Waste Isolation Pilot Plant

Compliance Certification Application

Reference 664

Wallace, M. 1996.
Leakage from abandoned boreholes. Summary Memo of Record for NS-7b. SWCF-A 1.1.6.3:PA:QA:TSK:NS-7b. Sandia National Laboratories, Albuquerque, NM WPO 40819.

Submitted in accordance with 40 CFR §194.13, Submission of Reference Materials.

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Sandia National Laboratories
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Albuquerque, New Mexico 87185-1328

INFORMATION ONLY

date: September 23, 1996

to: Kathy Economy, 6848
Bob Guzowski, 6822

from: Rip Anderson, 6849, MS 1328

subject: Technical Review for FEP NS7b

Please provide a technical review of the attached FEP, NS7b. Reviewers should strive to complete their review by September 30, 1996, to allow for timely comment resolution. Documentation of the review, at a minimum, will consist of completing a *FEP Technical Review Sheet* and *Document Review and Comment Form* (form 430-A from QAP 6-3). As a reminder, reviewer comments and their resolution will be documented on form 430-A. The *Technical Review Sheet* should be completed after all reviewer comments have been resolved between the lead staff and technical reviewers. Guidance for the FEP technical review and a copy of the Technical Review Sheet may be found in *Features, Events, and Processes (FEPs) Screening Analysis Plan, Version 5-4*. A copy of the analysis plan is available electronically under the NWMP Applications Icon.

Attachments: as stated

Copy to (w/o attachments):
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SWCF-A:1.2.07.3:PA:QA:~~MGT:PLN~~ NS7b (2 copies)

CWG 10/3/96

Records Package for Screening Effort NS7b: Leakage from Abandoned Boreholes

For Perm
D.R. Anderson
Sept/23/96

WBS #

APS 9/23/96

SWDF file designator SWCF-A:1.2.07.3:PA:QA:TSK:NS7b

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APS 9/23/96
1.2.07.3

Table of Contents:

Summary Memo of Record for NS7b: Leakage from Abandoned Boreholes

Michael Wallace 6849
Martin Tierney 6849

Recommended Screening Decision:

NS7b is recommended to be screened out on the basis of low consequence.

Statement of Screening Issues:

Sedimentary units occur down to approximately 5500 meters below the land surface in the WIPP region. The permeabilities and pressures vary from unit to unit and within each unit. There is evidence of overpressure in some areas of some units, and evidence of underpressure in others. Many of these units are exploited for petroleum resources. Concerns have been raised that a leaky borehole(s) could create a connection(s) between a deep unit(s) and the Culebra in such a manner as to enhance flow rates within the Culebra (and therefore, potentially increase cumulative releases of radionuclides) to the boundary of the accessible environment.

Approach for NS7b

As with any sidebar effort, the purpose is to screen FEPs into or out of the full PA based on a variety of criteria. One of the principle criteria concerns how sensitive the PA results would be to the inclusion of a particular FEP. If the PA were shown to be sensitive, then the FEP would be screened in. If the PA were shown to be insensitive, then the FEP might be screened out. Unfortunately, it is generally difficult to determine the sensitivity of the PA to a FEP without actually running the full sensitivity analyses with the FEP included (thereby defeating the purpose of a sidebar calculation).

In the case of groundwater transport, a preliminary result that in some cases can be used in the development of a proxy sensitivity metric is the velocity field. As it is implemented in the PA for the Culebra flow and transport leg, SECOFL2D calculates darcy velocity fields for each transmissivity vector. Those fields can be used to estimate average groundwater velocities. The following section discusses when and how velocity fields may be used as a screening metric. The concept of an equivalent contaminant plume velocity (epv) is introduced. An equation is presented that embodies this concept. It is then shown how the epv varies with respect to the independent variables that make up the equation. The coefficients of variation for each variable are discussed, which are ultimately used to develop sensitivity criteria for screening of this FEP in later sections.

<u>Velocity Based Screening Metric</u>

In groundwater transport, a quantum of contaminant migrates through a domain due to the processes of advection and dispersion, influenced by the additional processes of decay, physical retardation, and chemical retardation. A contaminant plume's centroid will move at the average linear groundwater velocity, as influenced by physical and chemical retardation processes.

The retardation coefficients used in PA have a large effect on transport. Dispersion can have an important effect on transport as well. The outer fringe of a contaminant plume may lie at a significant distance from the plume centroid, primarily because of dispersion. Dispersion is also the reason that the concentration distribution within a plume may range over several orders of magnitude. In other words, different areas of the plume can have vastly different effective velocities. Clearly, dispersion processes can significantly affect a plume's spread, thereby making it difficult to develop generalizations about integrated releases across a boundary over time (or ultimately PA sensitivities) purely as a function of average linear groundwater velocities.

If the contaminant plume spread is relatively narrow, then the velocity variation within the plume is low, and generalizations of this sort can be justified. For the current PA, longitudinal and transverse dispersivities are each assigned a value of zero. This ensures contaminant plumes with spreads as narrow as possible. Therefore, for certain relevant FEPs, comparisons of average linear groundwater velocities may be employed in the development of screening arguments.

In such a comparison, the impact on groundwater velocities due to the FEP is accounted for. If the impact is deemed significant, then the FEP is screened in. If the impact is not deemed significant, then the FEP is screened out.

An equation for an 'equivalent' or steady state conntaminant plume velocity (epv) is developed in Dudley et al., (1988):

$$v_i = \frac{q}{\theta_m R_m^i + \theta_f R_f^i} \qquad (1.0)$$

where:

v_i = effective advective transport speed of nuclide i(m/s)

q = darcy velocity (m/s)

θ_m = effective matrix porosity

R_m^i =retardation in the matrix for nuclide i

R_f^i =retardation in the fracture for nuclide i

θ_f = effective fracture porosity

In the 92 PA, it was shown that chemical retardation in pure fracture flows is negligible. Thus $R_f^i = 1$. Also, the matrix retardation term can be expanded, changing equation 1.0 in this manner:

$$v_i = \frac{q}{\theta_m\left(1+\rho_b\frac{k_{di}}{\theta_m}\right)+\theta_f} \tag{2.0}$$

ρ_b = bulk density of matrix (kg/m^3)
k_{di} = sorption coefficient for i'th element

This equation can be used to estimate the sensitivities of plume 'velocity' to the listed variables. It bears repeating that this is only an estimate. Notably, this equation is not exactly suited for this exercise, as not all of the variables of importance are lumped into this equation. Also, the equation assumes advection occurs in both the matrix and the fracture domains, whereas, in the 96PA, only diffusion occurs in the matrix domain. Yet, the equation does capture the salient features governing steady plume movement on a gross level, and as such, should be suitable for this largely qualitative investigation.

The sensitivity of the epv to the equation variables that have ranges in the 96PA can be estimated according to the following relationship:

$$\frac{\Delta v}{v} = cv(q) - f_1 cv(\theta_m) - f_2 cv(\theta_f) - f_3 cv(k_a) \tag{3.0}$$

where:

$cv(q) = \dfrac{\sigma(q)}{\bar{q}}$, determined by numerical experiment

$$f_1 = \frac{\overline{\theta}_m}{\overline{\theta_m} + \overline{\theta_f} + \overline{\rho_b k_d}}$$

$$f_2 = \frac{\overline{\theta}_f}{\overline{\theta_m} + \overline{\theta_f} + \overline{\rho_b k_d}}$$

$$f_3 = \frac{\overline{\rho_b k_d}}{\overline{\theta_m} + \overline{\theta_f} + \overline{\rho_b k_d}}$$

The term cv( ) stands for the coefficient of variation and σ ( ) stands for the standard deviation. The f terms stand for the coefficients of sensitivity. The coefficient of variation of several of these variables can be directly estimated from the PA database, which contains mean values and standard deviation values for the parameters θ_m, θ_f, and k_{di}.

From those values, the f coefficients can be calculated, and the total sensitivities (f * cv) of the epv to each parameter can be determined. The next section concerns $cv(q)$ and estimation of the relative change in $cv(q)$ due to incorporation of this FEP into the PA.

Data Development and Problem Setup:

Information was gathered on the sedimentary units underlying the WIPP in the Delaware Basin. Their pressures, permeabilities, thicknesses, and other pertinent information were identified. Zones were determined which are overpressured with respect to the Culebra. Other zones were identified which are underpressured with respect to the Culebra. A summary of this information is provided in Table NS7b.1.

The Atoka had the documented greatest pressures of all the units, with an equivalent fresh-water (efw) head of 3589m (amsl) in the Sand Dunes play area. Although this unit is primarily a gas reservoir, for this screening effort pressures are utilized as if the unit were saturated with water.

The Strawn had the highest documented permeabilities of the deeper units (although still four times lower than the permeabilities of the Culebra high-T zone). The Strawn also had zones with the lowest pressures, with a documented efw head of approximately 650 m (< hydrostatic). It should be noted that some Strawn zones are significantly overpressured as well.

If this FEP were to be included in the PA, it would likely be done by first assuming random couplings/pairings of interconnections between the Culebra and two deep units. One unit, A, would be overpressured (a range of overpressures would be sampled on). The other unit, B, would be underpressured (a range, again). the positions of A and B would vary randomly. Each of the pairings would have the effect of a gradient component through the Culebra between the overpressure connection and the underpressured connection. This gradient component would be superimposed (linearly) upon the existing gradients, causing a modification to the original flow rates and patterns. The particular configurations of positions of A, B, pressures for each, and

Table NS7b.1 Various Hydrologic and Physical Parameters for the Culebra and Sub-Salado Units

elevation of repository	(m a.m.s.l.)	380.5
elevation of culebra	"	840
culebra thickness (m)		7.7
land surface el. (m)		1036
depth to rep. (m)		655.5

Unit Designation	estimated elev. of top of unit in WIPP area (m)	depth from land surface to top of unit (1) (m)	estimated representative thickness (m)	approximate shortest vertical separation from WIPP (m)	closest Delaware Basin recorded literature permeability (2) (md)	estimated representative hydraulic conductivity (m/s)	closest Delaware Basin recorded literature pressure gradient (2) (psi/ft)	estimated representative pressure (psi)	estimated representative e.f.w. head (m)
[redacted]	840	196	7.7	[redacted]	high T zone 445	[redacted]			[redacted]
DMG	-206	1242	1196	587	Getty Fed. 24 24.8	2.40E-07	Paducah 0.439	1788.839	1052.967
Bone Springs	-1402	2438	1036	1783	no data		Lea 0.423	3383.445	979.235
Wolfcamp	-2439	3475	427	2820	Red Hills 1.04	1.00E-08	Big Sinks 0.585	6669.537	2254.954
[redacted]	-2865	3901	91	[redacted]	Big Eddy 100	[redacted]	Antelope Ridge 0.390	4991.437	[redacted]
[redacted]	-2957	3993	213	[redacted]	Antelope Ridge 22	[redacted]	Sand Dunes 0.710	9301.280	[redacted]
Morrow	-3170	4206	381	3551	Antelope Ridge 40	3.86E-07	Sand Dunes 0.430	5933.661	1006.052

(1) Powers et al., 1978
(2) Robertson et al., 1993

borehole permeabilities, would be lumped into a single parameter. That parameter would have a range and a ranking and would be sampled on as a vector with 100 elements, similar to the current T-Field vector. Figure NS7b.1 is a schematic of possible interconnection pairings.

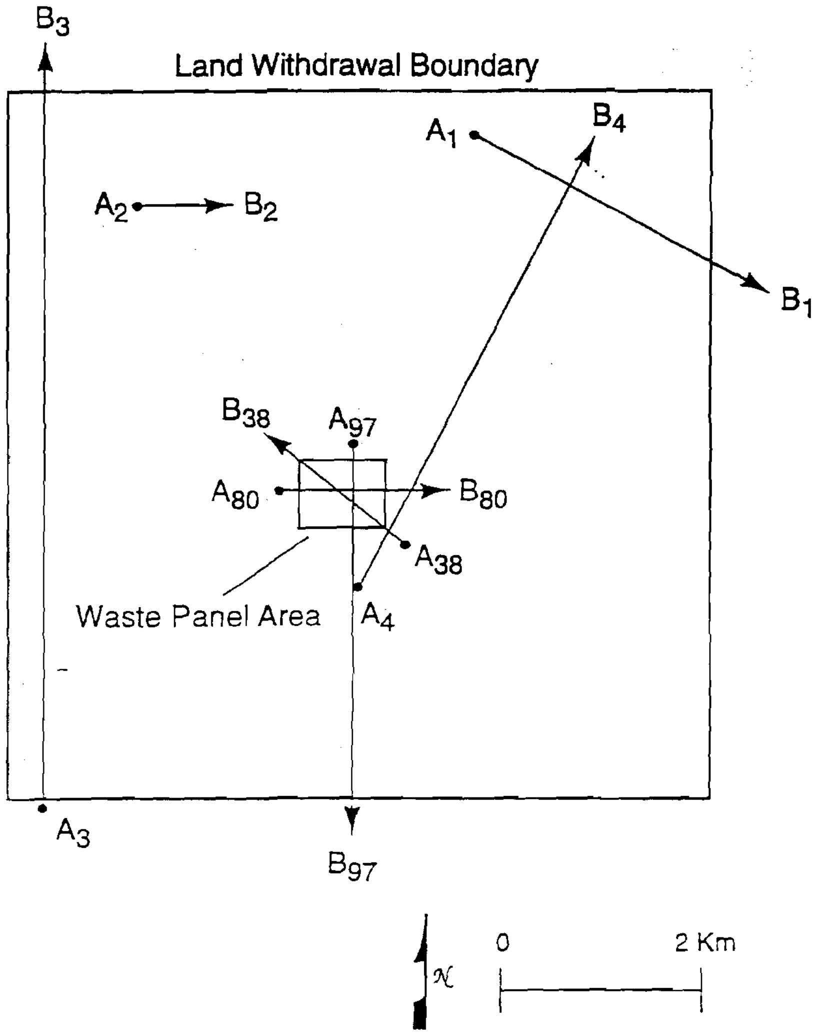
Currently, even without interconnections, a spectrum of flow directions and speeds are predicted. Directions of flow through the LWB range from south-by-southeast to west by southwest. Travel times from the waste panel area to the LWB (assuming equivalent porous media flow) range from ~2,000 years to > 1 million years. As part of the 96 PA, scatter plots were made depicting travel times for the two sets of 100 Culebra model velocity fields (full mining and partial mining) Travel times were estimated for the horizontal line of 13 particle release points that stretched across the panel area, and mean travel times were calculated.

Results are shown in Figures NS7b.2 and NS7b.3. In those scatterplot figures, travel times are plotted along the abscissa and rankings along the ordinate. The configurations are ordered according to magnitude of mean travel time. For each configuration all thirteen travel times are shown (see legend), as well as the mean travel time. Details of this process are provided in Appendix NS7b.1. Consideration of the variations in interconnection pairing as illustrated (in conjunction with the diverse flow directions they would be matched to) shows that the configurations can have three possible effects on groundwater travel times:

neutral (no effect)
a slowdown in travel times
a speed up in travel times

Given the current range of flow fields in PA, a configuration as described may make a flow field that is already 'rapid' even more rapid. Conversely, it may make such a flow field slower. Therefore, applying this method to PA may or may not increase the range in 'effective' velocities over the ranges already developed. But the crucial issue is not whether the range might be increased, but what is the possible magnitude of this increase relative to the base velocity range.

As can be inferred from Figure NS7b.1, and considering the above discussion, most of the sampled interconnections, if applied to the PA, would merely generate velocities that are already bounded by the current range. The increases in the range will be generated by the new (interconnections FEP-based) worst case slow-down and speed-up runs. One could force the two tail-end values as follows; first take the slowest existing velocity field, and apply the most effective custom configuration of AB borehole connections to slow it down even further. Second, take the fastest existing velocity field, and apply the most effective custom configuration of AB borehole connections to speed it up even further. Yet, the slowest velocities are already so slow as to be essentially immobile. Therefore, extending the 'slow' range is meaningless. However, extending the 'fast' range is still a valid exercise.



A_i = connection between the Culebra and a deeper unit of higher head
B_i = connection between the Culebra and a deeper unit of lower head

The image shows 7 possible sample pairings of A_iB_i from a likely population of 100 random pairings. Arrows show the likely direction of influence (but not necessarily the directions of flow) due to these particular pairings.

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Figure NS7b.1. Possible Interconnection Pairings

Figure NS7b.2 Scatter Plot of Travel Times: Full Mining Case (no Interconnections)

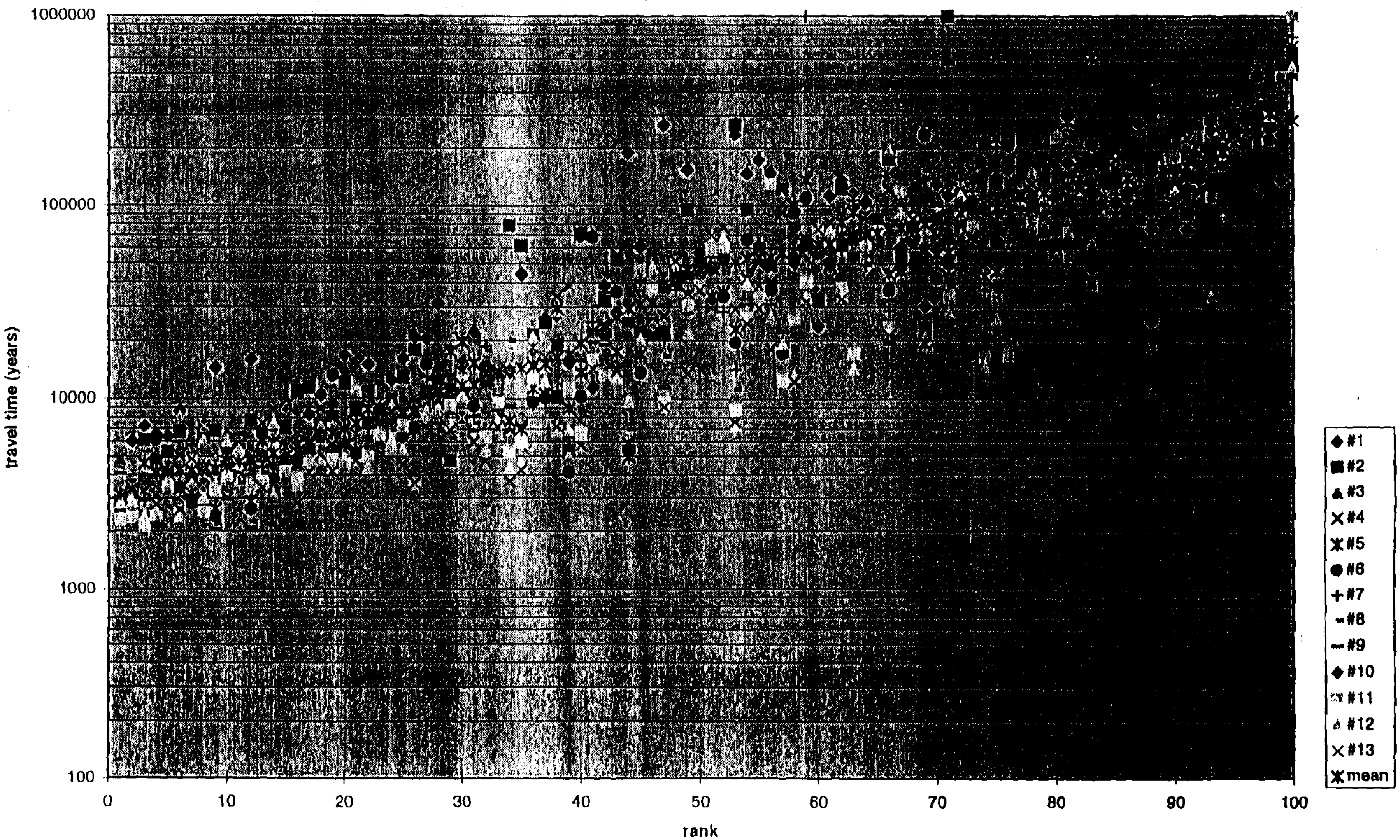
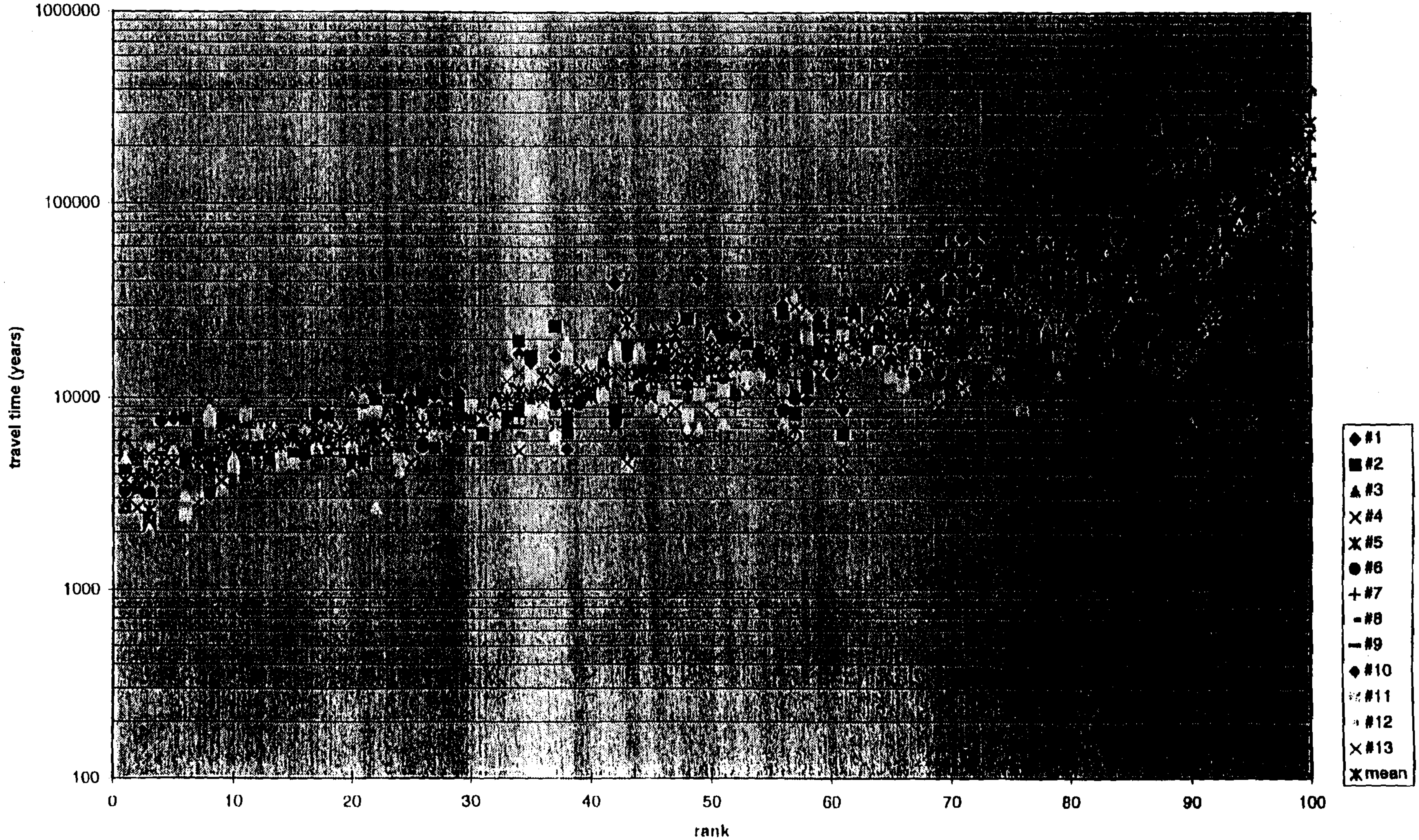


Figure NS7b.3 Scatter Plot of Travel Times: Partial Mining Case
(no Interconnections)



Note that this approach overestimates the effects of velocity increases or slowdowns, because it customizes a setup and coupling that has a small probability of occurring in a truly random approach, particularly given the wide range in travel paths and directions now due to mining effects. For example, in Figure NS7b.1, coupling $A_{97}B_{97}$ may speed up travel times if the velocity field it is paired with is a north-to-south flow regime. However, for many of the velocity fields flow is to the west (due to mining effects). Therefore, without prior knowledge of the initial flow field, there is no way to anticipate what effect any particular A_iB_i coupling will have on velocities. It also overestimates the effects due to the other specified parameters, such as the borehole K, which, because it is set to the highest sampled value, ignores the limitations on flow due to the consistently lower Ks of the deeper units themselves. An additional conservative assumption is the use of the highest and lowest recorded pressures in the Delaware Basin deep units for the respective source and sink values.

The fastest travel times for full and partial mining cases are for vectors R095 and R030 respectively. Figure NS7b.4a shows the particle tracks for R095 (full mining set), indicating the groundwater flow directions through the panel area out to the LWB. Figure NS7b.4b shows the customized AB configuration for speedup of this vector. Figure NS7b.5a shows the particle tracks for R030 (partial mining set), indicating the groundwater flow directions through the panel area out to the LWB. Figure NS7b.5b shows the AB configuration for speedup of this vector.

Darcy's law was used according to the setups shown in figure NS7b.6 to estimate constant fluxes into the flow field at the respective positions. The flux rates were determined assuming the efw heads described above for the deep units and an efw head for the Culebra of 930 m. The interconnection borehole had a cross-sectional area of 0.196 m^2 and a hydraulic conductivity (K) of 1.E-4 m/s. The borehole diameter used falls within the range documented in the current PA database. The K used is the highest value from the range contained in the current PA database. That determined a flow rate of approximately 0.2 gpm for the source term at the northern end and 0.02 gpm for the sink term at the southern end. See Table NS7b.2 for summary information. Those fluxes were inputs to the steady state flow runs performed here on the two respective vectors. Otherwise, the runs were identical to the originals (using SECOFL2D, as performed for the 96 PA).

Table NS7b.2 Summary of Source and Sink Term Information

case	unit	distance between unit top and culebra (m)	unit head - culebra head (m)	Q (m^3/s)	Q (gpm)
source	atoka	3798	2659	1.37e-5	0.22
sink	strawn	3706	280	-1.48e-6	-0.02

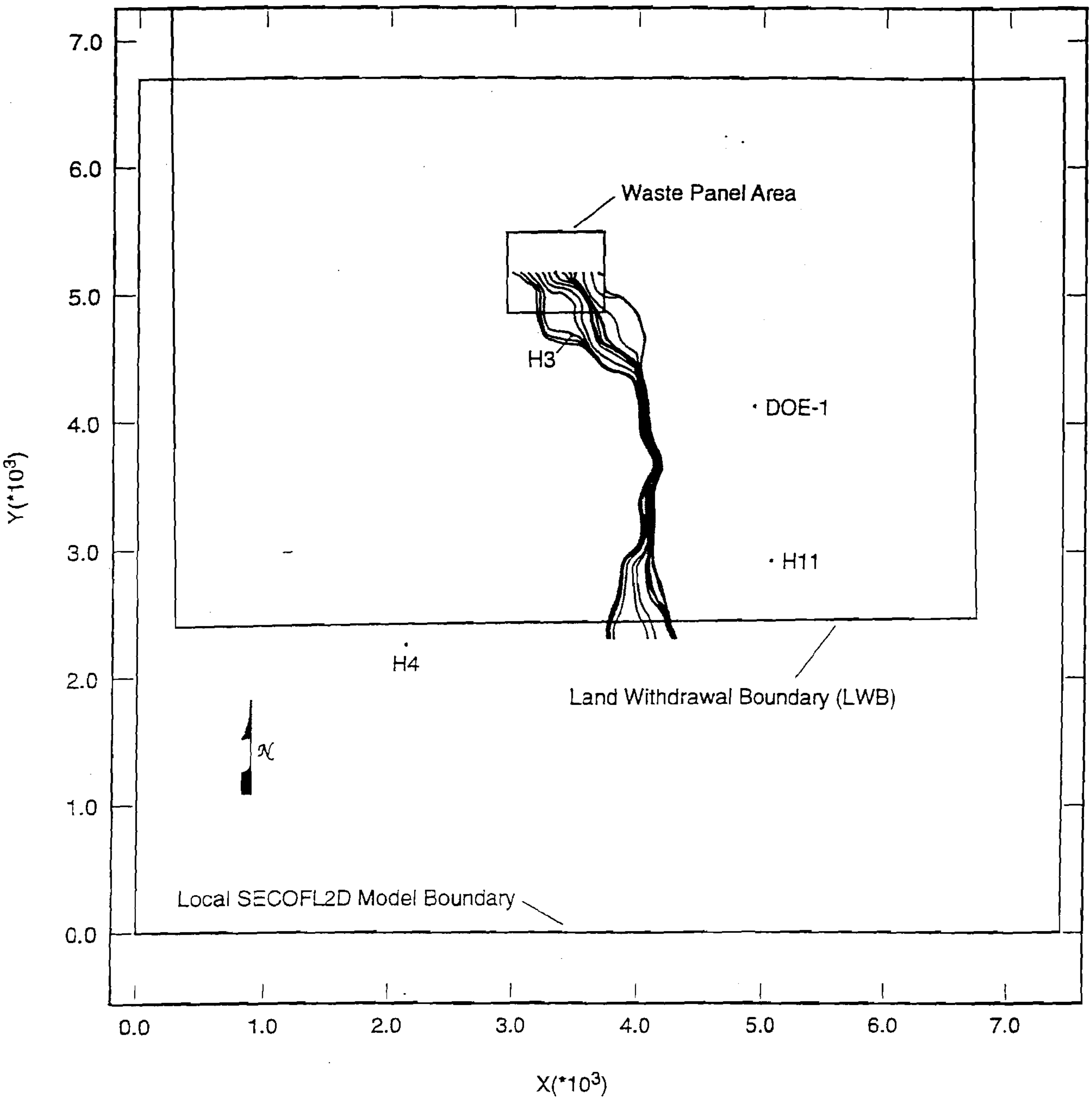


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Figure NS7b.4a. Thirteen Particle Tracks from the Fastest Flow Field for the Full Mining Case

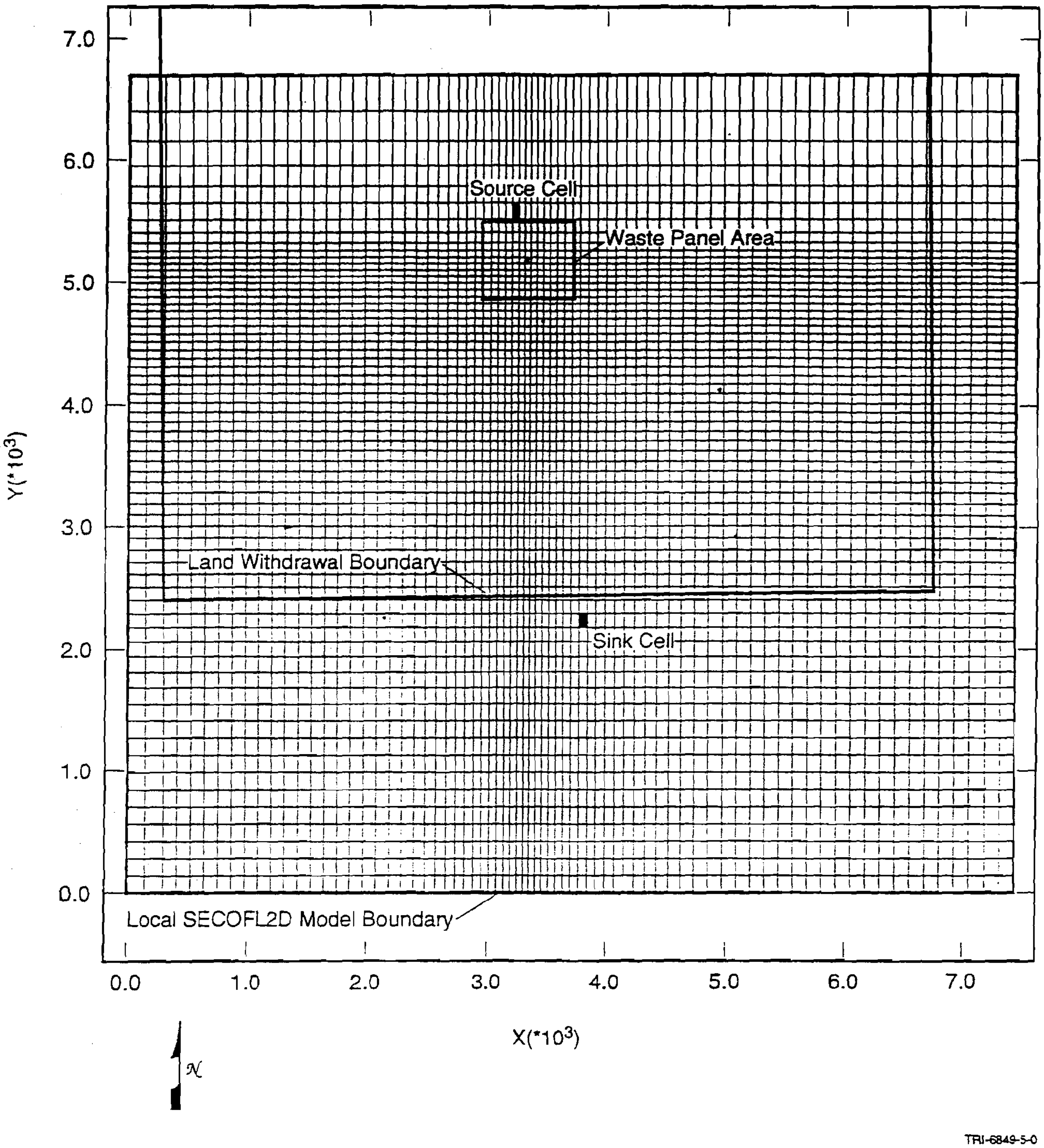


Figure NS7b.4b. Source and Sink Cell Assignments for Interconnections Study for the Full Mining Case

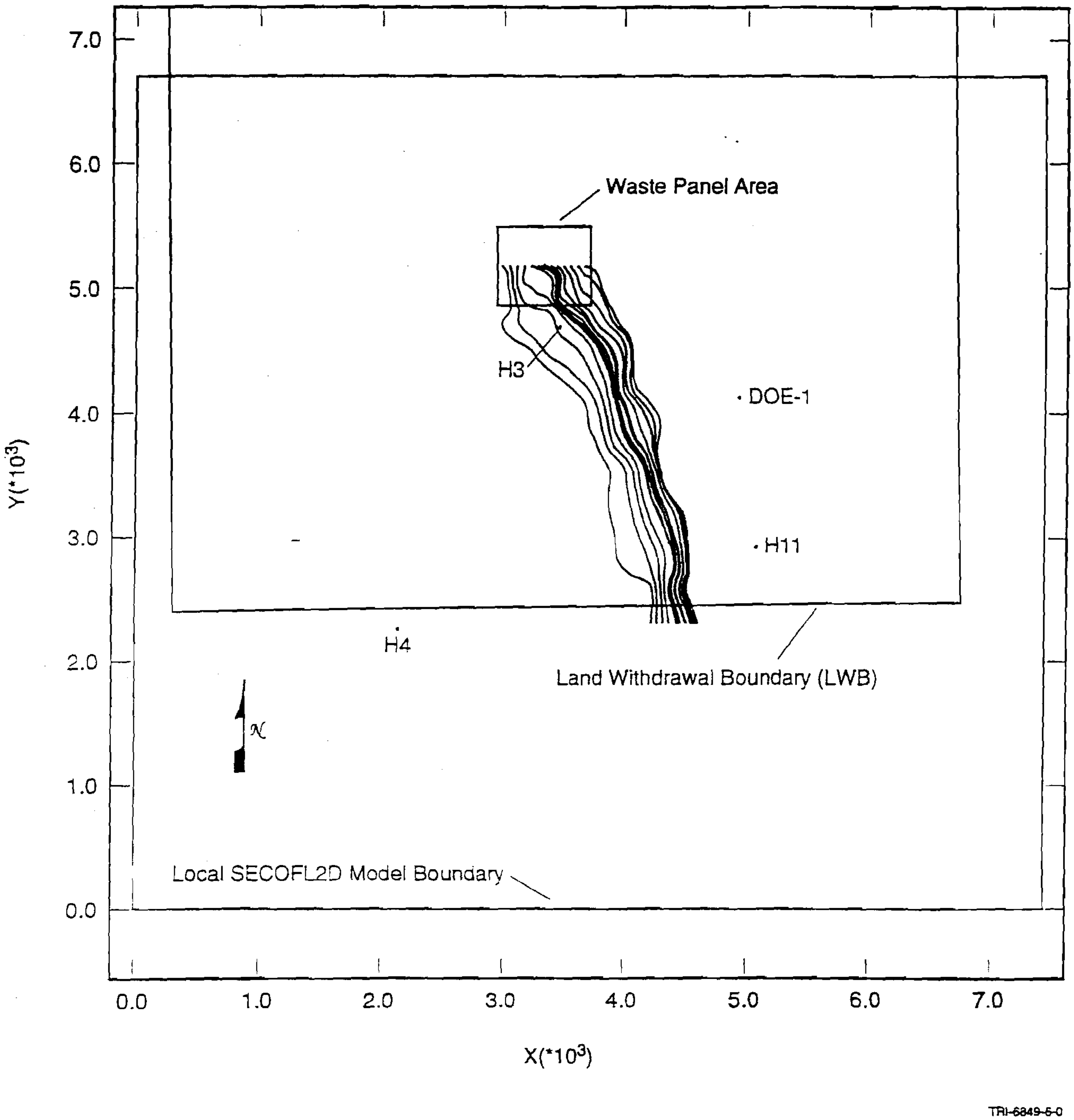


Figure NS7b.5a. Thirteen Particle Tracks from the Fastest Flow Field for the Partial Mining Case

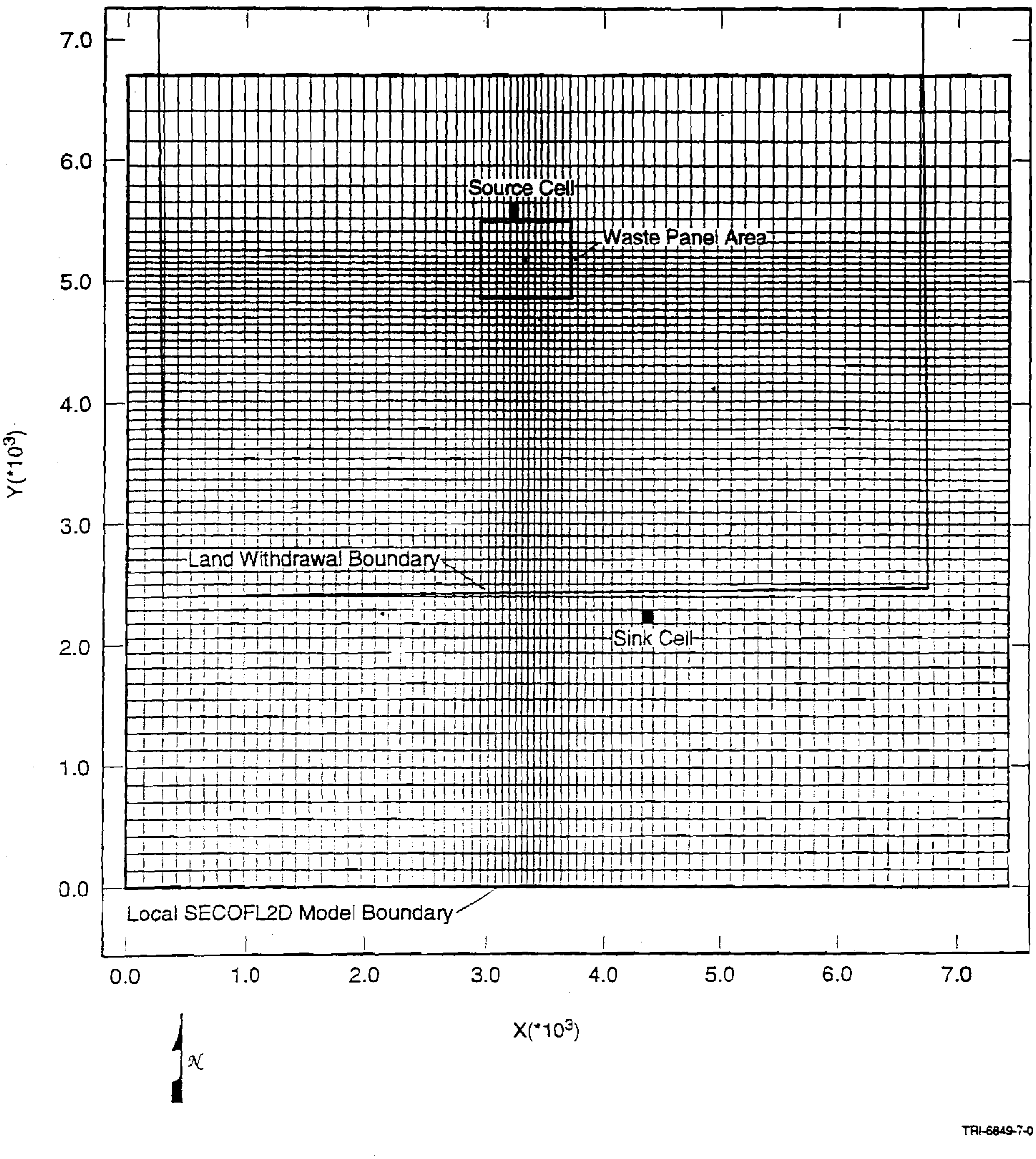
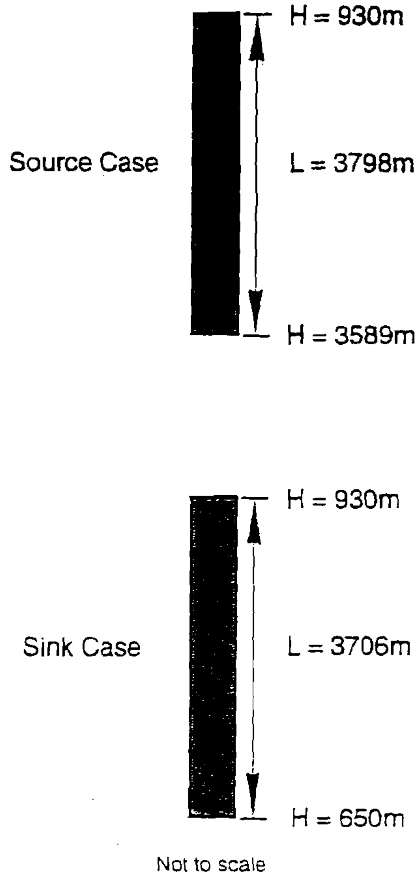


Figure NS7b.5b. Source and Sink Cell Assignments for Interconnections Study for the Partial Mining Case



Boreholes each have a cross sectional area of $0.196 m^2$
$K = 1.0 \times 10^{-4}$ m/s

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Figure NS7b.6. Application of Darcy's Law to Calculate Fluxes through Boreholes Connecting the Culebra to Deeper Units

Results and Discussion for NS7b

As part of the 96 PA, scatter plots were made depicting travel times, via particle tracking, for the two sets of 100 velocity fields (full mining and partial mining) Travel times were estimated for the horizontal line of 13 particle release points that stretched across the panel area, and mean travel times were calculated. Results are shown in Figures NS7b.2 and NS7b.3. Details of this process are provided in Appendix NS7b.1. Also, figures NS7b.7 and NS7b.8 show new extended ranges of travel times estimated by merely substituting the two new travel time samples for the original vectors that they stemmed from.

Visual examination shows that the decrease in travel times is not great, at approximately 1/2 of the previous fastest times, when compared to the range of travel times, covering 2 to 3 orders of magnitude. The new minimum travel times are listed in table NS7b.3

Table NS7b.3 Changes in Mean Travel Times for Vectors in which Interconnections were Considered.

	a	b	c
case	vector; slowest mean travel time (yrs)	vector; fastest mean travel time (yrs)	new mean travel time due to borehole interconnection (applied to vector in column b) (yrs)
full mining	vector R094 696,749	vector R095 3,113	1,787
partial mining	vector R094 228,105	vector R030 3,694	2,756

As discussed in the Approach section, (f * cv) can be used to estimate the sensitivies of the epv to the parameters that make up equation 2.0. Data was readily available from the PA Database to compute these terms for all of the parameters except for q. The travel time analysis primarily dealt in travel times, t, as opposed to darcy fluxes, q. By Gauss's approximation formulae (Blom, 1989), it can be shown that:

$$\frac{\sigma_t^2}{(\bar{t})^2} \approx \frac{\sigma_L^2}{(\bar{L})^2} + \frac{\sigma_v^2}{(\bar{v})^2}$$

where L is travel distance, which is relatively constant.

Then, since

$$\frac{\sigma_L}{\bar{L}} << 1,$$

Figure NS7b.7 Scatter Plot of Travel Times: Partial Mining Case (with interconnection for rank #1)

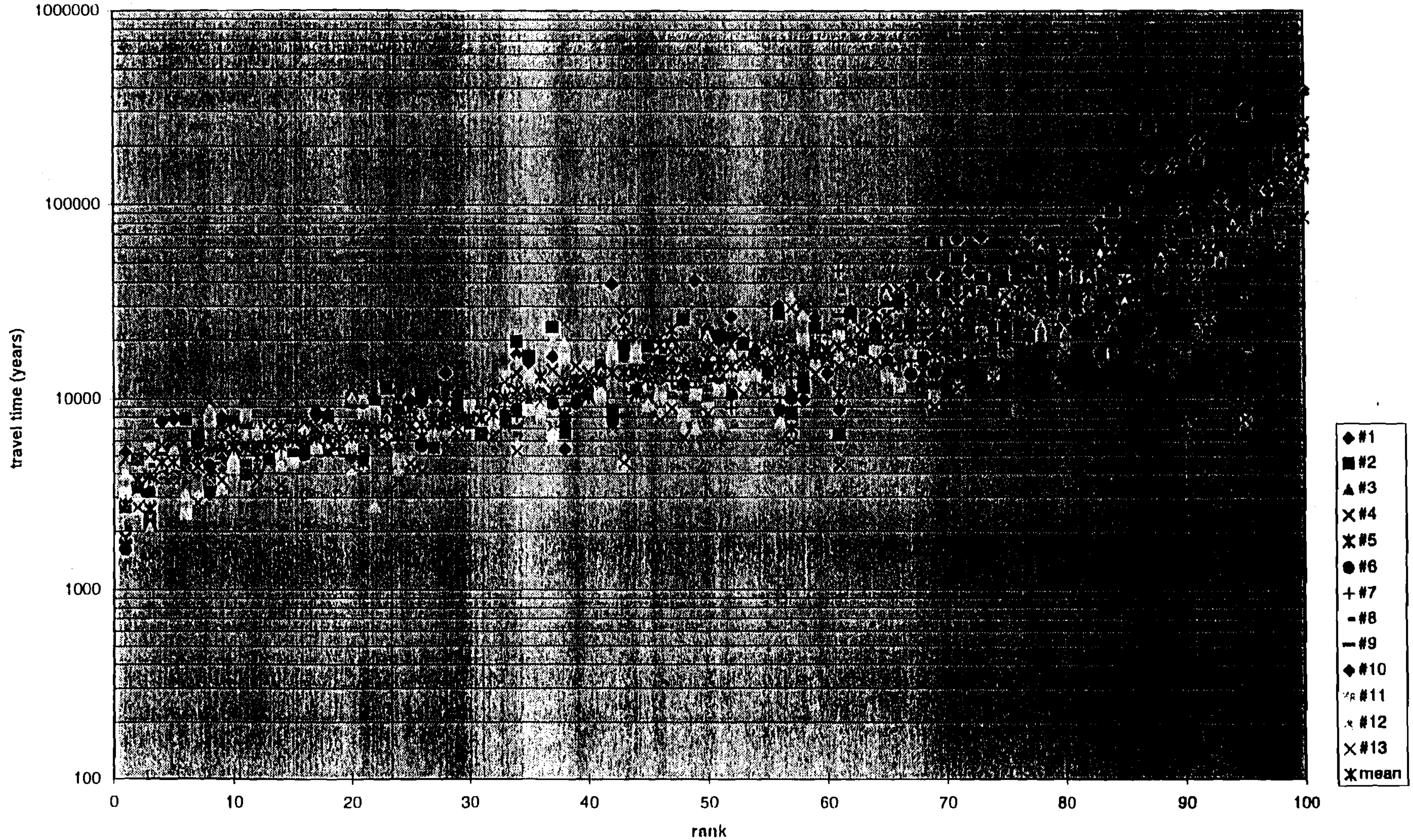
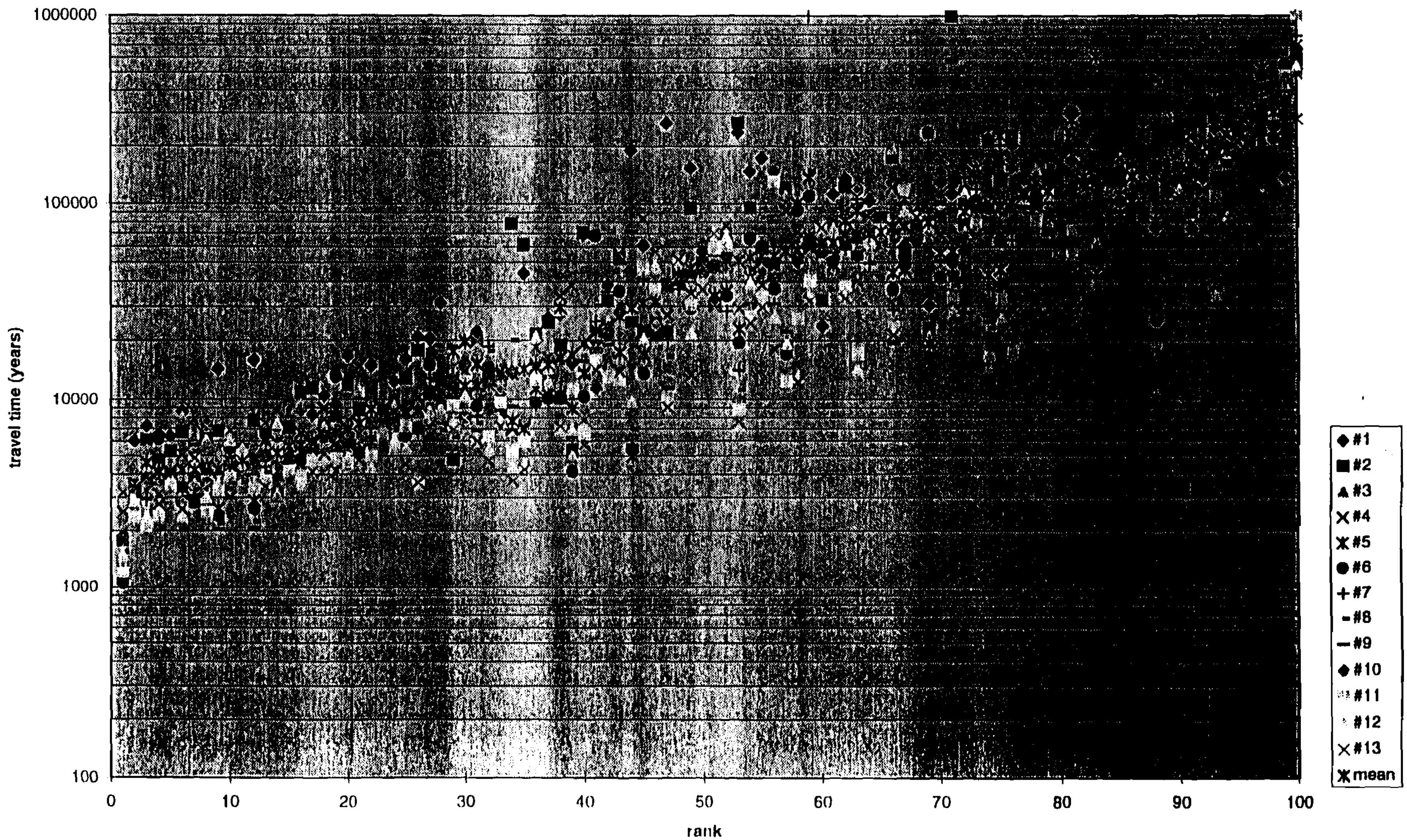


Figure NS7b.8 Scatter Plot of Travel Times: Full Mining Case
(with interconnection for rank #1)



it follows that

$$\left|\frac{\sigma_t}{\bar{t}}\right| = \left|\frac{\sigma_v}{\bar{v}}\right|$$

And, assuming an equivalent porous media, for purposes of particle tracking only, and that θ is a constant (the implementation that was used in the flow analysis):

$$\left|\frac{\sigma_v}{\bar{v}}\right| = \left|\frac{\sigma_q}{\bar{q}}\right|$$

$$\therefore \left|\frac{\sigma_t}{\bar{t}}\right| = \left|\frac{\sigma_q}{\bar{q}}\right|$$

The table below summarizes the key information.

Table NS7b.4 Summary of Statistical and Sensitivity Data for Parameters Associated with Equation 2.0

Parameter	mean	std. dev.	f	cv	f*cv
θ_m	.16	3.5e-2	5.7143e-6	0.21875	1.25e-6
θ_f	2.1e-3	2.5e-3	7.5e-8	1.1905	8.93e-8
k_{di}	10 m^3/kg (pu^{239} ensemble)	5.5 m^3/kg	1	0.55	−0.55
t full mining t partial mining	72,996.94 y 25,715.84 y	6459.216 y 2150.221 y	na	0.088486 0.083615	na
q full mining q partial mining	na na	na na	(1, by default)	0.088486 0.083615	0.088486 0.083615
ρ_b	constant, no range 2.8e3 kg/m^3	na na	na na	na na	na na

The sensitivity of the PA to the variables θ_m, θ_f, k_{di} (pu239), and q, can now be approximated through these surrogate values. As can be seen in the final column of the above table, the PA will be most sensitive to k_{di}. The q s are a distant second, with respect to sensitivity, followed by θ_m and θ_f respectively.

The impact of interconnections (this FEP) upon performance is estimated by calculating new sensitivities, based upon the new ranges of travel times produced by these sidebar calculations, as summarized in Table NS7b.3. The new sensitivities for full mining and partial mining are compared to the original ones in Table NS7b.5.

Table NS7b.5 Effect of Interconnections on Sensitivities of Darcy Velocities

Parameter	no interconnections	with interconnections	% change
$\text{sensitivity}_{\text{, full mining}}$	0.088486	0.088502	.01808
$\text{sensitivity}_{\text{, partial mining}}$	0.083615	0.083646	.0031

As shown, there is no more than a two-hundreths of a percent difference in the sensitivity values.

Basis for Recommended Screening Decision for NS7b

A set of extreme-case calculations was conducted to estimate the greatest possible increase in the range of velocities due to this FEP. That increase in the range can be used to estimate sensitivity of the PA to this FEP. The above section described and quantified the various sensitivites of plume velocity to the factors discussed that are already included in the PA and the sensitivity due to this FEP. As was shown, the Pa is expected to be at least five times more sensitive to k_{di} than to q. Inclusion of interconnections, which could widen the range of possible q values, will not change this relationship. In fact, the changes in the sensitivities for the q s (due to interconnections) are less than 0.02%.

Therefore this FEP is screened out on the basis of low consequence.

References:

Blom, Gunnar, 1989, *Probability and Statistics; Theory and Applications*, Springer-Verlag New York, NY

Corbet, T., 1995, *A Conceptual Model of Regional Groundwater Flow in Strata above the Salado Formation in the Vicinity of the WIPP, FEP NS-8, Climate Change, Appendix #1.* Record # SWCF-A:1.1.6.3:PA:QA:TSK:NS-8

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Powers, D.W., S. J. Lambert, S. E. Shaffer, L. R. Hill, and W. D. Weart, eds., 1978, *Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico*: SAND78-1596, v. I and II, Sandia National Laboratories, Albuquerque, NM_87185

Robertson et al., editors, 1993, *Atlas of Major Rocky Mountain Gas Reservoirs*, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM

Calculations:

This section summarizes some basic features of the analysis.
Complete discussion of data development is contained in the attached Summary Memo of Record.

Type of analyses:

Two ground water flow model sets, using SECOFL2D and TRACKER numerical codes.

- Horizontal 2-D flow, all steady state
- Equivalent porous media approximation
- Single phase, single density flow approximation.

Model characteristics and parameters:

Regional grid and associated boundary conditions and material properties from 1996 PA Culebra regional flow model.

Local grid and associated boundary conditions and material properties also from 1996 PA Culebra regional flow model.

Full Mining Case. Uses T-field from vector R095, replicate #1.
Internal fluid source at cell at row 60, column 33 of regional model (corresponds to x=3199m, y=5511m in local model domain).
fluid injected into Culebra at a constant rate of 1.37e-5 m^3/s.

Internal fluid sink at cell at row 17, column 43 of regional model (corresponds to x=3772m, y=2176m in local model domain).
fluid withdrawn from Culebra at a constant rate of 1.48e-6 m^3/s.

Partial Mining Case. Uses T-field from vector R030, replicate #1.
Internal fluid source at cell at row 60, column 33 of regional model (corresponds to x=3199m, y=5511m in local model domain).
fluid injected into Culebra at a constant rate of 1.37e-5 m^3/s.

Internal fluid sink at cell at row 17, column 50 of regional model (corresponds to x=4334m, y=2176m in local model domain).
fluid withdrawn from Culebra at a constant rate of 1.48e-6 m^3/s.

Names of Participants:

Michael Wallace Dept. 6849 (RE/SPEC, Inc.) MS 1328
Martin Tierney Dept. 6848 MS 1328
Rebecca Blaine Dept. 6849 (EcoDynamics, Inc.) MS 1328

Dates Analysis Conducted:

Summer, 1996

Plan of Work:

A set of screening analyses have been performed to evaluate the sensitivity of the WIPP repository performance to the following FEP:

FEP Screening Issue NS7b: Leakage from Abandoned Boreholes

This records package provides background information on the process used for conducting the screening analyses and summarizes the scenarios considered, identifies the computer codes and input and output files used in the calculations, and describes the performance measures that are used to help establish FEPs screening decisions. The statement of recommended screening decision for the FEP is provided in the attached Summary Memo of Record.

Planning Memos of Record:

The Approved Planning Memo of Record is provided on the following page.

NS-7: LEAKAGE FROM WELLS (OUTSIDE OF THE CONTROLLED AREA)
Planning Memo of Record

TO: **D.R. Anderson**

FROM: **M. Wallace**

SUBJECT: **FEP Screening Issue NS-7**

STATEMENT OF SCREENING ISSUE

Sedimentary units occur down to approximately 5500 meters below the land surface in the WIPP region. The permeabilities and pressures vary from unit to unit and within each unit. There is evidence of overpressure in some areas of some units, and evidence of underpressure in others. Many of these units are exploited for petroleum resources. Concerns have been raised that a leaky borehole(s) could create a connection(s) between a deep unit(s) and the Culebra in such a manner as to enhance flow rates to the boundary of the accessible environment.

APPROACH
Calculation Design

Information will be gathered on the sedimentary units underlying the WIPP. Their pressures, permeabilities, thicknesses, and other pertinent information will be identified. Zones will be determined, if any, which are overpressured with respect to the Culebra. Other zones will be identified which are underpressured with respect to the Culebra. A 2-D areal numerical modeling study will be conducted. In this model, a strategic placement of theoretical overpressured and underpressured source and sink nodes will be placed just outside of the controlled area to maximize the impact upon Culebra flow rates. The source and sink nodes will probably be constant-flux terms that add or remove fluid based on expected conditions of certain key deep units that have been identified.

The rate of flux into or out of the Culebra will be controlled not only by the relative pressures between the Culebra and those other units, but also by their relative permeabilities. The rates perhaps might also be modeled as affected by wellbore conditions (possibly developed through calculations for brine flow).

Resource estimate for NS-7: LEAKAGE FROM WELLS (OUTSIDE OF THE CONTROLLED AREA)

Michael Wallace: 100 hrs. Rebecca Blaine: 50 hrs. Tech Reps 20 hrs.

Documentation of Changes from Work Analysis Plan:

In the work analysis plan (Planning Memo of Record) the source node was to have been placed just outside and north of the Controlled Area.

In actuality, the source node was placed just north of the waste panel area. This resulted in a more conservative analysis.

Software:
Title and version of software used:

Pre-Processor	NS7b Calc partial mining run dates	NS7b Calc full mining run dates	pointer to SWCF records
GENMESH, Ver. 6.08 1-31-96	6-12-96	6-12-96	WPO23290
MATSET, Ver. 9.00 2-20-96	6-12-96	6-12-96	WPO23560
RELATE, Ver 1.43 3-6-96	6-12-96	6-12-96	WPO22267
POSTLHS, 4.07 2-7-96	6-12-96	6-12-96	WPO21464
Algebra 2.35 1-31-96	6-12-96	6-12-96	WPO21247
preSECOFL2D, Ver. 4.05 6-11-96	6-17-96	6-17-96	WPO32397
Analysis			
SECOFL2D, Ver. 3.03 5-7-96	6-17-96	6-17-96	WPO37271
Post Processor			
postSECOFL2D, 4.04 4-23-96	6-17-96	6-17-96	WPO23298
TRACKER, Ver. 5.01Z0 3-8-94	6-17-96	6-17-96	WPO7483
Spreadsheets			
Microsoft Excel Ver. 5.0c	various dates summer, 96	various dates summer, 96	na
Plotting and Data Presentation Packages			
BLOTCDB Ver. 1.37 6-4-96	various dates summer, 96	various dates summer, 96	WPO21260
Adobe Illustrator Ver. 5.0	various dates summer, 96	various dates summer, 96	na

Pointer to SWCF Records:

A copy of the Grade X code is available in the Records Center. Other codes have been archived by Department 6351, Computational Support, on the following tapes: F95074, F95080, F95654, F95714, F95738, and F95081.

Source Listing of Macros and Other Application Software Codes:

see attachments of macros from Microsoft Excel spreadsheets used for SMOR Appendix NS7b.1. two pages follow.

These two macros are stored in the Gateway 2000 computer at the desk of Michael Wallace, Dept. 6849, SNL (as of 9-19-96) in C:/data/paramete, as parmin2.xls and fulmin2.xls, respectively.

The function of each of these modules was to read in 100 individual files that had been temporarily imported over to this PC from the WIPP Alpha Cluster. Each file contained travel times for the 13 particles tracked by TRACKER for each of the 100 flow fields for the first PA replicate, for the partial mining and full mining cases, respectively. Elsewhere in these spreadsheets the travel times were converted from units of seconds to units of years, and subsequent ranking and graphing operations were performed.

```
' mactime Macro
' Macro recorded 4/30/96 by Authorized Gateway Customer
 Sub mactime()
   Counter = 0
   Do While Counter < 9   'Loop.
      Counter = Counter + 1   ' Increment Counter.
   Workbooks.OpenText Filename:="C:\DATA\Paramete\R00" & Counter & ".DAT",
Origin:= _
      xlWindows, StartRow:=1, DataType:=xlFixedWidth, FieldInfo:= _
      Array(Array(0, 1), Array(12, 1), Array(24, 1), Array(36, 1), Array(48, 1), _
      Array(60, 1), Array(72, 1), Array(84, 1), Array(96, 1), Array(108, 1), Array( _
      120, 1), Array(132, 1), Array(144, 1))
   ActiveWindow.LargeScroll ToRight:=1
   Range("A1:M1").Select
   Selection.Copy
   ActiveWorkbook.Close
   Windows("parmin.XLS").Activate
   ActiveSheet.Paste
   Range("A" & Counter + 1).Select
      Loop
End Sub
' mactime2 Macro
' Macro recorded 4/30/96 by Authorized Gateway Customer
Sub mactime2()
   Counter = 9
   Do While Counter < 100   'Loop.
      Counter = Counter + 1   ' Increment Counter.
   Workbooks.OpenText Filename:="C:\DATA\Paramete\R0" & Counter & ".DAT",
Origin:= _
      xlWindows, StartRow:=1, DataType:=xlFixedWidth, FieldInfo:= _
      Array(Array(0, 1), Array(12, 1), Array(24, 1), Array(36, 1), Array(48, 1), _
      Array(60, 1), Array(72, 1), Array(84, 1), Array(96, 1), Array(108, 1), Array( _
      120, 1), Array(132, 1), Array(144, 1))
   ActiveWindow.LargeScroll ToRight:=1
   Range("A1:M1").Select
   Selection.Copy
   ActiveWorkbook.Close
   Windows("parmin.XLS").Activate
   ActiveSheet.Paste
   Range("A" & Counter + 1).Select

      Loop
End Sub
```

```
' mactime Macro
' Macro recorded 4/30/96 by Authorized Gateway Customer
'
Sub mactime()
  Counter = 0
  Do While Counter < 9  'Loop.
    Counter = Counter + 1  ' Increment Counter.
  Workbooks.OpenText Filename:="C:\DATA\Paramete\R00" & Counter & ".DAT",
Origin:= _
    xlWindows, StartRow:=1, DataType:=xlFixedWidth, FieldInfo:= _
    Array(Array(0, 1), Array(12, 1), Array(24, 1), Array(36, 1), Array(48, 1), _
    Array(60, 1), Array(72, 1), Array(84, 1), Array(96, 1), Array(108, 1), Array( _
    120, 1), Array(132, 1), Array(144, 1))
  ActiveWindow.LargeScroll ToRight:=1
  Range("A1:M1").Select
  Selection.Copy
  ActiveWorkbook.Close
  Windows("fulmin.XLS").Activate
  ActiveSheet.Paste
  Range("A" & Counter + 1).Select
    Loop
End Sub
' mactime2 Macro
' Macro recorded 4/30/96 by Authorized Gateway Customer
'
Sub mactime2()
  Counter = 9
  Do While Counter < 98  'Loop.
    Counter = Counter + 1  ' Increment Counter.
  Workbooks.OpenText Filename:="C:\DATA\Paramete\R0" & Counter & ".DAT",
Origin:= _
    xlWindows, StartRow:=1, DataType:=xlFixedWidth, FieldInfo:= _
    Array(Array(0, 1), Array(12, 1), Array(24, 1), Array(36, 1), Array(48, 1), _
    Array(60, 1), Array(72, 1), Array(84, 1), Array(96, 1), Array(108, 1), Array( _
    120, 1), Array(132, 1), Array(144, 1))
  ActiveWindow.LargeScroll ToRight:=1
  Range("A1:M1").Select
  Selection.Copy
  ActiveWorkbook.Close
  Windows("fulmin.XLS").Activate
  ActiveSheet.Paste
  Range("A" & Counter + 1).Select
    Loop
End Sub
```

Computer platform:

All codes other than the *Spreadsheets* and *Plotting and Data Presentation Packages* were run on the WIPP Alpha Cluster, open VMS Ver. 1.5.

Spreadsheets and *Plotting and Data Presentation Packages* (other than BLOTCDB)were run on a Gateway 2000
Operating System, Windows 95

Data set and information files used, including name and version of all databases, libraries, and data files:

All files are located currently in the WIPP Alpha Cluster, F1:[fep.rlblain.ns7b]

File Characteristic	*Full Mining Case*	*Partial Mining Case*
presecofl2d input files cdb input ascii input	 fl_r095.cdb, loc.cdb presecofl_1.inp	 fl_r030.cdb, loc.cdb presecofl_2.inp
general output data local regional	 secofl_r095_1.cdb secofl_r095_reg_1.cdb	 secofl_r030_2.cdb secofl_r030_reg_2.cdb
com procedure	secofl_1.com	secofl_2.com
travel time ascii data, local	tt_r095_1.dat tracker.inp	tt_r030_2.dat tracker.inp
particle tracks, local	track_r095_1.cdb	track_r030_2.cdb

Schematic of Data Flow for NS7b:

GENMESH
(Defines gridded mesh)

↓

MATSET
(Populates the grid with
material-property data)

↓

POSTLHS
(Adds sampled values to cdb
file)

↓

RELATE
(transfers t-field to the above cdb file)

↓

ALGEBRA
(multiplies affected t-field cells by the
appropriate mining factor)

↓

PRESECOFL2D
(Transforms all input data to required
binary formats)

↓

SECOFL2D
(Solves governing PDEs for head and
thereby velocity)

↓

POSTSECOFL2D
(Adds SECOFL2D results to cdb file)

↓

TRACKER
(performs particle track analyses)

↓

BLOT
(Generates plots)

Documentation of deviations from baseline data set, including rationale:

A primary purpose of this fep was to explore the need for incorporating new data and/or concepts into the next round of PA calculations. Therefore, there are deviations from the baseline data set, by necessity. See section ___., Summary Memo of Record (in this Records Package) for the related documentation and rationale.

Appendix NS7b.1 Summary of 96 PA Particle Tracking Study

This summary is adapted from the *Analysis Records Package for the Culebra Flow and Transport Calculations (Task 3) of the Performance Assessment Analyses Supporting the Compliance Certification Application, Analysis Plan 019, SWCF-A:WA;1.2.07.4.1:QA.*

The 96PA includes an activity in which the sensitivities of the outcomes to input parameters are estimated. For most parameters this is expedited by the fact that they consist of values that range in some manner from a low value to a high value, with associated means and standard deviations. The T-field vector series is not such a parameter.

The T-field vector series encompasses two subseries, each of 100 distinct 'maps' of hydraulic conductivity over the region within the Culebra that is modeled by SECOFL2D. These maps are the configurations of hydraulic conductivity that are used by this groundwater flow program. Series A represents the hydraulic conductivity configurations as influenced by the 'full-mining' case (also referred to as the 'disturbed performance' case). Series B represents the hydraulic conductivity configurations as influenced by the 'partial-mining' case (also referred to as the 'undisturbed performance' case).

Since the subseries represent configurations, it is not a straightforward effort to incorporate them into the sensitivity analyses. A ranking must somehow be imposed on each subseries to order the individual configurations. The option favored for this ranking is the travel time option. In this approach, steady state runs are first performed of SECOFL2D for both regional and local domains, for all T-fields, as required for the PA. Particle tracking is then conducted for each model run, and the T-fields are ranked according to the particle travel times.

These particle tracking runs are performed assuming equivalent porous media flow, with a constant porosity of 0.16. In the full PA, dual porosity transport is assumed, and the porosities vary from one realization (and therefore, configuration) to the next. Therefore, these calculated travel times do not represent expected actual travel times. In fact, these calculated travel times can differ significantly, by as much as several orders of magnitude, from expected actual travel times. However, they are appropriate for calculation of sensitivity parameters relative to darcy fluxes.

These calculated travel times have specific limited purposes, including:

1. Ranking of T-fields for PA sensitivity analyses.
2. Diagnostic tool for review of SECOFL2D results and to aid in iterative grid/model design.
3. Design tool to aid in auxiliary analyses, such as sidebar calculations (FEPS).
4. Stochastic tool for estimation of dispersion properties.

Purpose #4 necessitated that a spread of particles be tracked for each configuration. Otherwise, it might have been acceptable (although not perhaps ideal) to merely track one particle for each configuration, as was done in the 92PA. In that study, the single particle was released from the center of the waste panel footprint (within the Culebra).

Particle tracking was done using the TRACKER code. TRACKER develops particle tracks and travel times by first reading in darcy velocities, q_x and q_y (m/s), from the CAMDAT data base for each SECOFL2D run (and its corresponding T-field configuration). An origin cell is specified for each particle. The thirteen cells that extend from the west end to the east end of the waste panel footprint, centered at its midpoint, were selected for these origin locations, as shown in Figure APNS7b.1. Exit boundaries are also specified. The exit boundaries used represent the southern LWB, and the eastern and western boundaries of the local grid. Constant time steps of ~ten years were specified for each tracking calculation. Simulations were run until each particle crossed an exit boundary, or for a simulated time of ~1e6 years, whichever came first.

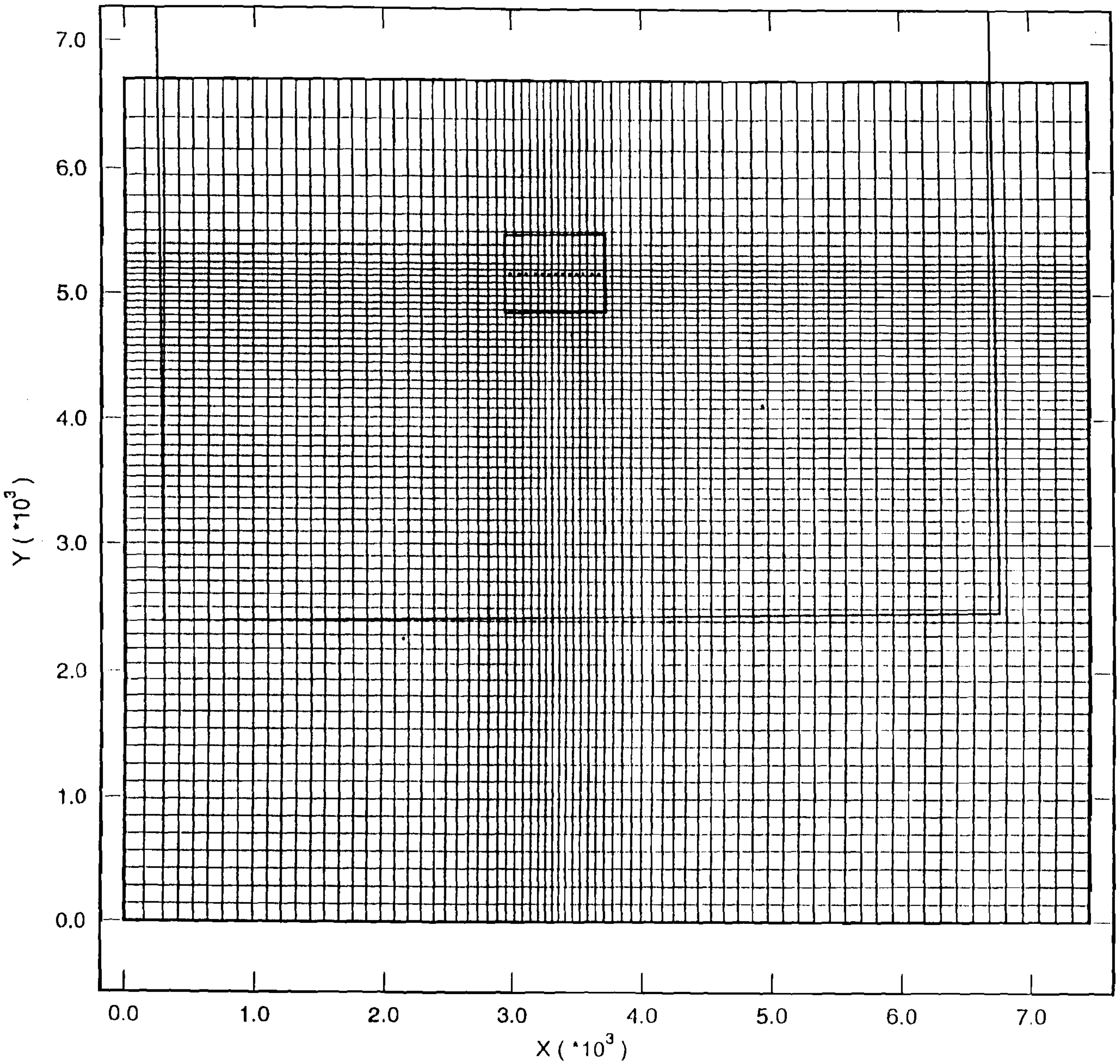
For Replicate 1, a total of 2600 individual particles were tracked; thirteen per configuration, with two subseries of 100 configurations each. 200 plots were made of the particle tracks, at one plot per configuration, They can be found in Appendix___ of the above-referenced analysis package.

For each configuration the mean and variance of the thirteen travel times were calculated. For each subseries, a mean and standard deviation (of the configuration means) of the travel times were calculated. Tables APNS7b.1 and APNS7b.2 summarize all of the travel times and the associated statistics for the base cases without interconnections. Tables APNS7b.3 and APNS7b.4 summarize all of the travel times and the associated statistics for the current FEP cases with interconnections (see main text for details).

The travel time results (for the cases without interconnections) are summarized graphically in Figures NS7b.2 and NS7b.3 corresponding to the two subseries (see main text). In those scatterplot figures, travel times are plotted along the abscissa and rankings along the ordinate. The configurations are ordered according to magnitude of mean travel time. For each configuration all thirteen travel times are shown (see legend), as well as the mean travel time. Figures NS7b.7 and NS7b.8 show the associated plots for the cases with interconnections.

As can be seen, both base subseries show a total range of travel times covering at least two orders of magnitude (o.o.m.). Spreads of travel times for individual configurations can range from relatively narrow (<1 o.o.m.) to relatively large (1 o.o.m <= spread <=2 o.o.m).

Generally the full mining subseries has a greater range of travel times for any configuration that the partial mining subseries. Examination of the travel path figures



GM_PA96 6.08 06/12/96
POSTSECO 4.04 06/12/96
TRACKER C-5.01ZO 07/19/96

Element Blocks Active:
1 of 1

Figure APNS 7B.1 Locations (dots) of origins used in Particle Tracking Analyses

DISK$CARLOS_CCA2:[SF2D.RLBLAIN]TRACK_FM_R001.CDB;1

BLOTCDB_PA96 1.37 08/06/96 16:29

shows a correspondingly greater range in flow directions for the full mining case than for the partial mining case.

The full mining subseries also has a somewhat greater total range of travel times. That subseries has the configurations with the slowest and the fastest mean travel times.

Table APNS7b.1

mgw, rlb, 8-14-96

Travel Times (years) of 13 Particles from a Constant Line of Release Points.

line is E-W, penetrating midpoint of waste panel area. constant porosity = 0.16

release points are equally spaced along this line.

exit boundary is the LWB. data sorted by mean travel time

Partial Mining Case

file is Microsoft Excel

Wallace PC

C:\data\parame\parmin2.xls, sheet parmin

rep 1 original cca run #	grasp/inv original T-field #	new rank	#1	#2	#3	#4	#5	PARTICLE NUMBER #6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
30	40	1	4753	4151	2880	3549	3993	3296	2880	2659	2548	2776	3676	4817	6052	3695	1040	1.08E+06
66	31	2	4722	4785	7035	4848	3296	3359	3264	2998	2893	2931	2776	2627	2665	3708	1289	1.66E+06
42	30	3	2389	2180	2050	2358	2598	3169	3803	4436	5704	6147	5419	4975	5070	3869	1491	2.22E+06
100	64	4	7575	5260	4120	3747	3755	3798	3830	4064	3769	3793	4619	5660	5684	4590	1159	1.34E+06
34	48	5	7795	5324	4151	3739	3739	3771	3803	4024	3834	3803	4563	5419	5831	4600	1207	1.46E+06
37	87	6	7827	7764	5831	5133	4753	4563	4373	4151	4373	3517	2459	3083	4310	4780	1588	2.52E+06
31	9	7	6528	6338	5545	4943	4373	5736	6496	6338	5957	3929	2976	3048	2830	5003	1416	2.01E+06
58	32	8	3131	3422	3676	3834	4056	4405	4246	4056	5292	7066	7542	8778	9570	5313	2170	4.71E+06
24	38	9	7985	7447	6654	6940	5862	5197	4817	4658	4531	4278	3676	3359	3676	5314	1527	2.33E+06
63	19	10	7542	7478	6750	6084	5514	4975	4468	4119	3961	4024	4310	4975	6591	5445	1311	1.72E+06
57	45	11	5894	4405	4056	4088	3961	3929	3993	4563	7162	9538	8144	6306	5767	5523	1830	3.35E+06
3	86	12	6401	5324	4722	3644	4880	5609	5989	6021	5957	6243	6433	6718	4341	5560	922	8.51E+05
5	71	13	6433	4341	4341	4531	4817	4785	4975	4975	5894	6623	7066	7098	7162	5619	1119	1.25E+06
4	62	14	5862	6274	6654	7035	7003	5704	5038	5197	5482	5704	5165	4436	3486	5619	1008	1.02E+06
95	97	15	6021	5419	5482	5577	5292	5197	5514	6052	7542	6718	4563	5862	9792	6079	1337	1.79E+06
78	91	16	5419	5355	5260	5672	5609	5038	5957	7288	6021	6243	6781	7352	7510	6116	854	7.29E+05
12	44	17	8049	6686	5799	5767	6845	8207	6116	5007	4500	4595	5450	5640	7193	6143	1196	1.43E+06
39	21	18	8207	7922	6971	5704	5292	5482	5482	5514	5767	5799	5862	5989	5894	6145	945	8.94E+05
59	16	19	6401	6147	6433	6781	6876	6369	5355	5007	5387	6021	6496	6750	6591	6201	598	3.58E+05
28	63	20	10489	9506	10045	7035	5704	4753	4658	4658	4817	5387	5577	4215	4373	6247	2275	5.18E+06
91	43	21	9316	7193	6021	4943	4626	4690	4753	5038	5450	6813	8144	9950	12041	6845	2381	5.67E+06
55	17	22	9538	9506	11059	6433	6559	6559	6654	6591	6274	5926	8492	2690	3803	6930	2288	5.24E+06
11	46	23	7985	11344	7922	6718	6401	6401	6591	6528	6369	6591	6496	6052	5767	7013	1447	2.09E+06
93	7	24	7669	8746	9285	10457	10140	8619	6147	7162	6179	5419	4817	4151	3612	7108	2260	5.11E+06
80	28	25	9792	9316	9443	9094	8809	9697	9918	4880	4215	4405	4658	4658	4531	7186	2552	6.51E+06
45	96	26	9475	10457	7605	7795	6274	5609	5894	7130	7605	7542	7193	8176	4088	7296	1638	2.68E+06
99	89	27	10299	10774	7383	10837	5545	5514	6813	5862	7066	6908	6401	6338	7225	7459	1910	3.65E+06
43	67	28	13467	7383	6306	8397	9380	7985	6528	6401	6559	6528	6243	6274	5831	7483	2071	4.29E+06
89	3	29	10520	9126	7985	7859	7827	7795	7320	7035	6908	7035	7035	7130	6940	7732	1045	1.09E+06
67	69	30	7859	7827	7732	7605	7542	7510	7447	7320	7669	8587	9126	8841	7637	7900	572	3.27E+05
79	4	31	7035	6433	10996	9348	8271	7510	7573	6845	6464	9094	8112	7637	7795	7932	1281	1.64E+06
19	35	32	10172	9855	9253	8271	7859	8049	8049	8049	8144	8461	7859	7478	6306	8293	1005	1.01E+06
16	49	33	7669	7764	7320	7130	7415	7985	8556	12992	12137	15686	12929	10996	12168	10057	2869	8.23E+06
33	33	34	16826	19583	15337	13499	10964	8778	8112	8144	7162	6401	5545	5324	5292	10074	4773	2.28E+07
7	6	35	15274	16383	11154	9190	9633	8302	7954	7542	7510	7700	8683	13024	10616	10228	2970	8.82E+06
84	12	36	9158	9792	11725	13024	12865	10584	10362	10109	9633	8968	9158	8429	9601	10262	1449	2.10E+06
38	81	37	16383	23291	19552	14006	9950	9380	10362	7035	6845	6718	6528	6147	7193	11030	5595	3.13E+07
64	11	38	5419	6623	7859	8334	8176	7193	8144	9221	10742	12960	15971	19235	24432	11101	5611	3.15E+07
83	52	39	12960	13087	13055	11344	9855	9380	9475	10330	11281	13119	14323	14513	14577	12100	1921	3.69E+06
10	41	40	12041	10457	11281	10267	10204	11534	12137	12612	13246	14957	14640	13499	13563	12341	1586	2.51E+06
76	72	41	10616	11851	11661	11566	12105	14608	14291	14735	14133	13277	10647	10330	11820	12434	1586	2.51E+06

Table APNS7b.1

original	original	new	PARTICLE NUMBER															
cca run #	T-field #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
20	23	42	39293	8207	7669	6971	7320	7605	7637	7985	9094	17524	16066	18538	22150	13543	9354	8.75E+07
70	51	43	18728	18506	21548	27632	23608	16414	12390	10552	8112	5070	4405	4722	4563	13558	8048	6.48E+07
68	5	44	14640	13341	11725	10330	10616	10996	11281	11851	13658	14925	16098	17682	20217	13643	2999	8.99E+06
32	57	45	22657	18728	22657	15147	12675	13087	13848	11313	10235	9506	9031	9253	10109	13711	4822	2.33E+07
50	68	46	14006	15464	19013	20312	18701	12644	9918	17397	13879	12802	10045	8334	7669	13887	4175	1.74E+07
56	58	47	19615	18664	18094	17428	22562	14672	12263	11408	10077	9063	9158	9094	8841	13918	4823	2.33E+07
87	39	48	25414	25477	21770	17492	14291	11820	11154	11218	11186	10013	8112	6940	6243	13933	6606	4.36E+07
77	59	49	40878	13467	14988	14988	10774	10647	12263	15495	15749	13119	10457	6940	6021	14291	8565	7.34E+07
46	82	50	22784	21675	20787	18031	15812	14386	13372	12390	10996	9760	8841	8809	8302	14304	5137	2.64E+07
14	26	51	19837	20851	15495	15939	15876	12770	13753	15084	20185	13721	10932	7415	5957	14447	4532	2.05E+07
40	53	52	26333	20375	16256	14260	13151	10362	8904	7098	10172	12992	13753	16953	18569	14552	5219	2.72E+07
9	76	53	15464	19045	24685	22499	14450	12422	12770	12992	13626	14925	12802	11281	10520	15191	4308	1.86E+07
75	78	54	17650	15907	15305	15484	15369	15432	15971	17365	17175	14703	13087	13689	14640	15520	1349	1.82E+06
82	93	55	15781	13943	11186	10901	13055	15464	13879	17935	19330	18854	16858	18506	18886	15737	2949	8.69E+06
47	10	56	30009	27410	20217	13531	15305	8619	10045	16224	20819	19108	11091	7478	5957	15832	7477	5.59E+07
41	6	57	10362	8302	6528	5894	6940	9855	12770	17143	19678	21453	29502	33272	29565	16251	9668	9.35E+07
21	84	58	9760	11313	14291	13753	12263	12770	13531	15876	14893	16985	20217	27315	29597	16351	5991	3.59E+07
29	15	59	26111	22974	20154	19425	18284	16985	16034	14386	13594	13721	14006	14038	13341	17158	4053	1.64E+07
6	54	60	13372	15464	15686	15876	18316	17904	18886	21801	22023	19837	18569	17872	17428	17926	2470	6.10E+06
15	75	61	8683	6496	4943	4436	10520	21706	45948	36124	26903	23132	20946	16351	14608	18523	12509	1.56E+08
13	14	62	28773	26364	23798	19330	17714	17270	15686	15591	16731	17365	17872	18316	18316	19471	4156	1.73E+07
90	100	63	19171	18506	17524	17524	17745	17745	18949	20439	21992	21928	21992	22087	22530	19856	2016	4.07E+06
35	27	64	23798	21453	33272	19837	28107	20566	19235	16605	16224	17048	17365	16066	15464	20388	5283	2.79E+07
92	94	65	36758	32639	34540	26935	18157	15559	14830	14418	14355	13689	12675	13087	23386	20848	8927	7.97E+07
52	70	66	31688	32639	27949	36758	30262	20787	14925	12897	12390	12865	11851	11503	15400	20917	9488	9.00E+07
60	18	67	38026	24432	19140	34223	22974	13309	15527	16509	16256	18284	17017	18886	19266	21065	7339	5.39E+07
1	36	68	15686	16636	18664	13563	15115	15876	18189	21738	24115	27759	28583	30040	28171	21087	5939	3.53E+07
53	66	69	44363	63376	50701	28741	16858	13436	16351	14133	13594	11820	10172	9538	8968	23235	18015	3.25E+08
36	1	70	41511	35808	29660	26871	24875	22308	17840	15749	16890	18316	22403	27917	24590	24980	7553	5.71E+07
97	37	71	66545	52602	43096	42145	31435	16953	11851	10457	10394	10964	11313	11154	11376	25407	19521	3.81E+08
73	98	72	46265	35808	33272	25224	22499	24527	25382	24495	23101	21009	17080	18379	16129	25628	8387	7.03E+07
17	95	73	68763	41828	30072	25255	27062	22403	19393	16953	15781	22277	22023	20502	19995	27101	14203	2.02E+08
98	90	74	35491	36124	36441	35808	36124	36124	37709	30040	21389	15686	13467	13214	12707	27717	10578	1.12E+08
23	92	75	26523	23101	20629	18886	17714	19900	25921	34540	38343	39610	34540	30801	34223	28056	7709	5.94E+07
88	73	76	57672	47849	54504	36124	44046	41511	29343	33272	18728	11788	8524	8651	6559	30659	18218	3.32E+08
27	88	77	71932	46265	40878	38659	25129	21009	19742	29818	24432	24051	26903	31688	29185	33053	14096	1.99E+08
2	2	78	63693	60841	58306	42145	28076	23132	21294	21136	20471	19678	20851	23861	29438	33302	16876	2.85E+08
26	29	79	36124	44997	56722	50384	30072	40878	24007	21928	37709	50067	16414	12770	11693	33436	15074	2.27E+08
65	34	80	47532	51018	54820	64644	56722	26016	22467	18664	17967	18157	17935	22055	17017	33463	18228	3.32E+08
51	74	81	35491	32956	32639	33589	33589	30579	27981	27917	31244	37709	43413	42145	35491	34211	4729	2.24E+07
61	61	82	42779	41195	39293	37709	37075	36441	35491	34857	34540	34540	32639	30104	28139	35754	4092	1.67E+07
69	65	83	80171	54820	48166	25794	21770	16985	15686	18031	23069	30737	46265	55137	51335	37536	19850	3.94E+08
74	56	84	67179	93163	43096	42779	60841	27505	22372	21485	20566	20154	16953	23417	31593	37777	23113	5.34E+08
48	83	85	44997	41195	38026	36124	34540	32005	33272	44363	56722	55137	41195	31371	28234	39783	8784	7.72E+07
44	42	86	121365	89360	74784	58940	44680	45314	33272	28424	23037	21992	18062	15844	16319	45492	32532	1.06E+09

Table APNS7b.1

original cca run #	original T-field #	new rank	PARTICLE NUMBER #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
8	99	87	155589	249068	39610	30516	29026	22784	13087	12834	19013	12580	14038	14957	15020	48317	71448	5.10E+09
96	24	88	58940	58940	65594	51018	44363	37709	36441	36441	37392	42462	45948	53236	60841	48410	10336	1.07E+08
54	20	89	53236	77953	73199	74150	158124	64644	24368	18538	24210	24717	14767	13531	13404	48834	41496	1.72E+09
81	55	90	83973	72883	95381	115345	97282	54504	50701	41828	35491	33589	16256	7510	6179	54686	35811	1.28E+09
18	79	91	207874	165412	95064	52602	44363	32956	24843	21326	20471	19742	21326	23132	19425	57580	61630	3.80E+09
72	47	92	82389	67813	46265	31403	25857	51652	54504	70031	90311	82072	70664	63693	59890	61273	19251	3.71E+08
25	50	93	109324	79537	64327	61475	60841	56088	57355	63693	55137	51652	50384	53553	62426	63522	15663	2.45E+08
86	80	94	99184	83340	68446	66862	69714	70031	72883	72249	64010	64644	73199	79220	74467	73711	9381	8.80E+07
85	85	95	305790	292481	213261	60841	77319	84290	34540	17840	9665	8239	7669	7288	7732	86689	110101	1.21E+10
62	60	96	154955	148617	158440	159708	118513	100768	85875	64961	62109	72883	85241	82706	56405	103937	39287	1.54E+09
71	77	97	127069	111225	96332	91262	96015	100768	104571	110275	122950	127703	117563	125168	126119	112078	13270	1.76E+08
49	25	98	160025	110591	120732	139111	177453	180939	147983	134674	92846	72249	68446	62109	60207	117490	43387	1.88E+09
22	22	99	85558	89360	92212	120415	135308	199952	205973	192664	168264	165412	163511	160342	172383	150104	41903	1.76E+09
94	13	100	389763	231640	154321	142913	263645	245266	370751	178404	151469	380257	232591	138477	85875	228105	100220	1.00E+10
												summary mean, std. dev.:			25715.8	2150.22		
													coefficient of variation			0.08361		

Table APNS7b.2

mgw, rlb, 8-14-96

Travel Times (years) of 13 Particles from a Constant Line of Release Points.
line is E-W, penetrating midpoint of waste panel area. constant porosity = 0.16
release points are equally spaced along this line.
exit boundary is the LWB. data sorted by mean travel time

Full Mining Case
file is Microsoft Excel
Wallace PC
C:\data\parame.fulmin2.xls, sheet 2

rep 1 original cca run #	grasp./inv original T-field #	new rank	PARTICLE NUMBER #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
95	97	1	2811	2877	2808	2684	2557	2510	2462	3169	4056	4595	2320	2839	4785	3113	822	6.76E+05
67	69	2	5989	3486	3109	3296	3454	3359	3232	3039	2776	2674	2361	2871	3486	3318	874	7.64E+05
63	19	3	7193	6084	5355	4563	4595	3771	2925	2459	2199	2066	2101	2389	3264	3766	1675	2.80E+06
55	17	4	6528	4722	4310	3121	4119	6116	4690	3771	3549	3771	2411	2754	2776	4049	1245	1.55E+06
16	49	5	6369	5260	4436	3929	3676	3581	3549	3708	4024	3549	3486	3803	4056	4110	833	6.93E+05
66	31	6	8587	6718	8049	5070	3359	3391	3359	3001	2855	2833	2579	2399	2598	4215	2175	4.73E+06
42	30	7	4278	3898	3549	3169	2855	2814	3086	4278	5704	7288	4722	4373	4848	4220	1261	1.59E+06
24	38	8	7352	6179	6052	7193	4405	3549	3090	2808	2706	2576	2507	3004	3486	4224	1815	3.30E+06
100	64	9	14350	6820	4780	3670	2610	2387	2285	2190	2050	3170	3270	3539	4186	4254	3304	1.09E+07
58	32	10	3200	4246	4595	4753	4690	5419	4119	3549	2966	3296	3929	5989	6813	4428	1132	1.28E+06
59	16	11	5482	5355	5450	5133	4563	4626	3929	3612	4246	4817	5038	4500	3961	4670	612	3.75E+05
34	48	12	15844	7700	5229	4151	2871	2611	2586	2240	2069	4373	3359	3517	4943	4730	3677	1.35E+07
89	3	13	6654	6876	7542	7447	6021	4943	4373	4088	3803	3644	3708	3612	3422	5087	1587	2.52E+06
41	8	14	3834	3048	3105	3517	5894	7225	5260	4563	4531	4405	5419	7478	8714	5153	1764	3.11E+06
37	87	15	9190	7035	5799	5577	5260	4595	4246	4119	3993	3803	4151	5672	9348	5599	1873	3.51E+06
45	96	16	8746	10837	9316	6623	5229	4722	4912	5197	4310	3993	3834	3517	2820	5697	2467	6.09E+06
11	46	17	8271	11439	6813	5989	5767	5450	5197	5038	4943	4817	4595	4341	4119	5906	2000	4.00E+06
75	78	18	10425	7225	7098	8904	6433	6274	6433	5355	5229	5038	4753	4817	5102	6391	1705	2.91E+06
19	35	19	9316	8080	7130	6211	5862	13055	5926	5514	5324	6338	4848	4373	4183	6628	2405	5.78E+06
28	63	20	16731	11946	7827	6940	5926	4531	4785	5387	5609	6052	4595	4912	5609	6988	3530	1.25E+07
21	84	21	7162	8904	5862	4722	5260	5165	5102	5387	8334	7225	7478	11123	14767	7422	2884	8.32E+06
29	15	22	14893	10711	9887	10330	8841	7383	6338	6179	6243	5514	5007	4310	3486	7625	3181	1.01E+07
13	14	23	8873	7890	7890	8080	8873	8366	8271	7605	6496	6084	6464	7066	7510	7651	901	8.12E+05
76	72	24	12422	9887	9221	8492	7922	7922	7542	6908	6179	5640	5419	6147	7415	7778	1935	3.75E+06
9	76	25	16034	12865	10711	8587	6940	6338	6591	6876	8049	9792	7130	5419	4500	8449	3206	1.03E+07
33	33	26	20851	17777	11820	10077	8651	7035	6686	7098	6686	4151	3612	3581	3612	8587	5428	2.95E+07
31	9	27	20439	10806	8176	7732	7732	14988	12897	12548	10489	9126	7859	8651	7193	10664	3792	1.44E+07
64	11	28	31149	12295	11408	8302	9792	11788	8778	6876	7510	8017	8207	8809	10394	11025	6279	3.94E+07
5	71	29	11313	4753	14735	11344	17492	10013	13309	6274	18379	12802	9285	7447	6908	11081	4222	1.78E+07
3	86	30	10774	12073	7542	14006	19678	7985	10425	11123	12517	15305	12358	10362	7954	11700	3328	1.11E+07
56	58	31	22055	20629	19171	19995	15147	9158	8176	7478	6845	6179	5989	6211	5957	11768	6518	4.25E+07
84	12	32	14133	13467	12517	12929	12612	14481	18664	17619	14260	8714	6338	5355	4690	11983	4434	1.97E+07
79	4	33	7415	9190	58623	13848	11218	9792	9950	8271	7478	11281	9570	7637	7162	13187	13786	1.90E+08
93	7	34	13784	77953	8587	7700	7669	6591	6686	20027	9126	6274	5197	4373	3676	13665	19796	3.92E+08
99	89	35	43970	61142	15399	5730	6960	7509	7430	7648	7480	7908	5918	4530	4239	14297	17547	3.08E+08
83	52	36	20280	21485	20724	14418	11313	9601	9380	12485	10045	17302	12517	13658	18347	14735	4395	1.93E+07
39	21	37	25953	24812	20280	12485	10520	10045	9823	11281	14006	13531	14513	12232	16319	15062	5388	2.90E+07
70	51	38	27030	18791	28583	33906	29438	10299	10964	15432	9633	7162	6781	7225	7193	16341	10016	1.00E+08
30	40	39	15210	5229	5007	38343	8936	4119	5704	7130	6306	52285	11313	6876	51018	16729	17906	3.21E+08
57	45	40	68763	70348	9158	5736	13626	10267	14038	13151	15591	8841	6750	6496	7732	19269	22541	5.08E+08
6	54	41	11408	15844	16098	22182	18601	68129	24939	30167	22435	17967	15812	14862	14196	22511	14614	2.14E+08

Table APNS7b.2

original cca run #	original T-field #	new rank	PARTICLE NUMBER #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
14	26	42	38343	32005	17904	15654	22403	21516	35491	21896	19045	16066	13087	24622	23988	23232	7752	6.01E+07
7	6	43	27917	52285	67179	55137	17302	35808	13467	12295	12168	12739	12739	13372	13911	26640	19577	3.83E+08
68	5	44	189812	25160	10742	5862	4943	5387	5672	6940	70981	9221	28424	9697	7985	29294	51541	2.66E+09
50	68	45	60524	22372	15400	83023	16763	13563	41195	19710	22150	25477	46581	20185	16478	31032	21042	4.43E+08
62	60	46	36758	24527	32322	37075	24083	21104	21801	23132	23639	23956	37075	47849	56405	31517	11077	1.23E+08
98	90	47	265546	38659	32639	26903	22182	22055	20185	16541	11408	9633	9633	9063	9063	37962	69043	4.77E+09
4	62	48	42779	43413	42779	41828	40878	40561	36758	38026	43096	46898	50701	48483	51335	43656	4511	2.04E+07
18	79	49	153370	94431	52285	43096	34857	28963	29121	29185	42462	32005	30421	21580	13436	46555	37647	1.42E+09
32	57	50	56405	49750	48800	46265	43730	48166	56088	56088	46898	45631	38976	36124	36441	46874	6909	4.77E+07
12	44	51	32639	30294	28709	29914	33906	47532	47215	56088	54504	58306	58940	69714	69714	47498	15060	2.27E+08
40	53	52	65911	57672	62426	49750	35491	33906	28297	33906	44997	46581	60524	67496	76685	51050	15323	2.35E+08
52	70	53	236393	265546	22403	28995	22847	19361	14070	11154	9792	10013	8746	7288	7573	51091	89166	7.95E+09
73	98	54	147350	94747	48483	29121	41828	65911	65594	45948	30642	28583	26460	39610	24495	52982	34794	1.21E+09
60	18	55	173334	48800	32956	38659	58940	59574	62426	51652	33272	45948	33272	30611	29597	53772	37797	1.43E+09
51	74	56	146716	49117	43096	40561	38659	36758	30769	36441	80171	28361	130238	26333	17904	54240	40334	1.63E+09
10	41	57	117880	121048	109324	91579	17555	17080	19805	19266	22182	70031	12295	19076	101719	56834	45201	2.04E+09
20	23	58	50701	56088	59574	71298	99817	90945	90945	93163	76051	12802	25762	13055	12327	57887	32795	1.08E+09
47	10	59	61792	62742	53870	52602	66545	109007	1000000	147350	57355	53553	40561	33906	32005	136253	261419	6.83E+10
80	28	60	23766	32322	48483	55137	57989	56405	73833	78586	75418	74784	75101	75101	75101	61694	18009	3.24E+08
22	22	61	111859	64644	52919	48166	49117	50067	51335	53236	56405	60524	65277	73516	80805	62913	17761	3.15E+08
54	20	62	134991	121682	106155	89994	80805	61475	58623	59890	39927	42145	37709	33906	32956	69251	34657	1.20E+09
38	81	63	53870	55137	62109	66862	91895	118513	105521	99184	63693	119147	17175	14260	40561	69841	35022	1.23E+09
85	85	64	103620	86192	79537	66228	61475	63693	49433	49750	68129	64010	62426	69080	86192	69982	15283	2.34E+08
46	82	65	73199	86825	97916	73516	70348	66545	63059	61475	63059	65911	73199	72883	60841	71444	10638	1.13E+08
17	95	66	191713	174918	195516	121999	44363	36758	28773	22815	19298	71298	23386	23703	21231	75059	70061	4.91E+09
87	39	67	60841	55137	49750	45314	46265	48483	53553	65277	108056	141646	117246	91262	104254	75930	32436	1.05E+09
43	67	68	89044	74467	72249	71298	86192	64961	80171	66228	67813	71298	83973	85241	84607	76734	8429	7.10E+07
23	92	69	30262	23006	21009	19298	19140	234809	73516	152420	83340	181573	74784	67813	58940	79993	68794	4.73E+09
72	47	70	130238	96332	84924	69714	55771	42145	51018	96966	95381	89360	90311	91895	88727	83291	23409	5.48E+08
49	25	71	112810	1000000	67813	57355	57039	50384	44046	38659	573554	41828	33569	27917	22942	163687	290785	8.46E+10
53	66	72	77319	78270	70664	85875	106789	116295	137209	94114	47532	57355	90311	113760	100451	90457	24914	6.21E+08
86	80	73	70348	96966	80171	68446	152420	103620	118513	78270	96332	141963	77319	75735	68446	94504	27889	7.78E+08
92	94	74	218965	211676	268081	101719	43413	94747	36758	23196	24780	20692	16383	14545	173651	96047	91045	8.29E+09
15	75	75	138794	131189	187277	226887	45948	63693	202170	87459	52285	38659	32956	25921	21738	96537	72470	5.25E+09
78	91	76	154638	226570	210726	168581	159391	205339	64644	19583	10013	44997	17112	16605	28393	102045	85796	7.36E+09
25	50	77	126435	118513	130238	119464	116612	98550	94431	95381	99184	108373	116929	106155	115978	111250	11799	1.39E+08
81	55	78	96015	96966	109007	129604	105521	97599	106472	100768	102353	85875	81122	150835	202487	112663	32437	1.05E+09
2	2	79	82072	72883	81122	86192	105204	132773	149568	156222	144181	127386	114077	110908	141646	115710	28676	8.22E+08
91	43	80	54820	53870	54504	74150	75101	77002	73833	78903	108056	219282	225936	237344	184742	116734	71730	5.15E+09
97	37	81	166362	130872	135625	229105	275686	306107	79220	70031	32639	70664	53870	72883	25002	126774	92438	8.54E+09
65	34	82	133090	126752	144815	172066	137209	126435	118197	109007	108056	115345	120098	121682	120415	127167	17090	2.92E+08
35	27	83	47849	49750	55771	153370	614749	207874	128020	147666	64010	49750	38659	63693	51968	128702	155512	2.42E+10
26	29	84	136259	147350	151469	157807	136259	101402	110591	133724	159074	147033	114711	91579	96332	129507	23801	5.66E+08
71	77	85	179671	131822	97916	80488	87776	102669	114077	127703	141646	153687	163511	175235	173017	133017	34566	1.19E+09
90	100	86	109958	114394	123267	137209	157173	152737	152737	146399	153687	144181	141329	130555	138794	138648	15220	2.32E+08

Table APNS7b.2

original	original	new						PARTICLE NUMBER										
cca run #	T-field #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
44	42	87	269032	229105	134041	95698	84924	84290	100134	101402	94431	130872	115345	139744	224035	138696	61651	3.80E+09
77	59	88	74784	158124	443633	456308	80171	25477	26269	449971	41511	28424	17999	10837	15305	140678	180692	3.26E+10
88	73	89	137209	121682	116295	118830	122633	96966	102036	127703	109958	222450	284242	177453	94431	140914	55584	3.09E+09
82	93	90	154004	153687	257307	117246	137209	129287	107106	131506	139744	145131	177770	118513	108373	144376	39375	1.55E+09
1	36	91	74150	89994	112176	132773	141329	145448	150518	167313	177136	202170	213578	222450	226887	158148	49392	2.44E+09
8	99	92	137209	111859	109007	116929	155272	142280	161292	176820	238611	181890	231957	187910	186643	164437	41816	1.75E+09
74	56	93	248435	199952	205339	210726	284876	279172	392932	154321	36758	15876	110275	34223	191079	181843	110735	1.23E+10
36	1	94	217063	192664	186960	183791	231323	164144	176503	204071	255406	206289	184108	86192	186643	190397	39694	1.58E+09
96	24	95	203754	207557	226887	228471	211043	229422	339063	354907	285193	196466	196149	218014	211360	239099	53066	2.82E+09
61	61	96	220232	219915	236076	241463	309909	295650	282341	276637	265229	256990	251603	244949	238294	256869	27867	7.77E+08
48	83	97	285193	283925	280756	326387	526022	478490	351738	380257	405608	205656	209775	122316	110908	305156	125427	1.57E+10
27	88	98	250019	273468	329556	440464	279489	220549	256040	320050	314029	329556	292164	307374	367582	306180	56370	3.18E+09
69	65	99	134991	204705	177770	268081	348569	548204	342231	364413	342231	415114	484828	430958	99501	320123	136457	1.86E+10
94	13	100	671787	583061	522853	494334	560879	624255	779527	1000000	1000000	1000000	1000000	541866	279172	696749	238318	5.68E+10
													summary mean, std. dev.:			72996.9	6459.22	
														coefficient of variation			0.08849	

Table APNS7b.3

mgw, rib, 8-16-96			Travel Times (years) of 13 Particles from a Constant Line of Release Points									Partial Mining w/interconnections						
			line is E-W, penetrating midpoint of waste panel area.									file is Microsoft Excel						Interconnection effect applied only to first set (rank #1) of travel times
			release points are equally spaced along this line.					constant porosity = 0.16				Wallace PC						
rep 1	grasp/inv		exit boundary is the LWB.					data sorted by mean travel time				C:\data\sldebar\ns7\travel times\par.xls, sheet 2						
original	original	new						PARTICLE NUMBER										
cca run #	T-field #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
30	40	1	[redacted]													2756	[redacted]	
66	31	2	4722	4785	7035	4848	3296	3359	3264	2998	2893	2931	2776	2627	2665	3708	1289	1.66E+06
42	30	3	2389	2180	2050	2358	2598	3169	3803	4436	5704	6147	5419	4975	5070	3869	1491	2.22E+06
100	64	4	7575	5260	4120	3747	3755	3798	3830	4064	3769	3793	4619	5660	5684	4590	1159	1.34E+06
34	48	5	7795	5324	4151	3739	3739	3771	3803	4024	3834	3803	4563	5419	5831	4600	1207	1.46E+06
37	87	6	7827	7764	5831	5133	4753	4563	4373	4151	4373	3517	2459	3083	4310	4780	1588	2.52E+06
31	9	7	6528	6338	5545	4943	4373	5736	6496	6338	5957	3929	2976	3048	2830	5003	1416	2.01E+06
58	32	8	3131	3422	3676	3834	4056	4405	4246	4056	5292	7066	7542	8778	9570	5313	2170	4.71E+06
24	38	9	7985	7447	6654	6940	5862	5197	4817	4658	4531	4278	3676	3359	3676	5314	1527	2.33E+06
63	19	10	7542	7478	6750	6084	5514	4975	4468	4119	3961	4024	4310	4975	6591	5445	1311	1.72E+06
57	45	11	5894	4405	4056	4088	3961	3929	3993	4563	7162	9538	8144	6306	5767	5523	1830	3.35E+06
3	86	12	6401	5324	4722	3644	4880	5609	5989	6021	5957	6243	6433	6718	4341	5560	922	8.51E+05
5	71	13	6433	4341	4341	4531	4817	4785	4975	4975	5894	6623	7066	7098	7162	5619	1119	1.25E+06
4	62	14	5862	6274	6654	7035	7003	5704	5038	5197	5482	5704	5165	4436	3486	5619	1008	1.02E+06
95	97	15	6021	5419	5482	5577	5292	5197	5514	6052	7542	6718	4563	5862	9792	6079	1337	1.79E+06
78	91	16	5419	5355	5260	5672	5609	5038	5957	7288	6021	6243	6781	7352	7510	6116	854	7.29E+05
12	44	17	8049	6686	5799	5767	6845	8207	6116	5007	4500	4595	5450	5640	7193	6143	1196	1.43E+06
39	21	18	8207	7922	6971	5704	5292	5482	5482	5514	5767	5799	5862	5989	5894	6145	945	8.94E+05
59	16	19	6401	6147	6433	6781	6876	6369	5355	5007	5387	6021	6496	6750	6591	6201	598	3.58E+05
28	63	20	10489	9506	10045	7035	5704	4753	4658	4658	4817	5387	5577	4215	4373	6247	2275	5.18E+06
91	43	21	9316	7193	6021	4943	4626	4690	4753	5038	5450	6813	8144	9950	12041	6845	2381	5.67E+06
55	17	22	9538	9506	11059	6433	6559	6559	6654	6591	6274	5926	8492	2690	3803	6930	2288	5.24E+06
11	46	23	7985	11344	7922	6718	6401	6401	6591	6528	6369	6591	6496	6052	5767	7013	1447	2.09E+06
93	7	24	7669	8746	9285	10457	10140	8619	6147	7162	6179	5419	4817	4151	3612	7108	2260	5.11E+06
80	28	25	9792	9316	9443	9094	8809	9697	9918	4880	4215	4405	4658	4658	4531	7186	2552	6.51E+06
45	96	26	9475	10457	7605	7795	6274	5609	5894	7130	7605	7542	7193	8176	4088	7296	1638	2.68E+06
99	89	27	10299	10774	7383	10837	5545	5514	6813	5862	7066	6908	6401	6338	7225	7459	1910	3.65E+06
43	67	28	13467	7383	6306	8397	9380	7985	6528	6401	6559	6528	6243	6274	5831	7483	2071	4.29E+06
89	3	29	10520	9126	7985	7859	7827	7795	7320	7035	6908	7035	7035	7130	6940	7732	1045	1.09E+06
67	69	30	7859	7827	7732	7605	7542	7510	7447	7320	7669	8587	9126	8841	7637	7900	572	3.27E+05
79	4	31	7035	6433	10996	9348	8271	7510	7573	6845	6464	9094	8112	7637	7795	7932	1281	1.64E+06
19	35	32	10172	9855	9253	8271	7859	8049	8049	8049	8144	8461	7859	7478	6306	8293	1005	1.01E+06
16	49	33	7669	7764	7320	7130	7415	7985	8556	12992	12137	15686	12929	10996	12168	10057	2869	8.23E+06
33	33	34	16826	19583	15337	13499	10964	8778	8112	8144	7162	6401	5545	5324	5292	10074	4773	2.28E+07
7	6	35	15274	16383	11154	9190	9633	8302	7954	7542	7510	7700	8683	13024	10616	10228	2970	8.82E+06
84	12	36	9158	9792	11725	13024	12865	10584	10362	10109	9633	8968	9158	8429	9601	10262	1449	2.10E+06
38	81	37	16383	23291	19552	14006	9950	9380	10362	7035	6845	6718	6528	6147	7193	11030	5595	3.13E+07
64	11	38	5419	6623	7859	8334	8176	7193	8144	9221	10742	12960	15971	19235	24432	11101	5611	3.15E+07
83	52	39	12960	13087	13055	11344	9855	9380	9475	10330	11281	13119	14323	14513	14577	12100	1921	3.69E+06
10	41	40	12041	10457	11281	10267	10204	11534	12137	12612	13246	14957	14640	13499	13563	12341	1586	2.51E+06
76	72	41	10616	11851	11661	11566	12105	14608	14291	14735	14133	13277	10647	10330	11820	12434	1586	2.51E+06

Table APNS7b.3

original cca run #	original T-field #	new rank	PARTICLE NUMBER #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
20	23	42	39293	8207	7669	6971	7320	7605	7637	7985	9094	17524	16066	18538	22150	13543	9354	8.75E+07
70	51	43	18728	18506	21548	27632	23608	16414	12390	10552	8112	5070	4405	4722	4563	13558	8048	6.48E+07
68	5	44	14640	13341	11725	10330	10616	10996	11281	11851	13658	14925	16098	17682	20217	13643	2999	8.99E+06
32	57	45	22657	18728	22657	15147	12675	13087	13848	11313	10235	9506	9031	9253	10109	13711	4822	2.33E+07
50	68	46	14006	15464	19013	20312	18791	12644	9918	17397	13879	12802	10045	8334	7669	13867	4175	1.74E+07
56	58	47	19615	18664	18094	17428	22562	14672	12263	11408	10077	9063	9158	9094	8841	13918	4823	2.33E+07
87	39	48	25414	25477	21770	17492	14291	11820	11154	11218	11186	10013	8112	6940	6243	13933	6606	4.36E+07
77	59	49	40878	13467	14988	14988	10774	10647	12263	15495	15749	13119	10457	6940	6021	14291	8565	7.34E+07
46	82	50	22784	21675	20787	18031	15812	14386	13372	12390	10996	9760	8841	8809	8302	14304	5137	2.64E+07
14	26	51	19837	20851	15495	15939	15876	12770	13753	15084	20185	13721	10932	7415	5957	14447	4532	2.05E+07
40	53	52	26333	20375	16256	14260	13151	10362	8904	7098	10172	12992	13753	16953	18569	14552	5219	2.72E+07
9	76	53	15464	19045	24685	22499	14450	12422	12770	12992	13626	14925	12802	11281	10520	15191	4308	1.86E+07
75	78	54	17650	15907	15305	15464	15369	15432	15971	17365	17175	14703	13087	13689	14640	15520	1349	1.82E+06
82	93	55	15781	13943	11186	10901	13055	15464	13879	17935	19330	18854	16858	18506	18886	15737	2949	8.69E+06
47	10	56	30009	27410	20217	13531	15305	8619	10045	16224	20819	19108	11091	7478	5957	15832	7477	5.59E+07
41	8	57	10362	8302	6528	5894	6940	9855	12770	17143	19678	21453	29502	33272	29565	16251	9668	9.35E+07
21	84	58	9760	11313	14291	13753	12263	12770	13531	15876	14893	16985	20217	27315	29597	16351	5991	3.59E+07
29	15	59	26111	22974	20154	19425	18284	16985	16034	14386	13594	13721	14006	14038	13341	17158	4053	1.64E+07
6	54	60	13372	15464	15686	15876	18316	17904	18886	21801	22023	19837	18569	17872	17428	17926	2470	6.10E+06
15	75	61	8683	6496	4943	4436	10520	21706	45948	36124	26903	23132	20946	16351	14608	18523	12509	1.56E+08
13	14	62	28773	26364	23798	19330	17714	17270	15686	15591	16731	17365	17872	18316	18316	19471	4156	1.73E+07
90	100	63	19171	18506	17524	17524	17745	17745	18949	20439	21992	21928	21992	22087	22530	19856	2016	4.07E+06
35	27	64	23798	21453	33272	19837	28107	20566	19235	16605	16224	17048	17365	16066	15464	20388	5283	2.79E+07
92	94	65	36758	32639	34540	26935	18157	15559	14830	14418	14355	13689	12675	13087	23386	20848	8927	7.97E+07
52	70	66	31688	32639	27949	36758	30262	20787	14925	12897	12390	12865	11851	11503	15400	20917	9488	9.00E+07
60	18	67	38026	24432	19140	34223	22974	13309	15527	16509	16256	18284	17017	18886	19266	21065	7339	5.39E+07
1	36	68	15686	16636	18664	13563	15115	15876	18189	21738	24115	27759	28583	30040	28171	21087	5939	3.53E+07
53	66	69	44363	63376	50701	28741	16858	13436	16351	14133	13594	11820	10172	9538	8968	23235	18015	3.25E+08
36	1	70	41511	35808	29660	26871	24875	22308	17840	15749	16890	18316	22403	27917	24590	24980	7553	5.71E+07
97	37	71	66545	52602	43096	42145	31435	16953	11851	10457	10394	10964	11313	11154	11376	25407	19521	3.81E+08
73	98	72	46265	35808	33272	25224	22499	24527	25382	24495	23101	21009	17080	18379	16129	25628	8387	7.03E+07
17	95	73	68763	41828	30072	25255	27062	22403	19393	16953	15781	22277	22023	20502	19995	27101	14203	2.02E+08
98	90	74	35491	36124	36441	35808	36124	36124	37709	30040	21389	15686	13467	13214	12707	27717	10578	1.12E+08
23	92	75	26523	23101	20629	18886	17714	19900	25921	34540	38343	39610	34540	30801	34223	28056	7709	5.94E+07
88	73	76	57672	47849	54504	36124	44046	41511	29343	33272	18728	11788	8524	8651	6559	30659	18218	3.32E+08
27	88	77	71932	46265	40878	38659	25129	21009	19742	29818	24432	24051	26903	31688	29185	33053	14096	1.99E+08
2	2	78	63693	60841	58306	42145	28076	23132	21294	21136	20471	19678	20851	23861	29438	33302	16876	2.85E+08
26	29	79	36124	44997	56722	50384	30072	40878	24907	21928	37709	50067	16414	12770	11693	33436	15074	2.27E+08
65	34	80	47532	51018	54820	64644	56722	26016	22467	18664	17967	18157	17935	22055	17017	33463	18228	3.32E+08
51	74	81	35491	32956	32639	33589	33589	30579	27981	27917	31244	37709	43413	42145	35491	34211	4729	2.24E+07
61	61	82	42779	41195	39293	37709	37075	36441	35491	34857	34540	34540	32639	30104	28139	35754	4092	1.67E+07
69	65	83	80171	54820	48166	25794	21770	16985	15686	18031	23069	30737	46265	55137	51335	37536	19850	3.94E+08
74	56	84	67179	93163	43096	42779	60841	27505	22372	21485	20566	20154	16953	23417	31593	37777	23113	5.34E+08
48	83	85	44997	41195	38026	36124	34540	32005	33272	44363	56722	55137	41195	31371	28234	39783	8784	7.72E+07
44	42	86	121365	89360	74784	58940	44680	45314	33272	28424	23037	21992	18062	15844	16319	45492	32532	1.06E+09

Table APNS7b.3

original	original	new						PARTICLE NUMBER										
cca run #	T-field #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
8	99	87	155589	249068	39610	30516	29026	22784	13087	12834	19013	12580	14038	14957	15020	48317	71448	5.10E+09
96	24	88	58940	58940	65594	51018	44363	37709	36441	36441	37392	42462	45948	53236	60841	48410	10336	1.07E+08
54	20	89	53236	77953	73199	74150	158124	64644	24368	18538	24210	24717	14767	13531	13404	48834	41496	1.72E+09
81	55	90	83973	72883	95381	115345	97282	54504	50701	41828	35491	33589	16256	7510	6179	54686	35811	1.28E+09
18	79	91	207874	165412	95064	52602	44363	32956	24843	21326	20471	19742	21326	23132	19425	57580	61630	3.80E+09
72	47	92	82389	67813	46265	31403	25857	51652	54504	70031	90311	82072	70664	63693	59890	61273	19251	3.71E+08
25	50	93	109324	79537	64327	61475	60841	56088	57355	63693	55137	51652	50384	53553	62426	63522	15663	2.45E+08
86	80	94	99184	83340	68446	66862	69714	70031	72883	72249	64010	64644	73199	79220	74467	73711	9381	8.80E+07
85	85	95	305790	292481	213261	60841	77319	84290	34540	17840	9665	8239	7669	7288	7732	86689	110101	1.21E+10
62	60	96	154955	148617	158440	159708	118513	100768	85875	64961	62109	72883	85241	82706	56405	103937	39287	1.54E+09
71	77	97	127069	111225	96332	91262	96015	100768	104571	110275	122950	127703	117563	125168	126119	112078	13270	1.76E+08
49	25	98	160025	110591	120732	139111	177453	180939	147983	134674	92846	72249	68446	62109	60207	117490	43387	1.88E+09
22	22	99	85558	89360	92212	120415	135308	199952	205973	192664	168264	165412	163511	160342	172383	150104	41903	1.76E+09
94	13	100	389763	231640	154321	142913	263645	245266	370751	178404	151469	380257	232591	138477	85875	228105	100220	1.00E+10
													summary mean, std. dev.:			25706.5	2150.23	
														coefficient of variation			0.08365	

Table APNS7b.4

mgw, rlb, 8-16-96

Travel Times (years) of 13 Particles from a Constant Line of Release Points
line is E-W, penetrating midpoint of waste panel area.
release points are equally spaced along this line.
exit boundary is the LWB.

constant porosity =0.16
data sorted by mean travel time

Full Mining w/Interconnections
file is Microsoft Excel
Wallace PC
C:\data\sldobar\ns7\travel times\.ful.xls, sheet 2

Interconnection effect applied only to first set (rank #1) of travel times

rep 1 original cca run #	grasp./inv original T-field #	new rank	PARTICLE NUMBER #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
95	97	1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1787	[redacted]	[redacted]
67	69	2	5989	3486	3109	3296	3454	3359	3232	3039	2776	2674	2361	2871	3486	3318	874	7.64E+05
63	19	3	7193	6084	5355	4563	4595	3771	2925	2459	2199	2066	2101	2389	3264	3766	1675	2.80E+06
55	17	4	6528	4722	4310	3121	4119	6116	4690	3771	3549	3771	2411	2754	2776	4049	1245	1.55E+06
16	49	5	6369	5260	4436	3929	3676	3581	3549	3708	4024	3549	3486	3803	4056	4110	833	6.93E+05
66	31	6	8587	6718	8049	5070	3359	3391	3359	3001	2855	2833	2579	2399	2598	4215	2175	4.73E+06
42	30	7	4278	3898	3549	3169	2855	2814	3086	4278	5704	7288	4722	4373	4848	4220	1261	1.59E+06
24	38	8	7352	6179	6052	7193	4405	3549	3090	2808	2706	2576	2507	3004	3486	4224	1815	3.30E+06
100	64	9	14350	6820	4780	3670	2610	2387	2285	2190	2050	3170	3270	3539	4186	4254	3304	1.09E+07
58	32	10	3200	4246	4595	4753	4690	5419	4119	3549	2966	3296	3929	5989	6813	4428	1132	1.28E+06
59	16	11	5482	5355	5450	5133	4563	4626	3929	3612	4246	4817	5038	4500	3961	4670	612	3.75E+05
34	48	12	15844	7700	5229	4151	2871	2611	2586	2240	2069	4373	3359	3517	4943	4730	3677	1.35E+07
89	3	13	6654	6876	7542	7447	6021	4943	4373	4088	3803	3644	3708	3612	3422	5087	1587	2.52E+06
41	8	14	3834	3048	3105	3517	5894	7225	5260	4563	4531	4405	5419	7478	8714	5153	1764	3.11E+06
37	87	15	9190	7035	5799	5577	5260	4595	4246	4119	3993	3803	4151	5672	9348	5599	1873	3.51E+06
45	96	16	8746	10837	9316	6623	5229	4722	4912	5197	4310	3993	3834	3517	2820	5697	2467	6.09E+06
11	46	17	8271	11439	6813	5989	5767	5450	5197	5038	4943	4817	4595	4341	4119	5906	2000	4.00E+06
75	78	18	10425	7225	7098	8904	6433	6274	6433	5355	5229	5038	4753	4817	5102	6391	1705	2.91E+06
19	35	19	9316	8080	7130	6211	5862	13055	5926	5514	5324	6338	4848	4373	4183	6628	2405	5.78E+06
28	63	20	16731	11946	7827	6940	5926	4531	4785	5387	5609	6052	4595	4912	5609	6988	3530	1.25E+07
21	84	21	7162	8904	5862	4722	5260	5165	5102	5387	8334	7225	7478	11123	14767	7422	2884	8.32E+06
29	15	22	14893	10711	9887	10330	8841	7383	6338	6179	6243	5514	5007	4310	3486	7625	3181	1.01E+07
13	14	23	8873	7890	7890	8080	8873	8366	8271	7605	6496	6084	6464	7066	7510	7651	901	8.12E+05
76	72	24	12422	9887	9221	8492	7922	7922	7542	6908	6179	5640	5419	6147	7415	7778	1935	3.75E+06
9	76	25	16034	12865	10711	8587	6940	6338	6591	6876	8049	9792	7130	5419	4500	8449	3206	1.03E+07
33	33	26	20851	17777	11820	10077	8651	7035	6686	7098	6686	4151	3612	3581	3612	8587	5428	2.95E+07
31	9	27	20439	10806	8176	7732	7732	14988	12897	12548	10489	9126	7859	8651	7193	10664	3792	1.44E+07
64	11	28	31149	12295	11408	8302	9792	11788	8778	6876	7510	8017	8207	8809	10394	11025	6279	3.94E+07
5	71	29	11313	4753	14735	11344	17492	10013	13309	6274	18379	12802	9285	7447	6908	11081	4222	1.78E+07
3	86	30	10774	12073	7542	14006	19678	7985	10425	11123	12517	15305	12358	10362	7954	11700	3328	1.11E+07
56	58	31	22055	20629	19171	19995	15147	9158	8176	7478	6845	6179	5989	6211	5957	11768	6518	4.25E+07
84	12	32	14133	13467	12517	12929	12612	14481	18664	17619	14260	8714	6338	5355	4690	11983	4434	1.97E+07
79	4	33	7415	9190	58623	13848	11218	9792	9950	8271	7478	11281	9570	7637	7162	13187	13786	1.90E+08
93	7	34	13784	77953	8587	7700	7669	6591	6686	20027	9126	6274	5197	4373	3676	13665	19796	3.92E+08
99	89	35	43970	61142	15399	5730	6960	7509	7430	7648	7480	7908	5918	4530	4239	14297	17547	3.08E+08
83	52	36	20280	21485	20724	14418	11313	9601	9380	12485	10045	17302	12517	13658	18347	14735	4395	1.93E+07
39	21	37	25953	24812	20280	12485	10520	10045	9823	11281	14006	13531	14513	12232	16319	15062	5388	2.90E+07
70	51	38	27030	18791	28583	33906	29438	10299	10964	15432	9633	7162	6781	7225	7193	16341	10016	1.00E+08
30	40	39	15210	5229	5007	38343	8936	4119	5704	7130	6306	52285	11313	6876	51018	16729	17906	3.21E+08
57	45	40	68763	70348	9158	5736	13626	10267	14038	13151	15591	8841	6750	6496	7732	19269	22541	5.08E+08
6	54	41	11408	15844	16098	22182	18601	68129	24939	30167	22435	17967	15812	14862	14196	22511	14614	2.14E+08

original cca run #	original T-field #	new rank	PARTICLE NUMBER #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
14	26	42	38343	32005	17904	15654	22403	21516	35491	21896	19045	16066	13087	24622	23988	23232	7752	6.01E+07
7	6	43	27917	52285	67179	55137	17302	35808	13467	12295	12168	12730	12739	13372	13911	26640	19577	3.83E+08
68	5	44	189812	25160	10742	5882	4943	5387	5672	6940	70981	9221	28424	9697	7985	29294	51541	2.66E+09
50	68	45	60524	22372	15400	83023	16763	13563	41195	19710	22150	25477	46581	20185	16478	31032	21042	4.43E+08
62	60	46	36758	24527	32322	37075	24083	21104	21801	23132	23639	23956	37075	47849	56405	31517	11077	1.23E+08
98	90	47	265546	38659	32639	26903	22182	22055	20185	16541	11408	9633	9633	9063	9063	37962	69043	4.77E+09
4	62	48	42779	43413	42779	41828	40878	40561	36758	38026	43096	46898	50701	48483	51335	43656	4511	2.04E+07
18	79	49	153370	94431	52285	43096	34857	28963	29121	29185	42462	32005	30421	21580	13436	46555	37647	1.42E+09
32	57	50	56405	49750	48800	46265	43730	48166	56088	56088	46898	45631	38976	36124	36441	46874	6909	4.77E+07
12	44	51	32639	30294	28709	29914	33906	47532	47215	56088	54504	58306	58940	69714	69714	47498	15060	2.27E+08
40	53	52	65911	57672	62426	49750	35491	33906	28297	33906	44997	46581	60524	67496	76685	51050	15323	2.35E+08
52	70	53	236393	265546	22403	28995	22847	19361	14070	11154	9792	10013	8746	7288	7573	51091	89166	7.95E+09
73	96	54	147350	94747	48483	29121	41828	65911	65594	45948	30642	28583	26460	39610	24495	52982	34794	1.21E+09
60	18	55	173334	48800	32956	38659	58940	59574	62426	51652	33272	45948	33272	30611	29597	53772	37797	1.43E+09
51	74	56	146716	49117	43096	40561	38659	36758	30769	36441	80171	28361	130238	26333	17904	54240	40334	1.63E+09
10	41	57	117880	121048	109324	91579	17555	17080	19805	19266	22182	70031	12295	19076	101719	56834	45201	2.04E+09
20	23	58	50701	56088	59574	71298	99817	90945	90945	93163	76051	12802	25762	13055	12327	57887	32795	1.08E+09
47	10	59	61792	62742	53870	52602	66545	109007	1000000	147350	57355	53553	40561	33906	32005	136253	261419	6.83E+10
80	28	60	23766	32322	48483	55137	57989	56405	73833	78586	75418	74784	75101	75101	75101	61694	18009	3.24E+08
22	22	61	111859	64644	52919	48166	49117	50067	51335	53236	56405	60524	65277	73516	80805	62913	17761	3.15E+08
54	20	62	134991	121682	106155	89994	80805	61475	58623	59890	39927	42145	37709	33906	32956	69251	34657	1.20E+09
38	81	63	53870	55137	62109	66862	91895	118513	105521	99184	63693	119147	17175	14260	40561	69841	35022	1.23E+09
85	85	64	103620	86192	79537	66228	61475	63693	49433	49750	68129	64010	62426	69080	86192	69982	15283	2.34E+08
46	82	65	73199	86825	97916	73516	70348	66545	63059	61475	63059	65911	73199	72883	60841	71444	10638	1.13E+08
17	95	66	191713	174918	195516	121999	44363	36758	28773	22815	19298	71298	23386	23703	21231	75059	70061	4.91E+09
87	39	67	60841	55137	49750	45314	46265	48483	53553	65277	108056	141646	117246	91262	104254	75930	32436	1.05E+09
43	67	68	89044	74467	72249	71298	86192	64961	80171	66228	67813	71298	83973	85241	84607	76734	8429	7.10E+07
23	92	69	30262	23006	21009	19298	19140	234809	73516	152420	83340	181573	74784	67813	58940	79993	68794	4.73E+09
72	47	70	130238	96332	84924	69714	55771	42145	51018	96966	95381	89360	90311	91895	88727	83291	23409	5.48E+08
49	25	71	112810	1000000	67813	57355	57039	50384	44046	38659	573554	41828	33589	27917	22942	163687	290785	8.46E+10
53	66	72	77319	78270	70664	85875	106789	116295	137209	94114	47532	57355	90311	113760	100451	90457	24914	6.21E+08
86	80	73	70348	96966	80171	68446	152420	103620	118513	78270	96332	141963	77319	75735	68446	94504	27889	7.78E+08
92	94	74	218965	211676	268081	101719	43413	94747	36758	23196	24780	20692	16383	14545	173651	96047	91045	8.29E+09
15	75	75	138794	131189	187277	226887	45948	63693	202170	87459	52285	38659	32956	25921	21738	96537	72470	5.25E+09
78	91	76	154638	226570	210726	168581	159391	205339	64644	19583	10013	44997	17112	16605	28393	102045	85796	7.36E+09
25	50	77	126435	118513	130238	119464	116612	98550	94431	95381	99184	108373	116929	106155	115978	111250	11799	1.39E+08
81	55	78	96015	96966	109007	129604	105521	97599	106472	100768	102353	85875	81122	150835	202487	112663	32437	1.05E+09
2	2	79	82072	72883	81122	86192	105204	132773	149568	156222	144181	127386	114077	110908	141646	115710	28676	8.22E+08
91	43	80	54820	53870	54504	74150	75101	77002	73833	78903	108056	219282	225936	237344	184742	116734	71730	5.15E+09
97	37	81	166362	130872	135625	229105	275686	306107	79220	70031	32639	70664	53870	72883	25002	126774	92438	8.54E+09
65	34	82	133090	126752	144815	172066	137209	126435	118197	109007	108056	115345	120098	121682	120415	127167	17090	2.92E+08
35	27	83	47849	49750	55771	153370	614749	207874	128020	147666	64010	49750	38659	63693	51968	128702	155512	2.42E+10
26	29	84	136259	147350	151469	157807	136259	101402	110591	133724	159074	147033	114711	91579	96332	129507	23801	5.66E+08
71	77	85	179671	131822	97916	80488	87776	102669	114077	127703	141646	153687	163511	175235	173017	133017	34566	1.19E+09
90	100	86	109958	114394	123267	137209	157173	152737	152737	146399	153687	144181	141329	130555	138794	138648	15220	2.32E+08

Table APNS7b.4

original cca run #	original T-field #	new rank	#1	#2	#3	#4	#5	PARTICLE NUMBER #6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
44	42	87	269032	229105	134041	95698	84924	84290	100134	101402	94431	130872	115345	139744	224035	138696	61651	3.80E+09
77	59	88	74784	158124	443633	456308	80171	25477	26269	449971	41511	28424	17999	10837	15305	140678	180692	3.26E+10
88	73	89	137209	121682	116295	118830	122633	96966	102036	127703	109958	222450	284242	177453	94431	140914	55584	3.09E+09
82	93	90	154004	153687	257307	117246	137209	129287	107106	131506	139744	145131	177770	118513	108373	144376	39375	1.55E+09
1	36	91	74150	89994	112176	132773	141329	145448	150518	167313	177136	202170	213578	222450	226887	158148	49392	2.44E+09
8	99	92	137209	111859	109007	116929	155272	142280	161292	176820	238611	181890	231957	187910	186643	164437	41816	1.75E+09
74	56	93	248435	199952	205339	210726	284876	279172	392932	154321	36758	15876	110275	34223	191079	181843	110735	1.23E+10
36	1	94	217063	192664	186960	183791	231323	164144	176503	204071	255406	206289	184108	86192	186643	190397	39694	1.58E+09
96	24	95	203754	207557	226887	228471	211043	229422	339063	354907	285193	196466	196149	218014	211360	239099	53066	2.82E+09
61	61	96	220232	219915	236076	241463	309909	295650	282341	276637	265229	256990	251603	244949	238294	256869	27867	7.77E+08
48	83	97	285193	283925	280756	326387	526022	478490	351738	380257	405608	205656	209775	122316	110908	305156	125427	1.57E+10
27	88	98	250019	273468	329556	440464	279489	220549	256040	320050	314029	329556	292164	307374	367582	306180	58370	3.18E+09
69	65	99	134991	204705	177770	268081	348569	548204	342231	364413	342231	415114	484828	430958	99501	320123	138457	1.86E+10
94	13	100	671787	583061	522853	494334	560879	624255	779527	1000000	1000000	1000000	1000000	541866	279172	696749	238316	5.68E+10
													summary mean, std. dev.:			72983.7	6459.21	
														coefficient of variation			0.0885	