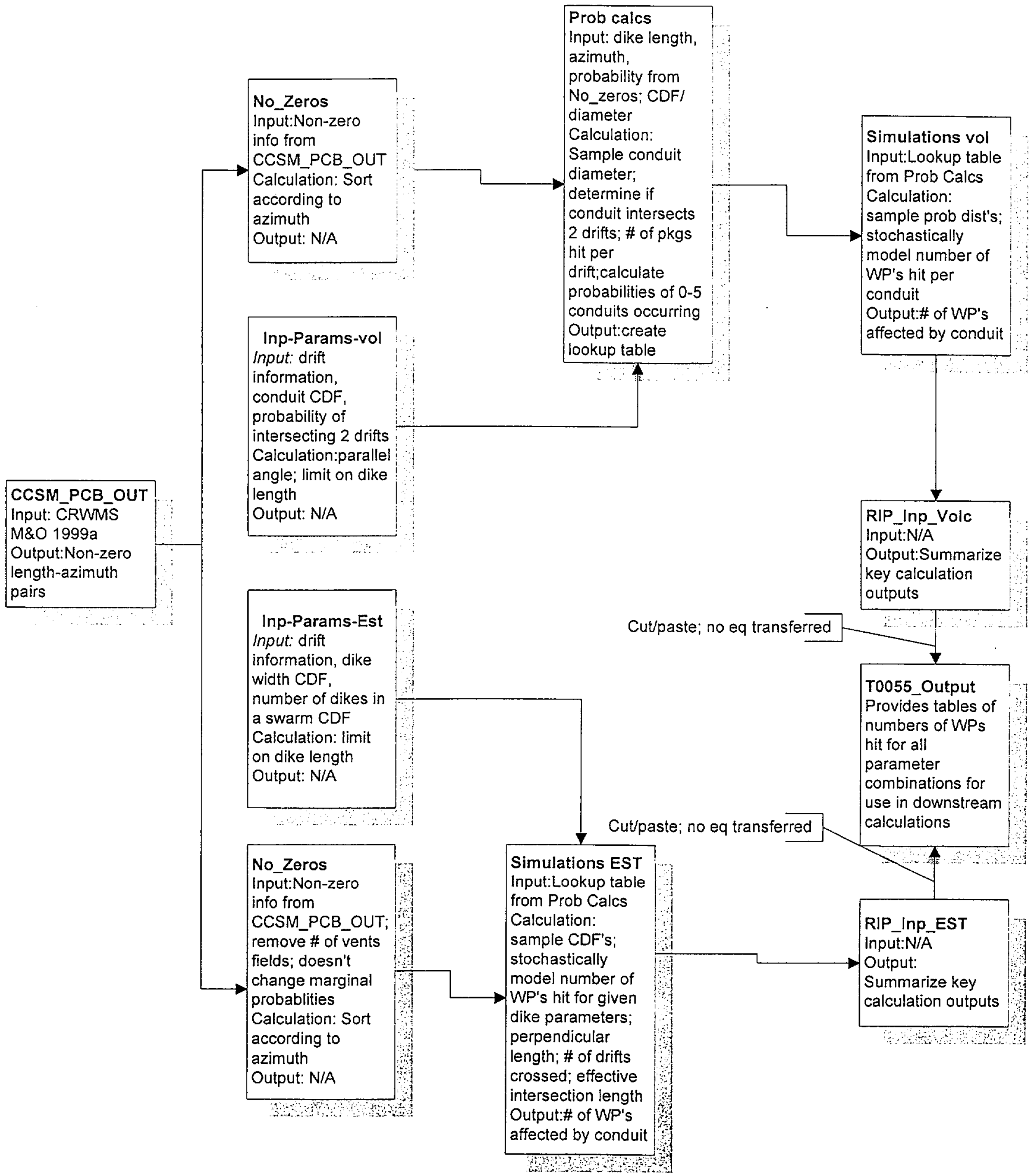

Figure I-4. Flowchart of Calculation of Number of Packages Impacted by Volcanic Event

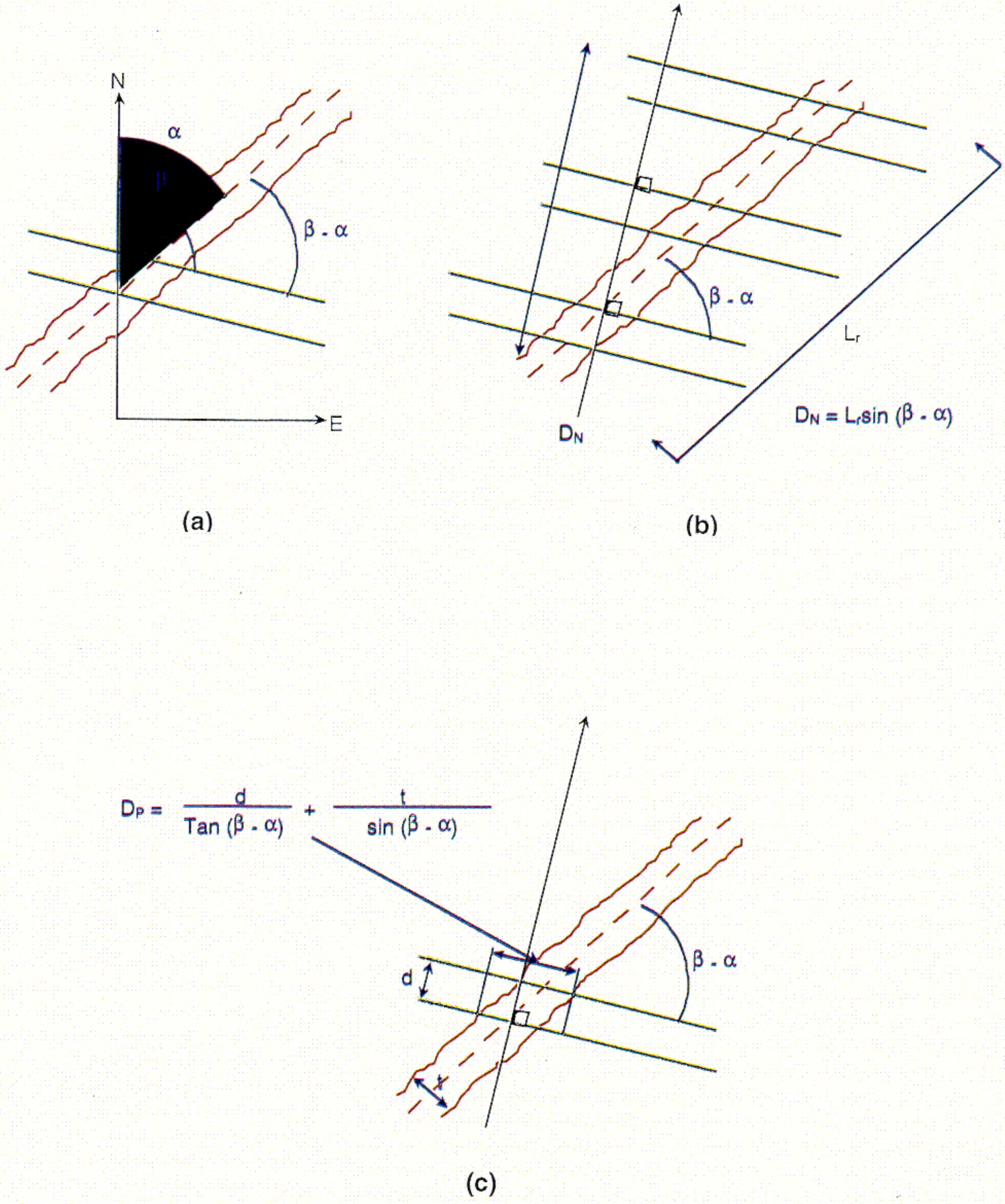

Figure I-5. Illustrations of Geometric Relationships between Dike and Drift

SDS 5/18/2000 for JM C04

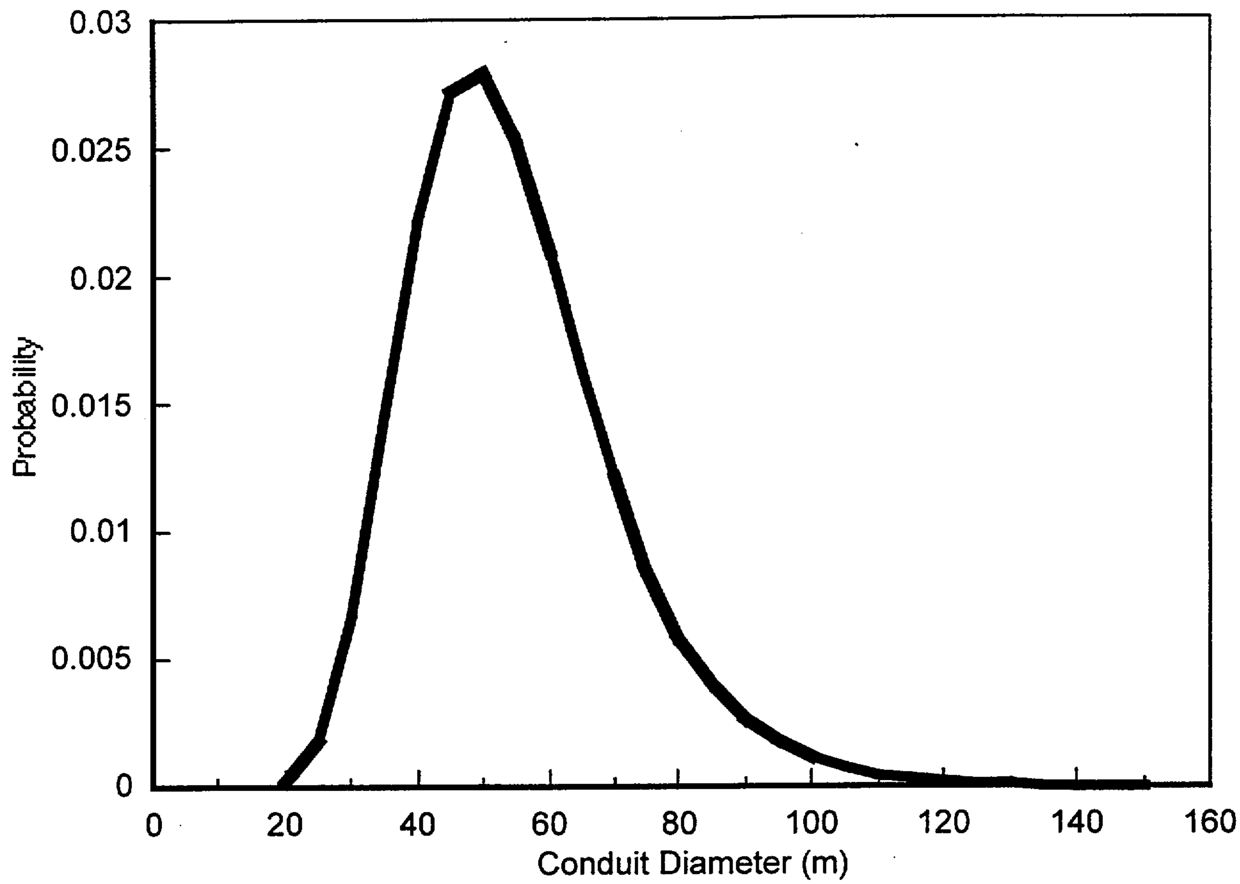

Figure I-6. PDF for Eruptive Conduit Diameter (after CRWMS M&O 2000d)

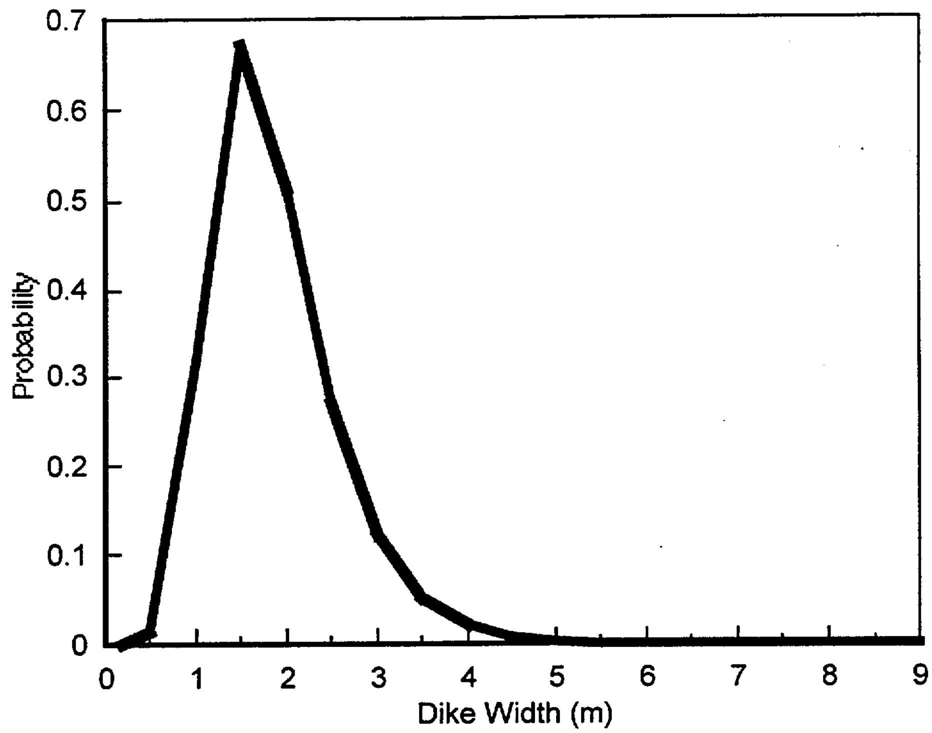

Figure I-7a. PDF for Dike Width (after CRWMS M&O 2000d)

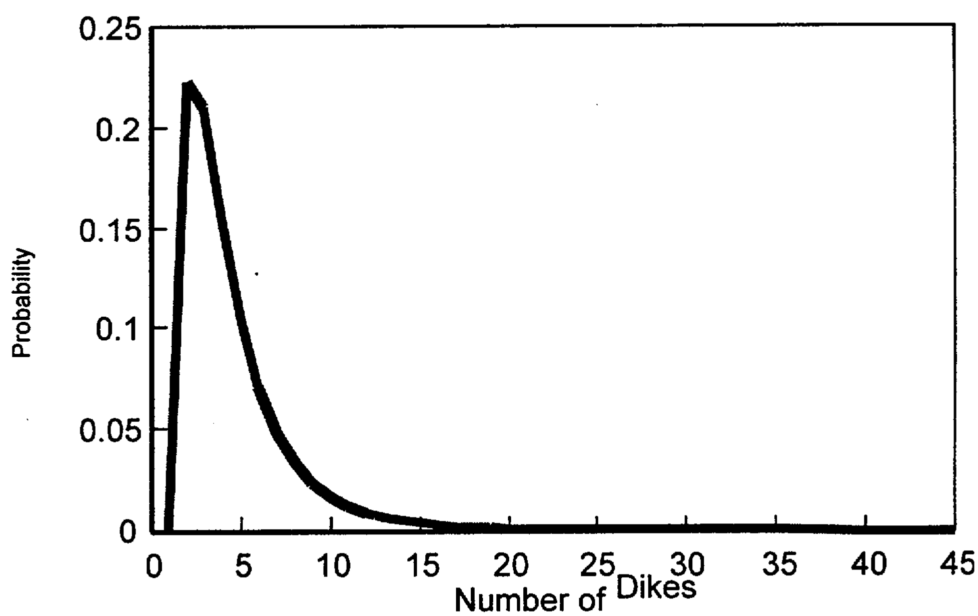

Figure I-7b. PDF for Number of Dikes in Swarm (after CRWMS M&O 2000d)

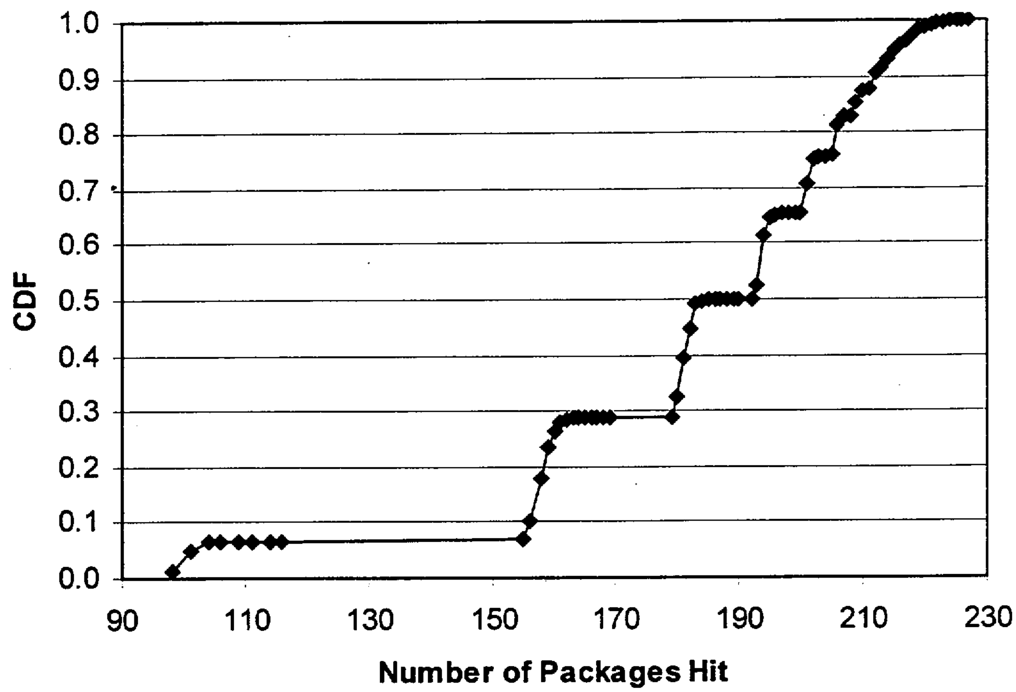

Figure I-8. CDF for Number of Packages Hit by Intrusion with a 108° Drift Orientation

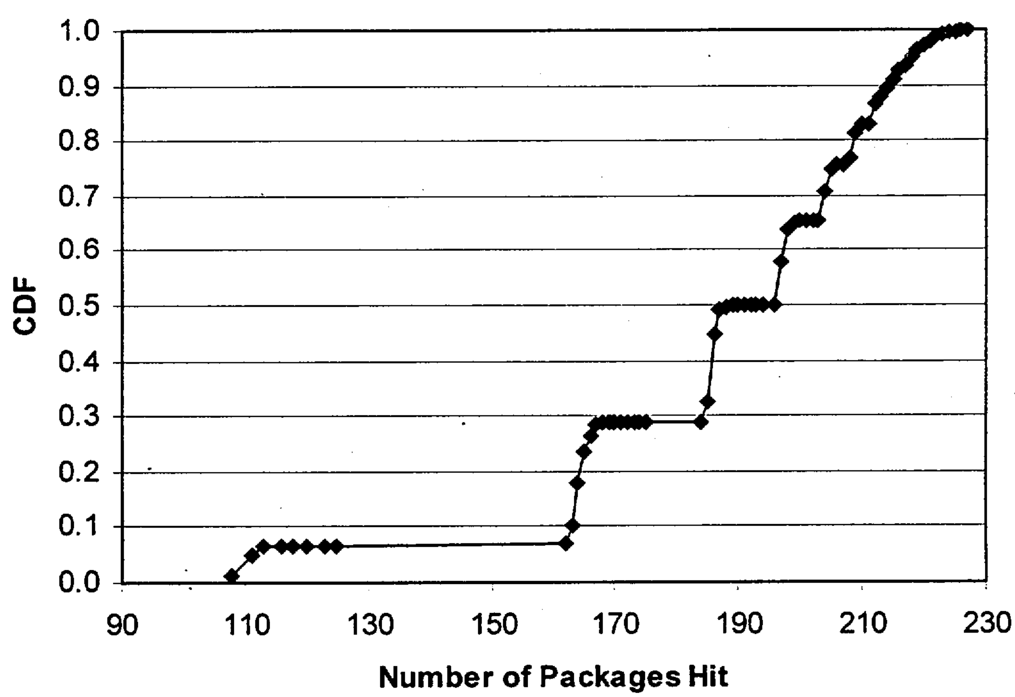

Figure I-9. CDF for Number of Packages Hit by Intrusion with a 72° Drift Orientation

ATTACHMENT II

TABLES

Table II-1. CCSM-PCB.OUT (Combined mean assessment over all experts. Primary + Contingency Block)

			IUD-UC						IUD-C					
3744	104	36 nec:	0	1	2	3	4	5	0	1	2	3	4	5
0	0	1.23E-04	0.98334	0.01653	0.00012	0	0	0	0.99655	0.00331	0.00015	0	0	0
0	5	1.70E-04	0.98307	0.0168	0.00013	0	0	0	0.99983	0.00017	0	0	0	0
0	10	3.46E-04	0.98303	0.01684	0.00013	0	0	0	0.99990	0.00010	0	0	0	0
0	15	2.36E-03	0.98343	0.01644	0.00012	0	0	0	1.00000	0	0	0	0	0
0	20	1.26E-03	0.98322	0.01665	0.00013	0	0	0	1.00000	0	0	0	0	0
0	25	2.63E-03	0.98372	0.01616	0.00012	0	0	0	0.99974	0.00024	0.00002	0	0	0
0	30	2.95E-03	0.98359	0.01628	0.00012	0	0	0	0.99998	0.00002	0	0	0	0
...	...	...	...											
1	25	3.73E-03	0.62606	0.29146	0.05589	0.00894	0.00184	0.01581	0.60082	0.33305	0.04593	0.00412	0.00055	0.01553
1	30	2.22E-03	0.55531	0.32696	0.07541	0.0109	0.00231	0.02912	0.52742	0.37303	0.06445	0.00550	0.00081	0.02880
1	35	3.08E-03	0.64643	0.26782	0.05582	0.00881	0.0023	0.01882	0.62310	0.30599	0.04705	0.00450	0.00089	0.01847
1	40	1.93E-03	0.59597	0.30241	0.06595	0.01138	0.00371	0.02058	0.56683	0.34995	0.05472	0.00667	0.00201	0.01983
...	...	...	...											
1	100	6.71E-05	0.74423	0.21034	0.03151	0.01109	0.00254	0.00029	0.72379	0.23609	0.03720	0.00285	0.00006	0.00001
1	105	3.47E-05	0.75609	0.20361	0.02906	0.00911	0.00191	0.00021	0.73664	0.23105	0.03050	0.00176	0.00003	0.00002
1	110	2.28E-05	0.73977	0.21555	0.03153	0.01051	0.00237	0.00027	0.71954	0.24218	0.03573	0.00250	0.00004	0.00002
1	115	9.62E-06	0.67738	0.26566	0.04155	0.01201	0.00288	0.00053	0.65245	0.30029	0.04393	0.00289	0.00027	0.00017
1	120	1.07E-05	0.71264	0.24417	0.03381	0.00668	0.00204	0.00066	0.69555	0.27048	0.03000	0.00322	0.00046	0.00030
...	...		...	...										
1.75	30	1.54E-03	0.40637	0.44351	0.09846	0.0221	0.01391	0.01565	0.37728	0.48664	0.08880	0.02378	0.01150	0.01199
1.75	35	3.10E-03	0.52726	0.36888	0.07156	0.01815	0.00879	0.00536	0.49781	0.41109	0.06745	0.01516	0.00492	0.00358
1.75	40	3.47E-03	0.50989	0.38091	0.07246	0.02152	0.01096	0.00426	0.48700	0.41050	0.07208	0.02204	0.00678	0.00160
1.75	45	1.60E-03	0.68808	0.25322	0.04245	0.01194	0.00370	0.00061	0.66382	0.28953	0.03797	0.00809	0.00059	0
1.75	50	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
1.75	55	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
...	...		...	...										
3	20	2.55E-04	0.24609	0.54612	0.13203	0.02819	0.02542	0.02216	0.21996	0.58116	0.12551	0.03384	0.02432	0.01521
3	25	2.42E-03	0.35501	0.48585	0.10186	0.02704	0.02002	0.01022	0.33788	0.50656	0.10037	0.03158	0.01846	0.00515
3	30	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
...	...		...	...										
3	100	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
3	105	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
3	110	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
...	...	...	...	...										
3	160	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0
3	165	8.16E-05	0.44586	0.40417	0.09566	0.02685	0.01548	0.01198	0.41556	0.44368	0.09455	0.02733	0.01048	0.00840
3	170	5.76E-05	0.21168	0.53147	0.15733	0.03387	0.02893	0.03672	0.19174	0.55777	0.15143	0.03922	0.03109	0.02875

JM 5.17.00

Table II-2. No Zeros (Sorted on azimuth/length/probability)

			IUD-UC						IUD-C					
1676			0	1	2	3	4	5	0	1	2	3	4	5
0.45	0	2.02E-04	0.54135	0.34303	0.08675	0.01484	0.00366	0.01038	0.51868	0.38297	0.07242	0.01293	0.00378	0.00921
0.5	0	2.30E-04	0.47231	0.38400	0.10740	0.01921	0.00378	0.01331	0.45078	0.42157	0.09366	0.01859	0.00341	0.01199
0.55	0	2.05E-04	0.50502	0.36691	0.09452	0.01533	0.00403	0.01419	0.48251	0.40677	0.08059	0.01288	0.00383	0.01342
0.6	0	2.40E-04	0.45995	0.39598	0.10575	0.01838	0.00445	0.01549	0.43386	0.44132	0.09019	0.01685	0.00319	0.01459
0.65	0	1.87E-04	0.37405	0.44924	0.13127	0.02308	0.00459	0.01776	0.3484	0.49223	0.11878	0.02007	0.00412	0.01641
0.7	0	1.98E-04	0.37743	0.44246	0.13153	0.02197	0.00473	0.02189	0.35838	0.47568	0.12137	0.01915	0.00433	0.02109
0.75	0	1.89E-04	0.38104	0.44375	0.12918	0.02198	0.00455	0.01949	0.35738	0.48433	0.11616	0.01968	0.00395	0.01851
...	...	...	...	...										
0.7	30	2.41E-03	0.56755	0.31499	0.07264	0.01056	0.00407	0.03019	0.54187	0.35914	0.0587	0.00692	0.00471	0.02866
0.75	30	9.03E-03	0.65095	0.28232	0.04659	0.00869	0.00277	0.00867	0.63024	0.31583	0.03933	0.00488	0.00167	0.00805
0.8	30	2.20E-03	0.56356	0.31923	0.07315	0.00972	0.00222	0.03211	0.53715	0.36346	0.06082	0.00555	0.00143	0.03160
0.85	30	3.08E-03	0.63705	0.27284	0.05799	0.00786	0.00168	0.02257	0.61519	0.30981	0.04788	0.00400	0.00076	0.02236
0.9	30	2.55E-03	0.56500	0.32472	0.0703	0.01113	0.00309	0.02576	0.53711	0.37006	0.05988	0.00608	0.00175	0.02512
0.95	30	7.42E-03	0.62741	0.29720	0.05206	0.01040	0.00282	0.01010	0.60316	0.33519	0.04568	0.00551	0.00083	0.00964
1	30	2.22E-03	0.55531	0.32696	0.07541	0.01090	0.00231	0.02912	0.52742	0.37303	0.06445	0.00550	0.00081	0.02880
1.05	30	4.29E-03	0.65810	0.27131	0.04910	0.00849	0.00186	0.01113	0.63367	0.31147	0.04012	0.00314	0.00083	0.01078
1.1	30	2.11E-03	0.59222	0.31669	0.06536	0.01319	0.00399	0.00856	0.56171	0.36378	0.0586	0.00587	0.00211	0.00794
...	...	...	...	...										
0.7	105	9.02E-06	0.78668	0.18156	0.02486	0.00590	0.00087	0.00012	0.76310	0.22038	0.01630	0.00012	0.00004	0.00005
0.75	105	1.20E-05	0.85100	0.13174	0.01383	0.00285	0.00048	0.00011	0.83811	0.15423	0.00748	0.00007	0.00005	0.00006
0.8	105	7.16E-06	0.76307	0.19927	0.02855	0.00759	0.00132	0.00020	0.73809	0.24041	0.02117	0.00018	0.00007	0.00008
0.85	105	8.22E-06	0.77640	0.18836	0.02640	0.00730	0.00135	0.00019	0.75326	0.22511	0.02130	0.00017	0.00010	0.00006
0.9	105	1.58E-05	0.76697	0.19551	0.02744	0.00822	0.00166	0.00019	0.74672	0.22452	0.02770	0.00098	0.00004	0.00003
0.95	105	1.67E-05	0.74363	0.21217	0.03147	0.01029	0.00219	0.00025	0.72204	0.24198	0.03431	0.00157	0.00007	0.00003
1	105	3.47E-05	0.75609	0.20361	0.02906	0.00911	0.00191	0.00021	0.73664	0.23105	0.03050	0.00176	0.00003	0.00002
1.05	105	1.98E-05	0.68985	0.25034	0.04010	0.01550	0.00379	0.00044	0.66766	0.27584	0.05152	0.00491	0.00006	0.00001
1.1	105	1.07E-05	0.82197	0.15556	0.01734	0.00412	0.00089	0.00012	0.80721	0.17959	0.01241	0.00075	0.00003	0.00001
...	...	...	...	...										
0.7	110	6.30E-06	0.79091	0.17909	0.02388	0.00513	0.00078	0.00021	0.76813	0.21736	0.01424	0.00008	0.00006	0.00014
0.75	110	5.76E-06	0.72828	0.22609	0.03449	0.00929	0.00161	0.00025	0.69964	0.26954	0.03035	0.00028	0.00008	0.00011
0.8	110	4.25E-06	0.78800	0.17980	0.02478	0.00594	0.00116	0.00032	0.76682	0.21526	0.01735	0.00025	0.00013	0.00020
0.85	110	4.68E-06	0.77991	0.18541	0.02587	0.00708	0.00146	0.00027	0.75609	0.22163	0.02177	0.00026	0.00014	0.00010
0.9	110	5.97E-06	0.69355	0.25042	0.04037	0.01261	0.00264	0.00041	0.66622	0.28856	0.04353	0.00143	0.00014	0.00012
0.95	110	9.40E-06	0.72667	0.22507	0.03411	0.01123	0.00257	0.00035	0.70450	0.25364	0.03988	0.00179	0.00012	0.00007
1	110	2.28E-05	0.73977	0.21555	0.03153	0.01051	0.00237	0.00027	0.71954	0.24218	0.03573	0.00250	0.00004	0.00002
1.05	110	1.84E-05	0.74722	0.20931	0.03007	0.01046	0.00260	0.00035	0.73027	0.23054	0.03585	0.00321	0.00009	0.00003
1.1	110	5.52E-06	0.78131	0.18590	0.02382	0.00709	0.00166	0.00023	0.76404	0.21038	0.02437	0.00115	0.00003	0.00003
...	...	...	...	...										
marginal Probabilities			0.62860	0.28569	0.05882	0.01215	0.00570	0.00904	0.60810	0.31827	0.05123	0.01038	0.00438	0.00765

Table II-3. Inp-params-vol-108°

Drift angle (°):	108	104.1	111.90	(Azimuth range)
Drift Spacing (m):	81	3.90	Parallel angle	
Drift diam (m):	5.5			
Package length (m):	5.13			
Package spacing (m):	0.1			
North Coordinate (m):	235997.80	5204.81	Repos N-S	
South Coordinate (m):	230792.99			
West Coordinate (m):	170056.85	1187.6	Drift Length	
East Coordinate (m):	171186.24	1129.4	Repos E-W	

CDF	**Diameter**		**Diameter**	**Prob of hitting 2 drifts**
0.0000	15		0	0.000
0.0000	20		80	0.060
0.0009	25		85	0.126
0.0094	30		90	0.192
0.0417	35		95	0.258
0.1133	40		100	0.325
0.2247	45		105	0.391
0.3605	50		110	0.457
0.5000	55		115	0.523
0.6267	60		120	0.589
0.7317	65		125	0.656
0.8131	70		130	0.722
0.8730	75		135	0.788
0.9154	80		140	0.854
0.9444	85		145	0.921
0.9640	90		150	0.987
0.9768	95			
0.9852	100			
0.9906	105			
0.9940	110			
0.9962	115			
0.9976	120			
0.9985	125			
0.9991	130			
0.9994	135			
0.9996	140			
0.9998	145			
0.9998	150			
1.0000				

Table II-4. Prob. Calcs-108°

		Rand (Conduit)		*Rand (drifts)*					
		0.8544		*0.3536*		1			
		Conduit Diam (km)		N-pkgs hit/ drift					
		0.070		14		Nec for IUD-UC			

Length (km)	Azimuth (°)	Dike Probability	Prob (vent @ drift)	0	1	2	3	4	5
0.45	0	2.02E-04	0.932	5.41E-01	3.43E-01	8.68E-02	1.48E-02	3.66E-03	1.04E-02
0.50	0	2.30E-04	0.932	4.72E-01	3.84E-01	1.07E-01	1.92E-02	3.78E-03	1.33E-02
0.55	0	2.05E-04	0.932	5.05E-01	3.67E-01	9.45E-02	1.53E-02	4.03E-03	1.42E-02
0.60	0	2.40E-04	0.932	4.60E-01	3.96E-01	1.06E-01	1.84E-02	4.45E-03	1.55E-02
0.65	0	1.87E-04	0.932	3.74E-01	4.49E-01	1.31E-01	2.31E-02	4.59E-03	1.78E-02
0.70	0	1.98E-04	0.932	3.77E-01	4.42E-01	1.32E-01	2.20E-02	4.73E-03	2.19E-02
0.75	0	1.89E-04	0.932	3.81E-01	4.44E-01	1.29E-01	2.20E-02	4.55E-03	1.95E-02
...	...	...	...	...					
0.70	30	2.41E-03	0.932	5.68E-01	3.15E-01	7.26E-02	1.06E-02	4.07E-03	3.02E-02
0.75	30	9.03E-03	0.932	6.51E-01	2.82E-01	4.66E-02	8.69E-03	2.77E-03	8.67E-03
0.80	30	2.20E-03	0.932	5.64E-01	3.19E-01	7.32E-02	9.72E-03	2.22E-03	3.21E-02
0.85	30	3.08E-03	0.932	6.37E-01	2.73E-01	5.80E-02	7.86E-03	1.68E-03	2.26E-02
0.90	30	2.55E-03	0.932	5.65E-01	3.25E-01	7.03E-02	1.11E-02	3.09E-03	2.58E-02
0.95	30	7.42E-03	0.932	6.27E-01	2.97E-01	5.21E-02	1.04E-02	2.82E-03	1.01E-02
1.00	30	2.22E-03	0.932	5.55E-01	3.27E-01	7.54E-02	1.09E-02	2.31E-03	2.91E-02
1.05	30	4.29E-03	0.932	6.58E-01	2.71E-01	4.91E-02	8.49E-03	1.86E-03	1.11E-02
1.10	30	2.11E-03	0.932	5.92E-01	3.17E-01	6.54E-02	1.32E-02	3.99E-03	8.56E-03
...	...	...	...	...					
0.70	105	9.02E-06	1.000	7.87E-01	1.82E-01	2.49E-02	5.90E-03	8.70E-04	1.20E-04
0.75	105	1.20E-05	1.000	8.51E-01	1.32E-01	1.38E-02	2.85E-03	4.80E-04	1.10E-04
0.80	105	7.16E-06	1.000	7.63E-01	1.99E-01	2.86E-02	7.59E-03	1.32E-03	2.00E-04
0.85	105	8.22E-06	1.000	7.76E-01	1.88E-01	2.64E-02	7.30E-03	1.35E-03	1.90E-04
0.90	105	1.58E-05	1.000	7.67E-01	1.96E-01	2.74E-02	8.22E-03	1.66E-03	1.90E-04
0.95	105	1.67E-05	1.000	7.44E-01	2.12E-01	3.15E-02	1.03E-02	2.19E-03	2.50E-04
1.00	105	3.47E-05	1.000	7.56E-01	2.04E-01	2.91E-02	9.11E-03	1.91E-03	2.10E-04
1.05	105	1.98E-05	1.000	6.90E-01	2.50E-01	4.01E-02	1.55E-02	3.79E-03	4.40E-04
1.10	105	1.07E-05	1.000	8.22E-01	1.56E-01	1.73E-02	4.12E-03	8.90E-04	1.20E-04
Columns									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

Table II-4. Prob. Calcs-108° (continued)

				IUD-UC					
				0.115	0.023	0.005	0.002	0.004	
			0	0.8516	0.9663	0.9896	0.9943	0.9965	1.0000
Length (km)	Azimuth (°)	Dike Probability	0	1	2	3	4	5	
0.45	0	2.02E-04		6.44E-05	1.63E-05	2.79E-06	6.88E-07	1.95E-06	
0.50	0	2.30E-04		8.25E-05	2.31E-05	4.13E-06	8.12E-07	2.86E-06	
0.55	0	2.05E-04		7.00E-05	1.80E-05	2.93E-06	7.69E-07	2.71E-06	
0.60	0	2.40E-04		8.87E-05	2.37E-05	4.12E-06	9.96E-07	3.47E-06	
0.65	0	1.87E-04		7.82E-05	2.28E-05	4.02E-06	7.99E-07	3.09E-06	
0.70	0	1.98E-04		8.15E-05	2.42E-05	4.05E-06	8.71E-07	4.03E-06	
0.75	0	1.89E-04		7.84E-05	2.28E-05	3.88E-06	8.03E-07	3.44E-06	
...	...	...							
0.70	30	2.41E-03		7.06E-04	1.63E-04	2.37E-05	9.13E-06	6.77E-05	
0.75	30	9.03E-03		2.38E-03	3.92E-04	7.32E-05	2.33E-05	7.30E-05	
0.80	30	2.20E-03		6.55E-04	1.50E-04	2.00E-05	4.56E-06	6.59E-05	
0.85	30	3.08E-03		7.84E-04	1.67E-04	2.26E-05	4.82E-06	6.48E-05	
0.90	30	2.55E-03		7.73E-04	1.67E-04	2.65E-05	7.36E-06	6.13E-05	
0.95	30	7.42E-03		2.06E-03	3.60E-04	7.20E-05	1.95E-05	6.99E-05	
1.00	30	2.22E-03		6.75E-04	1.56E-04	2.25E-05	4.77E-06	6.01E-05	
1.05	30	4.29E-03		1.09E-03	1.97E-04	3.40E-05	7.45E-06	4.46E-05	
1.10	30	2.11E-03		6.24E-04	1.29E-04	2.60E-05	7.86E-06	1.69E-05	
...	...	...							
0.70	105	9.02E-06		1.64E-06	2.24E-07	5.32E-08	7.85E-09	1.08E-09	
0.75	105	1.20E-05		1.58E-06	1.66E-07	3.43E-08	5.77E-09	1.32E-09	
0.80	105	7.16E-06		1.43E-06	2.04E-07	5.43E-08	9.45E-09	1.43E-09	
0.85	105	8.22E-06		1.55E-06	2.17E-07	6.00E-08	1.11E-08	1.56E-09	
0.90	105	1.58E-05		3.09E-06	4.33E-07	1.30E-07	2.62E-08	3.00E-09	
0.95	105	1.67E-05		3.54E-06	5.25E-07	1.72E-07	3.65E-08	4.17E-09	
1.00	105	3.47E-05		7.07E-06	1.01E-06	3.16E-07	6.63E-08	7.29E-09	
1.05	105	1.98E-05		4.97E-06	7.95E-07	3.07E-07	7.52E-08	8.73E-09	
1.10	105	1.07E-05		1.66E-06	1.85E-07	4.39E-08	9.48E-09	1.28E-09	
Columns									
(1)	(2)	(3)	(11)	(12)	(13)	(14)	(15)	(16)	(17)

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Table II-5. Simulations-vol-108°

	IUD-UC	IUD-C	USR-UC	USR-C	USR-FD	Probabilities
# Vents=1	537	608	693	800	889	0.4005
# Vents=2	114	103	114	86	158	0.0644
# Vents=3	15	12	22	11	16	0.0077
# Vents=4	13	7	7	1	1	0.0015
# Vents=5	18	17	1	0	0	0.0012

Rand (nec)	IUD-UC	IUD-C	USR-UC	USR-C	USR-FD	
0.3798	0	0	0	0	0	
0.4045	0	0	0	0	0	
0.0744	0	0	0	0	0	
0.2717	0	0	0	0	0	
0.2786	0	0	0	0	0	
0.0485	0	0	0	0	0	
0.3388	0	0	0	0	0	
0.5725	0	0	0	1	1	
0.3818	0	0	0	0	0	
0.0513	0	0	0	0	0	
0.7758	1	1	1	1	1	
0.2164	0	0	0	0	0	
0.4741	0	0	0	0	1	
0.9217	2	1	1	1	2	
0.5916	0	0	1	1	1	
0.2170	0	0	0	0	0	
0.0126	0	0	0	0	0	
0.8009	1	1	1	1	1	
0.9377	2	2	2	1	2	
0.9147	1	1	1	1	2	
0.6766	1	1	1	1	1	
0.8237	1	1	1	1	1	
0.1709	0	0	0	0	0	
0.2763	0	0	0	0	0	
0.1460	0	0	0	0	0	
0.5612	0	0	0	1	1	
0.1844	0	0	0	0	0	
0.1452	0	0	0	0	0	
0.2679	0	0	0	0	0	
0.0260	0	0	0	0	0	

Table II-5. Simulations-vol-108° (continued)

	IUD-UC	IUD-C	USR-UC	USR-C	USR-FD	Probabilities
0.5670	0	0	0	1	1	
0.0252	0	0	0	0	0	
0.9936	5	5	3	2	3	
0.5935	0	0	1	1	1	
0.4623	0	0	0	0	0	
0.2143	0	0	0	0	0	
0.6663	1	1	1	1	1	
0.2673	0	0	0	0	0	
0.2223	0	0	0	0	0	
0.2199	0	0	0	0	0	

For RIP Input							
Conduit Diameter	**N Packages Hit**	**P(0)**	**P(1)**	**P(2)**	**P(3)**	**P(4)**	**P(5)**
70	14	0.5248	0.4005	0.0644	0.0077	0.0015	0.0012
	IUD-UC	**IUD-C**	**USR-UC**	**USR-C**	**USR-FD**		
P(0)	0.6515	0.6265	0.5815	0.5510	0.4680		
P(1)	0.2685	0.3040	0.3465	0.4000	0.4445		
P(2)	0.0570	0.0515	0.0570	0.0430	0.0790		
P(3)	0.0075	0.0060	0.0110	0.0055	0.0080		
P(4)	0.0065	0.0035	0.0035	0.0005	0.0005		
P(5)	0.0090	0.0085	0.0005	0.0000	0.0000		
	Probabilities of Vent Models						
	IUD-UC	IUD-C	USRD-C	USR-C	USR-FD		
	0.05	0.075	0.15	0.225	0.5		

Table II-6. RIP-inp-Volc-108°

Inputs for RIP Direct Volcanic Release Calculation							
Conduit Diameter (m)	**N-Packages Hit/Vent**	**Probability: 0 Vents**	**Probability: 1 Vent**	**Probability: 2 Vents**	**Probability: 3 Vents**	**Probability: 4 Vents**	**Probability: 5 Vents**
15	3	0.8818	0.1011	0.0144	0.0021	0.0003	0.0004
20	4	0.8440	0.1326	0.0215	0.0016	0.0001	0.0002
25	5	0.8053	0.1637	0.0275	0.0026	0.0005	0.0004
30	6	0.7744	0.1898	0.0303	0.0040	0.0007	0.0007
35	7	0.7537	0.2070	0.0352	0.0031	0.0007	0.0004
40	8	0.7275	0.2296	0.0396	0.0027	0.0004	0.0002
45	9	0.6805	0.2628	0.0486	0.0062	0.0009	0.0009
50	10	0.6357	0.3136	0.0449	0.0045	0.0007	0.0007
55	11	0.6242	0.3157	0.0558	0.0034	0.0005	0.0003
60	12	0.5839	0.3518	0.0540	0.0077	0.0015	0.0012
65	13	0.5635	0.3717	0.0588	0.0048	0.0007	0.0006
70	14	0.5281	0.3987	0.0668	0.0048	0.0009	0.0007
75	15	0.5019	0.4142	0.0728	0.0087	0.0014	0.0010
80	16	0.5013	0.4182	0.0709	0.0072	0.0014	0.0010
85	17	0.5013	0.4224	0.0682	0.0059	0.0014	0.0009
90	18	0.4912	0.4258	0.0715	0.0093	0.0010	0.0012
95	19	0.4921	0.4154	0.0789	0.0095	0.0026	0.0015
100	40	0.4912	0.4241	0.0740	0.0086	0.0009	0.0012
105	21	0.4861	0.4368	0.0668	0.0082	0.0010	0.0013
110	22	0.4788	0.4375	0.0753	0.0065	0.0010	0.0009
115	44	0.4884	0.4340	0.0659	0.0094	0.0012	0.0012
120	46	0.4949	0.4334	0.0601	0.0080	0.0021	0.0015
125	24	0.4705	0.4497	0.0695	0.0078	0.0013	0.0012
130	25	0.4927	0.4332	0.0682	0.0048	0.0008	0.0004
135	52	0.4868	0.4356	0.0675	0.0074	0.0012	0.0015
140	54	0.4862	0.4417	0.0637	0.0066	0.0011	0.0008
145	56	0.4933	0.4338	0.0640	0.0073	0.0007	0.0010
150	58	0.4877	0.4415	0.0624	0.0060	0.0014	0.0010
	Diameters 80 - 150	**P(0)**	**P(1)**	**P(2)**	**P(3)**	**P(4)**	**P(5)**
Mean		0.4895	0.4322	0.0684	0.0075	0.0013	0.0011
Standard Error		0.0020	0.0024	0.0013	0.0004	0.0001	0.0001
Median		0.4912	0.4338	0.0682	0.0074	0.0012	0.0012
Standard Deviation		0.0078	0.0094	0.0051	0.0014	0.0005	0.0003
Sample Variance		0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
Minimum		0.4705	0.4154	0.0601	0.0048	0.0007	0.0004
Maximum		0.5013	0.4497	0.0789	0.0095	0.0026	0.0015

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Table II-7. Inp-params-EST-108°

Drift angle (°):	108		
Drift Spacing (m):	81		
Drift diameter (m):	5.5		
Package length (m):	5.13		
Package spacing (m):	0.1		
North Coordinate (m):	235997.80	5204.81	Repos N-S
South Coordinate (m):	230792.99		
West Coordinate (m):	170056.85	1187.6	Drift Length
East Coordinate (m):	171186.24	1129.4	Repos E-W

CDF	**Dike Width**		**CDF**	**Number of Dikes**
0.0000	0.1		0.0000	1
0.0000	0.2		0.0662	2
0.0000	0.5		0.2893	3
0.0041	1.0		0.5000	4
0.1643	1.5		0.6532	5
0.5000	2.0		0.7580	6
0.7559	2.5		0.8288	7
0.8908	3.0		0.8771	8
0.9526	3.5		0.9105	9
0.9794	4.0		0.9338	10
0.9909	4.5		0.9505	11
0.9959	5.0		0.9624	12
0.9981	5.5		0.9712	13
0.9991	6.0		0.9777	14
0.9996	6.5		0.9826	15
0.9998	7.0		0.9863	16
0.9999	7.5		0.9891	17
0.9999	8.0		0.9913	18
1.0000			0.9929	19
			0.9943	20
			0.9953	25
			0.9982	30
			0.9992	35
			0.9996	40
			0.9998	45
			1.0000	

Table II-8. Simulations-EST-108°

Rand (width)	Rand (number)
0.5235	0.2731

Dike Width (m)	Number of Dikes	Total Width of Swarm (m)	Weighted Average Packages Hit
2.0	2	64	162

Length (km)	Azimuth (°)	Dike Probability	Max Len Inside Repos (km)	Perpendicular Length (km)	N-Drifts Crossed	Effective Intersection Length (m)	Number of Packages Hit
0.45	0	2.02E-04	0.45	0.428	6	70.1	87
0.50	0	2.30E-04	0.50	0.476	6	70.1	87
0.55	0	2.05E-04	0.55	0.523	7	70.1	100
0.60	0	2.40E-04	0.60	0.571	8	70.1	114
0.65	0	1.87E-04	0.65	0.618	8	70.1	114
0.70	0	1.98E-04	0.70	0.666	9	70.1	127
0.75	0	1.89E-04	0.75	0.713	9	70.1	127
...	...	...	...	...			
0.70	30	2.41E-03	0.70	0.685	9	67.6	123
0.75	30	9.03E-03	0.75	0.734	10	67.6	136
0.80	30	2.20E-03	0.80	0.783	10	67.6	136
0.85	30	3.08E-03	0.85	0.831	11	67.6	149
0.90	30	2.55E-03	0.90	0.880	11	67.6	149
0.95	30	7.42E-03	0.95	0.929	12	67.6	162
1.00	30	2.22E-03	1.00	0.978	13	67.6	175
1.05	30	4.29E-03	1.05	1.027	13	67.6	175
...	...	...	...	...			
0.70	105	9.02E-06	0.70	0.037	1	1187.6	226
0.75	105	1.20E-05	0.75	0.039	1	1187.6	226
0.80	105	7.16E-06	0.80	0.042	1	1187.6	226
0.85	105	8.22E-06	0.85	0.044	1	1187.6	226
0.90	105	1.58E-05	0.90	0.047	1	1187.6	226
0.95	105	1.67E-05	0.95	0.050	1	1187.6	226
...	...	...	...	...			
0.70	110	6.30E-06	0.70	0.024	1	1187.6	226
0.75	110	5.76E-06	0.75	0.026	1	1187.6	226
0.80	110	4.25E-06	0.80	0.028	1	1187.6	226
0.85	110	4.68E-06	0.85	0.030	1	1187.6	226
0.90	110	5.97E-06	0.90	0.031	1	1187.6	226
0.95	110	9.40E-06	0.95	0.033	1	1187.6	226
1.00	110	2.28E-05	1.00	0.035	1	1187.6	226
...	...	...	...	...			
0.70	140	3.34E-05	0.70	0.371	5	131.5	132
0.75	140	4.41E-05	0.75	0.397	5	131.5	132
0.80	140	3.79E-05	0.80	0.424	6	131.5	157
0.85	140	4.15E-05	0.85	0.450	6	131.5	157
0.90	140	8.15E-05	0.90	0.477	6	131.5	157
0.95	140	6.88E-05	0.95	0.503	7	131.5	182
1.00	140	4.93E-05	1.00	0.530	7	131.5	182

Table II-9. RIP-inp-EST-108°

RIP Input for Enhanced Source Term			
Number of Dikes	Dike Width	Number of Packages Hit	PDF
1	0.1	98	2.255E-12
2	0.1	155	7.603E-12
3	0.1	179	7.180E-12
4	0.1	192	5.222E-12
5	0.1	200	3.568E-12
...	...		
25	0.1	224	9.671E-14
30	0.1	225	3.526E-14
35	0.1	226	1.440E-14
40	0.1	227	6.417E-15
45	0.1	227	6.607E-15
...	...		
1	1.5	101	2.221E-02
2	1.5	158	7.491E-02
3	1.5	181	7.074E-02
4	1.5	194	5.145E-02
5	1.5	201	3.516E-02
...	...		
25	1.5	224	9.528E-04
30	1.5	225	3.474E-04
35	1.5	226	1.418E-04
40	1.5	227	6.323E-05
45	1.5	227	6.509E-05
...	...		
1	3.0	104	4.085E-03
2	3.0	161	1.378E-02
3	3.0	183	1.301E-02
4	3.0	195	9.462E-03
5	3.0	202	6.466E-03
...	...		
25	3.0	224	1.752E-04
30	3.0	225	6.389E-05
35	3.0	226	2.608E-05
40	3.0	227	1.163E-05
45	3.0	227	1.197E-05

Table II-10. Inp-Params-vol-72°

Drift angle (°):	72	68.10	75.90	(Azimuth range)
Drift Spacing (m):	81	3.90	Parallel angle	
Drift diam (m):	5.5			
Package length (m):	5.13			
Package spacing (m):	0.1			
North Coordinate (m):	235997.80	5204.8 1	Repos N-S	
South Coordinate (m):	230792.99			
West Coordinate (m):	170056.85	1187.6	Drift Length	
East Coordinate (m):	171186.24	1129.4	Repos E-W	

CDF	**Diameter**		**Diameter**	**Prob of hitting 2 drifts**
0.0000	15		0	0.000
0.0000	20		80	0.060
0.0009	25		85	0.126
0.0094	30		90	0.192
0.0417	35		95	0.258
0.1133	40		100	0.325
0.2247	45		105	0.391
0.3605	50		110	0.457
0.5000	55		115	0.523
0.6267	60		120	0.589
0.7317	65		125	0.656
0.8131	70		130	0.722
0.8730	75		135	0.788
0.9154	80		140	0.854
0.9444	85		145	0.921
0.9640	90		150	0.987
0.9768	95			
0.9852	100			
0.9906	105			
0.9940	110			
0.9962	115			
0.9976	120			
0.9985	125			
0.9991	130			
0.9994	135			
0.9996	140			
0.9998	145			
0.9998	150			
1.0000				

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Table II-11. Prob Calcs-72°

Rand (Conduit): 0.9999
Conduit Diam (km): 0.150

Rand (drifts): 0.0788 1
N-pkgs hit/ drift: 58

Nec for IUD-UC

Length (km)	Azimuth (°)	Dike Probability	Prob (vent @ drift)	0	1	2	3	4	5
0.45	0	2.02E-04	1.000	5.41E-01	3.43E-01	8.68E-02	1.48E-02	3.66E-03	1.04E-02
0.50	0	2.30E-04	1.000	4.72E-01	3.84E-01	1.07E-01	1.92E-02	3.78E-03	1.33E-02
0.55	0	2.05E-04	1.000	5.05E-01	3.67E-01	9.45E-02	1.53E-02	4.03E-03	1.42E-02
0.60	0	2.40E-04	1.000	4.60E-01	3.96E-01	1.06E-01	1.84E-02	4.45E-03	1.55E-02
0.65	0	1.87E-04	1.000	3.74E-01	4.49E-01	1.31E-01	2.31E-02	4.59E-03	1.78E-02
0.70	0	1.98E-04	1.000	3.77E-01	4.42E-01	1.32E-01	2.20E-02	4.73E-03	2.19E-02
0.75	0	1.89E-04	1.000	3.81E-01	4.44E-01	1.29E-01	2.20E-02	4.55E-03	1.95E-02
0.70	30	2.41E-03	1.000	5.68E-01	3.15E-01	7.26E-02	1.06E-02	4.07E-03	3.02E-02
0.75	30	9.03E-03	1.000	6.51E-01	2.82E-01	4.66E-02	8.69E-03	2.77E-03	8.67E-03
0.80	30	2.20E-03	1.000	5.64E-01	3.19E-01	7.32E-02	9.72E-03	2.22E-03	3.21E-02
0.85	30	3.08E-03	1.000	6.37E-01	2.73E-01	5.80E-02	7.86E-03	1.68E-03	2.26E-02
0.90	30	2.55E-03	1.000	5.65E-01	3.25E-01	7.03E-02	1.11E-02	3.09E-03	2.58E-02
0.95	30	7.42E-03	1.000	6.27E-01	2.97E-01	5.21E-02	1.04E-02	2.82E-03	1.01E-02
1.00	30	2.22E-03	1.000	5.55E-01	3.27E-01	7.54E-02	1.09E-02	2.31E-03	2.91E-02
1.05	30	4.29E-03	1.000	6.58E-01	2.71E-01	4.91E-02	8.49E-03	1.86E-03	1.11E-02
1.10	30	2.11E-03	1.000	5.92E-01	3.17E-01	6.54E-02	1.32E-02	3.99E-03	8.56E-03
0.70	105	9.02E-06	1.000	7.87E-01	1.82E-01	2.49E-02	5.90E-03	8.70E-04	1.20E-04
0.75	105	1.20E-05	1.000	8.51E-01	1.32E-01	1.38E-02	2.85E-03	4.80E-04	1.10E-04
0.80	105	7.16E-06	1.000	7.63E-01	1.99E-01	2.86E-02	7.59E-03	1.32E-03	2.00E-04
0.85	105	8.22E-06	1.000	7.76E-01	1.88E-01	2.64E-02	7.30E-03	1.35E-03	1.90E-04
0.90	105	1.58E-05	1.000	7.67E-01	1.96E-01	2.74E-02	8.22E-03	1.66E-03	1.90E-04
0.95	105	1.67E-05	1.000	7.44E-01	2.12E-01	3.15E-02	1.03E-02	2.19E-03	2.50E-04
1.00	105	3.47E-05	1.000	7.56E-01	2.04E-01	2.91E-02	9.11E-03	1.91E-03	2.10E-04
1.05	105	1.98E-05	1.000	6.90E-01	2.50E-01	4.01E-02	1.55E-02	3.79E-03	4.40E-04
1.10	105	1.07E-05	1.000	8.22E-01	1.56E-01	1.73E-02	4.12E-03	8.90E-04	1.20E-04
Columns									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)

5.18.00

Table II-11. Prob Calcs-72° (continued)

				IUD-UC					
				0.286	0.059	0.012	0.006	0.009	
			0	0.6286	0.9143	0.9731	0.9853	0.9910	1.0000
Length (km)	Azimuth (°)	Dike Probability	0	1	2	3	4	5	
0.45	0	2.02E-04		6.91E-05	1.75E-05	2.99E-06	7.38E-07	2.09E-06	
0.50	0	2.30E-04		8.85E-05	2.48E-05	4.43E-06	8.71E-07	3.07E-06	
0.55	0	2.05E-04		7.51E-05	1.94E-05	3.14E-06	8.25E-07	2.91E-06	
0.60	0	2.40E-04		9.51E-05	2.54E-05	4.42E-06	1.07E-06	3.72E-06	
0.65	0	1.87E-04		8.39E-05	2.45E-05	4.31E-06	8.57E-07	3.32E-06	
0.70	0	1.98E-04		8.74E-05	2.60E-05	4.34E-06	9.35E-07	4.33E-06	
0.75	0	1.89E-04		8.41E-05	2.45E-05	4.16E-06	8.62E-07	3.69E-06	
...	...	...							
0.70	30	2.41E-03		7.58E-04	1.75E-04	2.54E-05	9.79E-06	7.26E-05	
0.75	30	9.03E-03		2.55E-03	4.21E-04	7.85E-05	2.50E-05	7.83E-05	
0.80	30	2.20E-03		7.03E-04	1.61E-04	2.14E-05	4.89E-06	7.07E-05	
0.85	30	3.08E-03		8.41E-04	1.79E-04	2.42E-05	5.18E-06	6.95E-05	
0.90	30	2.55E-03		8.29E-04	1.80E-04	2.84E-05	7.89E-06	6.58E-05	
0.95	30	7.42E-03		2.21E-03	3.87E-04	7.72E-05	2.09E-05	7.50E-05	
1.00	30	2.22E-03		7.24E-04	1.67E-04	2.41E-05	5.12E-06	6.45E-05	
1.05	30	4.29E-03		1.17E-03	2.11E-04	3.65E-05	7.99E-06	4.78E-05	
1.10	30	2.11E-03		6.69E-04	1.38E-04	2.79E-05	8.43E-06	1.81E-05	
...	...	...							
0.70	105	9.02E-06		1.64E-06	2.24E-07	5.32E-08	7.85E-09	1.08E-09	
0.75	105	1.20E-05		1.58E-06	1.66E-07	3.43E-08	5.77E-09	1.32E-09	
0.80	105	7.16E-06		1.43E-06	2.04E-07	5.43E-08	9.45E-09	1.43E-09	
0.85	105	8.22E-06		1.55E-06	2.17E-07	6.00E-08	1.11E-08	1.56E-09	
0.90	105	1.58E-05		3.09E-06	4.33E-07	1.30E-07	2.62E-08	3.00E-09	
0.95	105	1.67E-05		3.54E-06	5.25E-07	1.72E-07	3.65E-08	4.17E-09	
1.00	105	3.47E-05		7.07E-06	1.01E-06	3.16E-07	6.63E-08	7.29E-09	
1.05	105	1.98E-05		4.97E-06	7.95E-07	3.07E-07	7.52E-08	8.73E-09	
1.10	105	1.07E-05		1.66E-06	1.85E-07	4.39E-08	9.48E-09	1.28E-09	
Columns									
(1)	(2)	(3)	(11)	(12)	(13)	(14)	(15)	(16)	(17)

5.18.00

Table II-12. Simulations-vol-72°

	IUD-UC	IUD-C	USR-UC	USR-C	USR-FD	Probabilities
# vents=1	586	650	723	873	936	0.4255
# vents=2	145	137	167	115	206	0.0857
# vents=3	27	21	24	12	17	0.0089
# vents=4	13	10	9	2	2	0.0021
# vents=5	25	21	3	1	0	0.0018

Rand (nec)	IUD-UC	IUD-C	USR-UC	USR-C	USR-FD	
0.9540	2	2	2	2	2	
0.4381	0	0	0	0	1	
0.7362	1	1	1	1	1	
0.9678	2	2	2	2	2	
0.1605	0	0	0	0	0	
0.1689	0	0	0	0	0	
0.1963	0	0	0	0	0	
0.9932	5	5	3	2	3	
0.2895	0	0	0	0	0	
0.7620	1	1	1	1	1	
0.9521	2	2	2	2	2	
0.3416	0	0	0	0	0	
0.2107	0	0	0	0	0	
0.5831	0	0	1	1	1	
0.5226	0	0	0	1	1	
0.2102	0	0	0	0	0	
0.5320	0	0	0	1	1	
0.1034	0	0	0	0	0	
0.9450	2	2	2	1	2	
0.5978	0	0	1	1	1	
0.0373	0	0	0	0	0	
0.8126	1	1	1	1	1	
0.3963	0	0	0	0	0	
0.5416	0	0	0	1	1	
0.0817	0	0	0	0	0	
0.4503	0	0	0	0	1	
0.2639	0	0	0	0	0	
0.1573	0	0	0	0	0	
0.5676	0	0	1	1	1	
0.6076	0	0	1	1	1	
0.5451	0	0	0	1	1	
0.7093	1	1	1	1	1	
0.4809	0	0	0	0	1	
0.9652	2	2	2	2	2	
0.7062	1	1	1	1	1	
0.6307	1	1	1	1	1	

Table II-12. Simulations-vol-72° (continued)

0.9285	2	2	2	1	2	
0.6878	1	1	1	1	1	
0.0167	0	0	0	0	0	
0.1733	0	0	0	0	0	
0.9568	2	2	2	2	2	
0.7539	1	1	1	1	1	
0.8653	1	1	1	1	1	
0.4042	0	0	0	0	0	
0.8097	1	1	1	1	1	

For RIP Input							
Conduit Diameter	**N Packages Hit**	**P(0)**	**P(1)**	**P(2)**	**P(3)**	**P(4)**	**P(5)**
150	58	0.5007	0.4176	0.0694	0.0089	0.0019	0.0015
	IUD-UC	**IUD-C**	**USR-UC**	**USR-C**	**USR-FD**		
P(0)	0.6315	0.6115	0.5665	0.5280	0.4390		
P(1)	0.2785	0.3090	0.3495	0.4205	0.4670		
P(2)	0.0595	0.0520	0.0660	0.0450	0.0850		
P(3)	0.0125	0.0125	0.0130	0.0050	0.0085		
P(4)	0.0065	0.0055	0.0035	0.0015	0.0005		
P(5)	0.0115	0.0095	0.0015	0.0000	0.0000		
	Probabilities of Vent Models						
	IUD-UC	IUD-C	USR-UC	USR-C	USR-FD		
	0.05	0.075	0.15	0.225	0.5		

Table II-13. RIP-Inp-vol-72°

Inputs for RIP Direct Volcanic Release Calculation							
28							
Conduit Diam (m)	**N-pkgs hit/ vent**	**Prob: 0 vents**	**Prob: 1 vent**	**Prob: 2 vents**	**Prob: 3 vents**	**Prob: 4 vents**	**Prob: 5 vents**
15	3	0.8671	0.1107	0.0201	0.0019	0.0002	0.0001
20	4	0.8296	0.1485	0.0192	0.0021	0.0003	0.0003
25	5	0.8074	0.1680	0.0234	0.0008	0.0004	0.0001
30	6	0.7854	0.1877	0.0241	0.0024	0.0002	0.0003
35	7	0.7382	0.2348	0.0244	0.0022	0.0002	0.0003
40	8	0.7079	0.2496	0.0359	0.0050	0.0007	0.0008
45	9	0.6831	0.2683	0.0436	0.0037	0.0008	0.0006
50	10	0.6580	0.2899	0.0448	0.0055	0.0011	0.0008
55	11	0.6289	0.3129	0.0489	0.0073	0.0009	0.0011
60	12	0.5999	0.3398	0.0534	0.0058	0.0004	0.0007
65	13	0.5778	0.3600	0.0556	0.0048	0.0009	0.0009
70	14	0.5233	0.3970	0.0680	0.0092	0.0012	0.0013
75	15	0.5052	0.4180	0.0668	0.0073	0.0016	0.0011
80	16	0.4881	0.4290	0.0698	0.0098	0.0017	0.0016
85	17	0.4892	0.4423	0.0605	0.0064	0.0007	0.0009
90	18	0.5043	0.4127	0.0737	0.0065	0.0018	0.0011
95	19	0.4784	0.4446	0.0683	0.0065	0.0013	0.0010
100	40	0.4965	0.4260	0.0682	0.0068	0.0015	0.0010
105	21	0.4908	0.4377	0.0631	0.0062	0.0014	0.0009
110	44	0.4931	0.4301	0.0658	0.0072	0.0025	0.0014
115	22	0.4872	0.4400	0.0642	0.0070	0.0008	0.0010
120	46	0.4842	0.4311	0.0735	0.0090	0.0011	0.0013
125	24	0.5051	0.4203	0.0658	0.0069	0.0010	0.0009
130	50	0.4973	0.4211	0.0710	0.0075	0.0017	0.0014
135	52	0.5001	0.4276	0.0646	0.0062	0.0007	0.0008
140	27	0.4907	0.4314	0.0672	0.0084	0.0010	0.0014
145	56	0.4945	0.4298	0.0639	0.0090	0.0014	0.0013
150	58	0.4937	0.4233	0.0721	0.0083	0.0014	0.0012

Diameters 80 - 150	**P(0)**	**P(1)**	**P(2)**	**P(3)**	**P(4)**	**P(5)**
Mean	0.4895	0.4322	0.0684	0.0075	0.0013	0.0011
Standard Error	0.0020	0.0024	0.0013	0.0004	0.0001	0.0001
Median	0.4912	0.4338	0.0682	0.0074	0.0012	0.0012
Standard Deviation	0.0078	0.0094	0.0051	0.0014	0.0005	0.0003
Sample Variance	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
Minimum	0.4705	0.4154	0.0601	0.0048	0.0007	0.0004
Maximum	0.5013	0.4497	0.0789	0.0095	0.0026	0.0015

Table II-14. Inp-Params-EST-72°

Drift angle (°):	72		
Drift Spacing (m):	81		
Drift diam (m):	5.5		
Package length (m):	5.13		
Package spacing (m):	0.1		
North Coordinate (m):	235997.80	5204.81	Repos N-S
South Coordinate (m):	230792.99		
West Coordinate (m):	170056.85	1187.6	Drift Length
East Coordinate (m):	171186.24	1129.4	Repos E-W

CDF	Dike Width		CDF	Number of Dikes
0.0000	0.1		0.0000	1
0.0000	0.2		0.0662	2
0.0000	0.5		0.2893	3
0.0041	1.0		0.5000	4
0.1643	1.5		0.6532	5
0.5000	2.0		0.7580	6
0.7559	2.5		0.8288	7
0.8908	3.0		0.8771	8
0.9526	3.5		0.9105	9
0.9794	4.0		0.9338	10
0.9909	4.5		0.9505	11
0.9959	5.0		0.9624	12
0.9981	5.5		0.9712	13
0.9991	6.0		0.9777	14
0.9996	6.5		0.9826	15
0.9998	7.0		0.9863	16
0.9999	7.5		0.9891	17
0.9999	8.0		0.9913	18
1.0000			0.9929	19
			0.9943	20
			0.9953	25
			0.9982	30
			0.9992	35
			0.9996	40
			0.9998	45
			1.0000	

Table II-15. Simulations-EST-72°

Rand (width)	Rand (number)
0.4961	0.2107

Dike Width (m)	Number of Dikes	Total width of Swarm (m)	Weighted Average Pkgs hit
1.5	2	63	164

Length (km)	Azimuth (°)	Dike Probability	Max Len inside Repos	Perpendicular length	N-drifts crossed	Effective Intersection Length (m)	Number of Pkgs hit
0.45	0	2.02E-04	0.45	0.428	6	68.03	79
0.50	0	2.30E-04	0.50	0.476	6	68.03	79
0.55	0	2.05E-04	0.55	0.523	7	68.03	92
0.60	0	2.40E-04	0.60	0.571	8	68.03	105
0.65	0	1.87E-04	0.65	0.618	8	68.03	105
0.70	0	1.98E-04	0.70	0.666	9	68.03	118
0.75	0	1.89E-04	0.75	0.713	9	68.03	118
...	...	...	...	...	...	...	...
0.70	30	2.41E-03	0.70	0.468	6	100.26	116
0.75	30	9.03E-03	0.75	0.502	7	100.26	135
0.80	30	2.20E-03	0.80	0.535	7	100.26	135
0.85	30	3.08E-03	0.85	0.569	8	100.26	154
0.90	30	2.55E-03	0.90	0.602	8	100.26	154
0.95	30	7.42E-03	0.95	0.636	8	100.26	154
1.00	30	2.22E-03	1.00	0.669	9	100.26	173
...	...	...	...	...	...	...	...
0.70	105	9.02E-06	0.70	0.381	5	124.14	119
0.75	105	1.20E-05	0.75	0.408	6	124.14	143
0.80	105	7.16E-06	0.80	0.436	6	124.14	143
0.85	105	8.22E-06	0.85	0.463	6	124.14	143
0.90	105	1.58E-05	0.90	0.490	7	124.14	167
0.95	105	1.67E-05	0.95	0.517	7	124.14	167
...	...	...	...	...	...	...	...
0.70	110	6.30E-06	0.70	0.431	6	109.37	126
0.75	110	5.76E-06	0.75	0.462	6	109.37	126
0.80	110	4.25E-06	0.80	0.493	7	109.37	147
0.85	110	4.68E-06	0.85	0.523	7	109.37	147
0.90	110	5.97E-06	0.90	0.554	7	109.37	147
0.95	110	9.40E-06	0.95	0.585	8	109.37	168
1.00	110	2.28E-05	1.00	0.616	8	109.37	168
...	...	...	...	...	...	...	...
0.70	140	3.34E-05	0.70	0.649	9	70.17	121
0.75	140	4.41E-05	0.75	0.695	9	70.17	121
0.80	140	3.79E-05	0.80	0.742	10	70.17	135
0.85	140	4.15E-05	0.85	0.788	10	70.17	135
0.90	140	8.15E-05	0.90	0.834	11	70.17	148
0.95	140	6.88E-05	0.95	0.881	11	70.17	148
1.00	140	4.93E-05	1.00	0.927	12	70.17	162

Table II-16. RIP-Inp-EST-72°

RIP Input for Enhanced source Term			
Number of Dikes	Dike Width	Number of Packages Hit	PDF
1	0.1	108	2.2547E-12
2	0.1	162	7.6031E-12
3	0.1	184	7.1796E-12
4	0.1	196	5.2216E-12
5	0.1	203	3.5683E-12
...	...	...	...
25	0.1	226	9.6710E-14
30	0.1	226	3.5259E-14
35	0.1	226	1.4395E-14
40	0.1	226	6.4174E-15
45	0.1	227	6.6069E-15
...	...	...	...
1	1.5	111	2.2214E-02
2	1.5	164	7.4910E-02
3	1.5	186	7.0737E-02
4	1.5	197	5.1446E-02
5	1.5	204	3.5157E-02
...	...	...	...
25	1.5	226	9.5284E-04
30	1.5	226	3.4739E-04
35	1.5	226	1.4183E-04
40	1.5	227	6.3228E-05
45	1.5	227	6.5095E-05
...	...	...	...
1	3.0	113	4.0854E-03
2	3.0	167	1.3777E-02
3	3.0	187	1.3009E-02
4	3.0	199	9.4615E-03
5	3.0	206	6.4658E-03
...	...	...	...
25	3.0	226	1.7524E-04
30	3.0	226	6.3888E-05
35	3.0	226	2.6084E-05
40	3.0	227	1.1628E-05
45	3.0	227	1.1972E-05

ATTACHMENT III

T0055_OUTPUTS.XLS

Table III-1. Inp-Params-Vol

CDF	Diameter		Diameter	Prob of hitting 2 drifts
0.0000	15		0	0.000
0.0000	20		80	0.060
0.0009	25		85	0.126
0.0094	30		90	0.192
0.0417	35		95	0.258
0.1133	40		100	0.325
0.2247	45		105	0.391
0.3605	50		110	0.457
0.5000	55		115	0.523
0.6267	60		120	0.589
0.7317	65		125	0.656
0.8131	70		130	0.722
0.8730	75		135	0.788
0.9154	80		140	0.854
0.9444	85		145	0.921
0.9640	90		150	0.987
0.9768	95			
0.9852	100			
0.9906	105			
0.9940	110			
0.9962	115			
0.9976	120			
0.9985	125			
0.9991	130			
0.9994	135			
0.9996	140			
0.9998	145			
0.9998	150			
1.0000				

Table III-2. RIP Inp-Volc

Conduit Diam (m)	N-pkgs hit/ vent	Prob: 0 vents	Prob: 1 vent	Prob: 2 vents	Prob: 3 vents	Prob: 4 vents	Prob: 5 vents
15	3	0.8818	0.1011	0.0144	0.0021	0.0003	0.0004
20	4	0.8440	0.1326	0.0215	0.0016	0.0001	0.0002
25	5	0.8053	0.1637	0.0275	0.0026	0.0005	0.0004
30	6	0.7744	0.1898	0.0303	0.0040	0.0007	0.0007
35	7	0.7537	0.2070	0.0352	0.0031	0.0007	0.0004
40	8	0.7275	0.2296	0.0396	0.0027	0.0004	0.0002
45	9	0.6805	0.2628	0.0486	0.0062	0.0009	0.0009
50	10	0.6357	0.3136	0.0449	0.0045	0.0007	0.0007
55	11	0.6242	0.3157	0.0558	0.0034	0.0005	0.0003
60	12	0.5839	0.3518	0.0540	0.0077	0.0015	0.0012
65	13	0.5635	0.3717	0.0588	0.0048	0.0007	0.0006
70	14	0.5281	0.3987	0.0668	0.0048	0.0009	0.0007
75	15	0.5019	0.4142	0.0728	0.0087	0.0014	0.0010
80	16						
85	17						
90	18						
95	19						
100	40						
105	21						
110	22						
115	44	0.4895	0.4322	0.0684	0.0075	0.0013	0.0011
120	46						
125	24						
130	25						
135	52						
140	54						
145	56						
150	58						

Table III-3. RIP-Inp-EST (drift azimuth angle 108°)

Number of Packages Hit	CDF
98	0.0109
101	0.0500
104	0.0630
106	0.0656
109	0.0660
111	0.0661
114	0.0662
116	0.0662
155	0.0671
156	0.1028
158	0.1777
159	0.2348
160	0.2649
161	0.2787
162	0.2847
163	0.2873
164	0.2889
165	0.2891
166	0.2892
167	0.2893
168	0.2893
169	0.2893
179	0.2893
180	0.3239
181	0.3946
182	0.4486
183	0.4900
184	0.4957
185	0.4981
186	0.4996
187	0.4999
188	0.5000
189	0.5000
190	0.5000
192	0.5006
193	0.5252
194	0.6158

Table III-3. RIP-Inp-EST (drift azimuth angle 108°) - continued

Number of Packages Hit	CDF
195	0.6460
196	0.6519
197	0.6530
198	0.6532
199	0.6532
200	0.6537
201	0.7056
202	0.7530
203	0.7570
204	0.7579
205	0.7582
206	0.8115
207	0.8274
208	0.8287
209	0.8530
210	0.8748
211	0.8772
212	0.9068
213	0.9142
214	0.9327
215	0.9464
216	0.9564
217	0.9638
218	0.9744
219	0.9820
220	0.9865
221	0.9907
222	0.9947
223	0.9953
224	0.9981
225	0.9991
226	0.9996
227	1.0000

Table III-4. RIP-Inp-EST (drift azimuth angle 72°)

Number of Packages Hit	CDF
108	0.01087
111	0.05002
113	0.06303
116	0.06557
118	0.06605
120	0.06614
123	0.06616
125	0.06617
162	0.06707
163	0.10282
164	0.17773
165	0.23484
166	0.26494
167	0.28471
168	0.28728
169	0.28839
170	0.28888
171	0.28911
172	0.28925
173	0.28928
174	0.28929
175	0.28930
184	0.29015
185	0.32391
186	0.44857
187	0.49001
188	0.49566
189	0.49809
190	0.49961
191	0.49991
192	0.49998
193	0.49999
194	0.50000
196	0.50062
197	0.57662
198	0.63651
199	0.65009

Table III-4. RIP-Inp-EST (drift azimuth angle 72°) - continued

Number of Packages Hit	CDF
200	0.65262
201	0.65311
202	0.65321
203	0.65324
204	0.70560
205	0.74653
206	0.75701
207	0.75777
208	0.76959
209	0.81153
210	0.82818
211	0.82896
212	0.86532
213	0.87668