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Records Package for Screening Effort NS11:
Subsidence Associated with Mining Inside or Outside the Controlled Area

Michael L. Wallace

Lead Staff Member: Michael Wallace, Dept. 6849 (Contractor) (MS 1328)

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Table of Contents:

Page #

Summary Memo of Record for NS11; Subsidence Associated with Mining Inside or Outside the Controlled Area: 1

Glossary: 29

References: 30

Calculations: 31

Names of Participants: 31

Dates Analysis Conducted: 31

Plan of Work: 32

Planning Memos of Record: 32,33

Documentation of Changes from Work Analysis Plan: 32

General Schematic of Data Flow for NS11: 34

Software: 35

Data Set and Information Files Used, Including Name and Version of All Databases, Libraries, and Data files: 37

Computer Platform: 40

Source Listing of Macros and Other Application Software Codes: 40

Documentation of Deviations from Baseline Data Set, Including Rationale: 42

Appendix NS11.1 40CFR 194 43

Appendix NS11.2 Future Mining Events in the Performance Assessment (reproduced from WID memo) 67

Appendix NS11.3 Summary of 96 PA Particle Tracking Study 88

Information Only

Summary Memo of Record for NS11;
Subsidence Associated with Mining Inside or Outside the Controlled Area
Michael Wallace

Recommended Screening Decision:

NS11 is screened in on a regulatory basis.

Statement of Screening Issues:

Subsidence over future potash mines could modify the rate and direction of groundwater flow in strata overlying the Salado Formation. Concerns have been raised that such a modification could lead to an increase in flow rates within the Culebra aquifer member of the Rustler Formation from the waste panel footprint to the boundary of the accessible environment (AE). If such an increase were to occur, concerns would focus on whether or not this would have an impact on compliance calculations involving the Culebra aquifer in the Performance Assessment (PA).

Background and Approach for NS11

In the current regulation, 40CFR Part 194, which applies to certification of WIPP, the Environmental Protection Agency (EPA) has developed minimum specifications for incorporating potash mining impacts upon the performance of the WIPP repository. Pertinent excerpts from the published rule are shown below. The complete text (Federal Register/vol. 61, No. 28) is included as Appendix NS11.1:

" **194.32 Scope of performance assessments**

(a) Performance assessments shall consider natural processes and events, mining, deep drilling, and shallow drilling that may affect the disposal system during the regulatory time frame.

(b) Assessments of mining effects may be limited to changes in the hydraulic conductivity of the hydrogeologic units of the disposal system from excavation mining for natural resources. Mining shall be assumed to occur with a one in 100 probability in each century of the regulatory time frame. Performance assessments shall assume that mineral deposits of those resources, similar in quality and type to those resources currently extracted from the Delaware Basin, will be completely removed from the controlled area during the century in which such mining is randomly calculated to occur. Complete removal of such mineral resources shall be assumed to occur only once during the regulatory time frame.

(c) Performance assessments shall include an analysis of the effects on the disposal system of any activities that occur in the vicinity of the disposal system prior to disposal and are expected to occur in the vicinity of the disposal system soon after

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disposal. Such activities shall include, but shall not be limited to, existing boreholes and the development of any existing leases that can be reasonably expected to be developed in the near future, including boreholes and leases that may be used for fluid injection activities."

Furthermore, in the preamble contained in that regulation document, on page 5229, it is stated:

"With respect to man-made processes and events, performance assessments must include the effects of drilling events and excavation mining. Some natural resources in the vicinity of the WIPP can be extracted by mining. These natural resources lie within the geologic formations found at shallower depths than the tunnels and shafts of the repository and do not lie vertically above the repository. Were mining of these resources to occur, this could alter the hydrologic properties of overlying formations-including the most transmissive layer in the disposal system, the Culebra dolomite--so as to either increase or decrease ground-water travel times to the accessible environment. For the purposes of modeling these hydrologic properties, this change can be well represented by making corresponding changes in the values for the hydraulic conductivity. The Agency has conducted a review of the data and scientific literature discussing the effects mining can induce in the hydrologic properties of a formation. Based on its review of available information, the Agency expects that mining can, in some instances, increase the hydraulic conductivity of overlying formations by as much as a factor of 1,000, although smaller or even negligible changes can also be expected to occur. Thus, the final rule requires DOE to consider the effects of mining in performance assessments. *In order to consider the effects of mining in performance assessments, DOE may use the location-specific values of hydraulic conductivity, established for the different spatial locations within the Culebra dolomite, and treat them as sampled parameters with each having a range of values varying between unchanged and increased 1,000-fold relative to the value that would exist in the absence of mining. . . . .*

Pursuant to 194.34 of the final rule, *performance assessments must randomly sample across the full range of values that have been established for all uncertain variables, including the hydraulic conductivity of the Culebra dolomite established as discussed above.*"

This guidance was developed by the EPA and its contractors. Prior to the issuing of the guidance, two versions of this FEP had already been developed. The first version, by T. Corbet, was a consequence argument, supported by calculations, in which the FEP was recommended to be screened in. The conceptual model of potash mining effects on Culebra flow in that version was fundamentally different than the one adopted by the EPA. Corbet had conceptualized potash-induced subsidence as primarily affecting the hydraulic conductivities of the Rustler confining units (such as the Tamarisk and the Forty Niner) not the Culebra. Before that version could complete internal review, but as part of that review, it was superseded by a regulatory argument by S. Bertram to screen

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out. That version did complete internal review, but was in turn superseded by the recent changes to 40CFR 194 and the guidance, as documented above. Both of these prior versions of the FEP are included in the same Nuclear Waste Management Center (NWMC) file that contains this records package, for informational purposes. This current version does not rely on either of those versions in any way.

Sandia National Labs conducted a cursory review of the EPA guidance, after it became official. Two meetings of experts in geomechanics and hydrogeology were held to consider and evaluate the EPA's approach. Partial documentation of those meetings is provided in same Nuclear Waste Management Center (NWMC) file that contains this records package, for informational purposes. This current version of NS11 is stand-alone. Any data or conceptual issues developed through those meetings that might have been relevant is already documented in this version.

Under this specific EPA guidance, the current FEP must be incorporated into the PA analyses. The purpose of this effort, then, is to document this incorporation and provide analysis on relative impacts to the Culebra ground water flow system.

The implementation of mining is divided up into the following steps:

- Determination of areas of the Culebra to be affected by 'present' and 'near-future' mining.
- Determination of areas of the Culebra to be affected by 'future' mining.
- Reconsideration of Culebra flow model geometry and boundary conditions, in light of mining issues.
- Digitizing of mining-affected areas into the Culebra flow model(s).
- Determination of multiplication factors to use for the hydraulic conductivity of such areas for each of the 100 base transmissivity fields.
- Running of the Culebra ground water flow codes with these modified transmissivity fields.
- Integration of these flow results into the solute transport models, taking into account the regulatory criteria for probability of 'future' mining cases and the intrusion scenarios.

The discussion below follows these steps.

<u>Determination of areas of the Culebra to be affected by 'present', 'near-future', and 'future' mining.</u>

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(See the Glossary section of this records package for definitions of present, near future, and future states).

Most of this work was performed by Westinghouse Waste Isolation Division (WID) and is documented in a recent memo (Howard, 96) included in this package as Appendix NS11.2. That memo details the pertinent regulations, the rationales, the procedures, and the results of defining precisely the areas and subsurface horizons within the Delaware Basin which have been mined for potash and which, according to regulatory guidelines, are to be mined in the near future and future. Figure 1 is taken directly from Figure 5 of their report and identifies the areas for which present and near-future mining conditions would apply according to WID interpretations. Those areas are limited to the regions labeled "Extent of Mining Outside the Controlled Area".

By those interpretations, there would be no obligation to apply the mining effect to areas that have already been mined. The Performance Assessment (PA) group felt it would be appropriate, and conservative to include such already-mined areas. Therefore, an additional map was utilized, "Preliminary Map showing Distribution of Potash Resources, Carlsbad Mining District, Eddy and Lea Counties, New Mexico", 1993, Roswell District, U. S. Bureau of Land Management (BLM). This map contains fairly up to date and detailed representations of the areas in the region of concern that have already been mined. That map is reproduced here as Figure 2.

WID made another interpretation that led to their exclusion of potash zones outside of the Delaware Basin. The PA group felt that it was necessary to include any such zones if they lay within the final regional flow model boundary. This ultimately led to the addition of a mining-affected area at the northern corner of the regional model domain that projected out of the Delaware Basin and into the area that overlies the Capitan Reef.

For the case of future mining events within the Controlled Area (CA), Figure 8 of the WID memo was utilized without modification. That figure depicts zones of Langbenite and Sylvite within the Controlled Area which are considered economically extractable according to current technologies. That figure is included here as Figure 3. The rationale for this domain is described in the WID memo.

This assembly of data led to two starting maps. The first map reflects the conditions associated with the present to near-future case, hereafter called the partial-mining case map. The second map reflects the conditions associated with the future case, hereafter called the full-mining case map. The partial-mining case map is a subset of the full mining case map. All of the areas that fall outside of the Controlled Area in which the mining effect is to be applied (to the Culebra) are identical for both the full-mining and partial-mining cases. Only the full-mining case contains the additional areas that fall inside of the Controlled Area in which the mining effect is to be applied (to the Culebra).

The areas covered by these mining zones had to then be expanded to account for subsidence induced angle-of-draw effects. Three rationales are provided that support the

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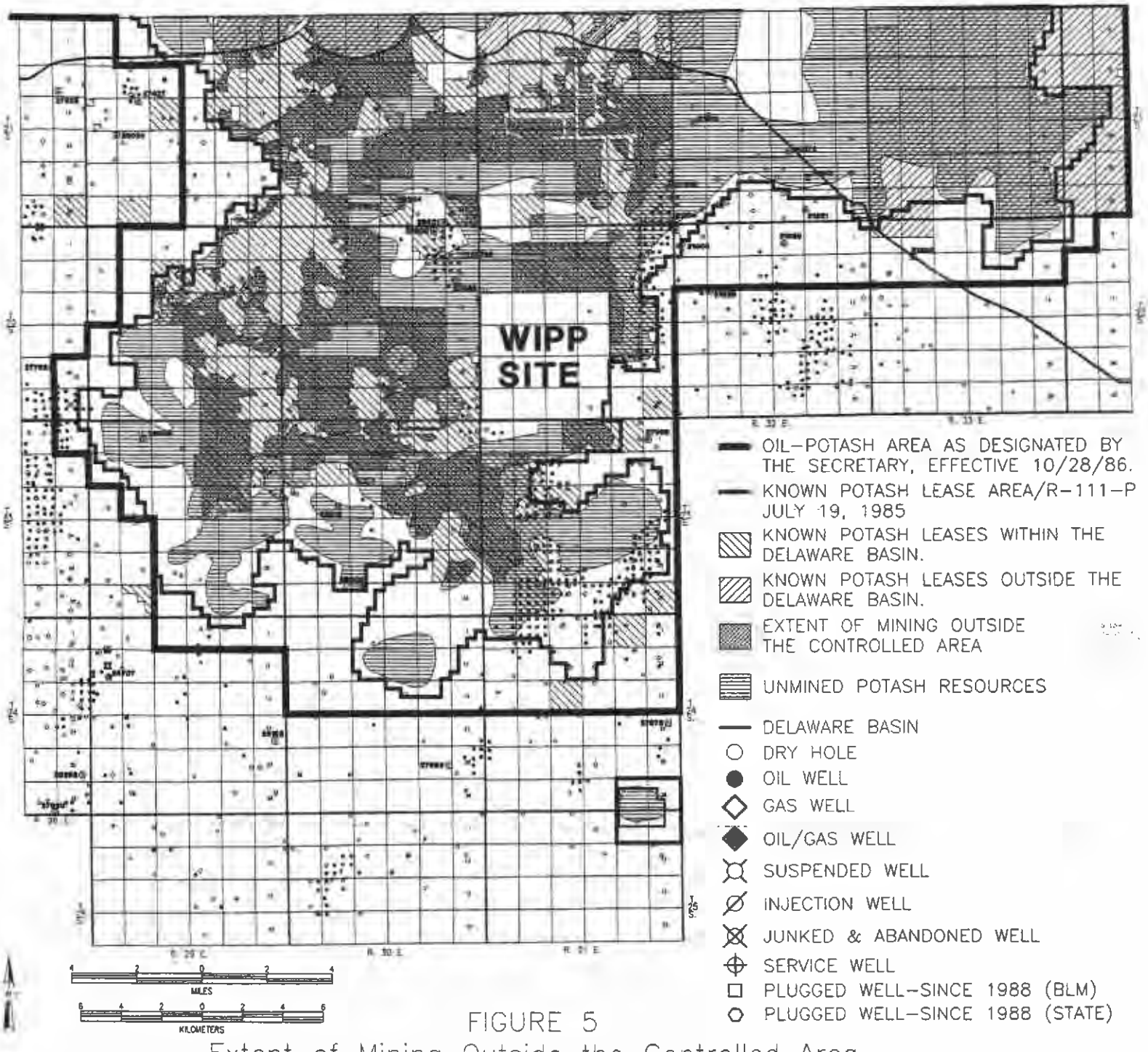

FIGURE 5
Extent of Mining Outside the Controlled Area

Figure 1. Reproduced from Westinghouse (96) (Howard, 96)

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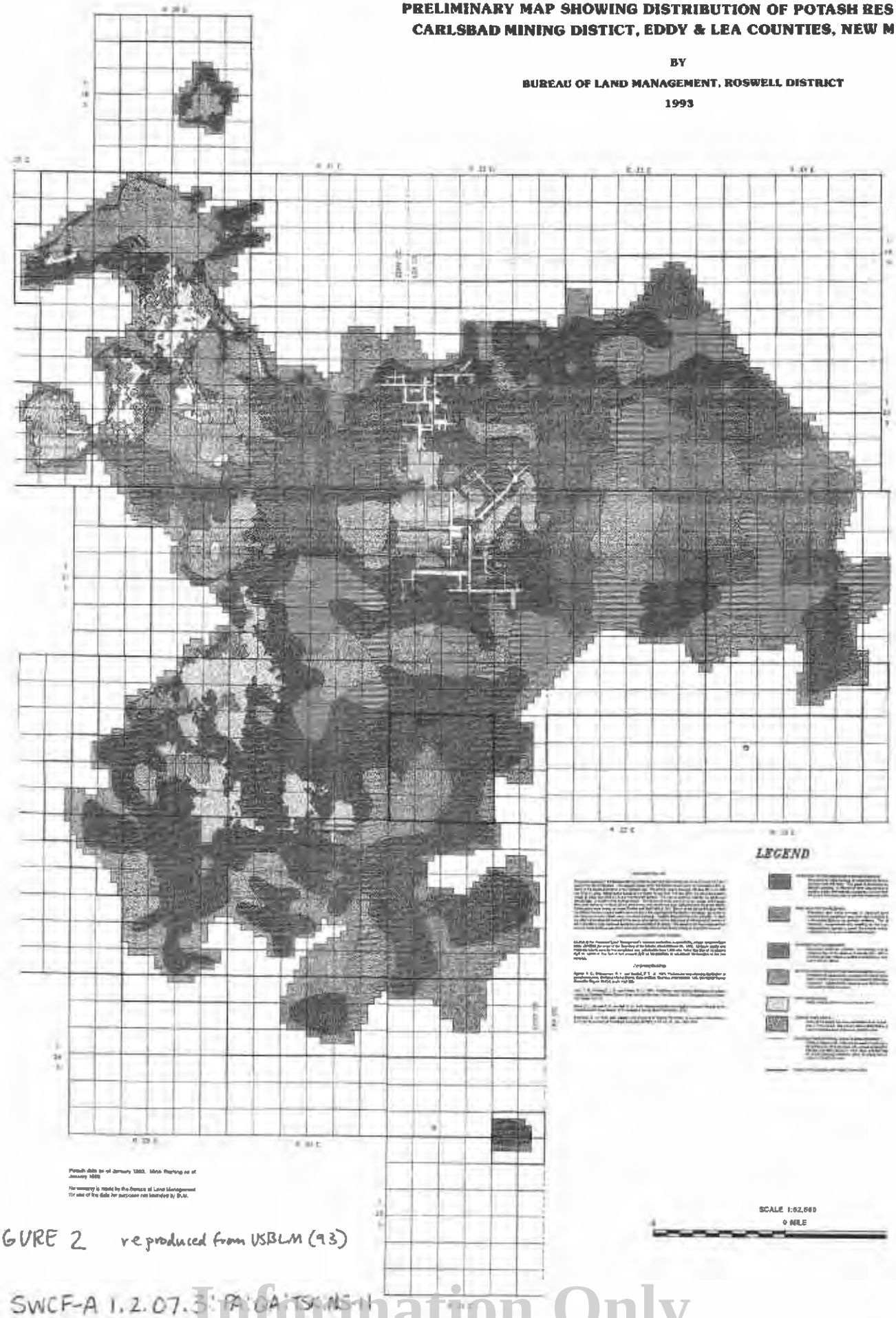

FIGURE 2 reproduced from USBLM (93)

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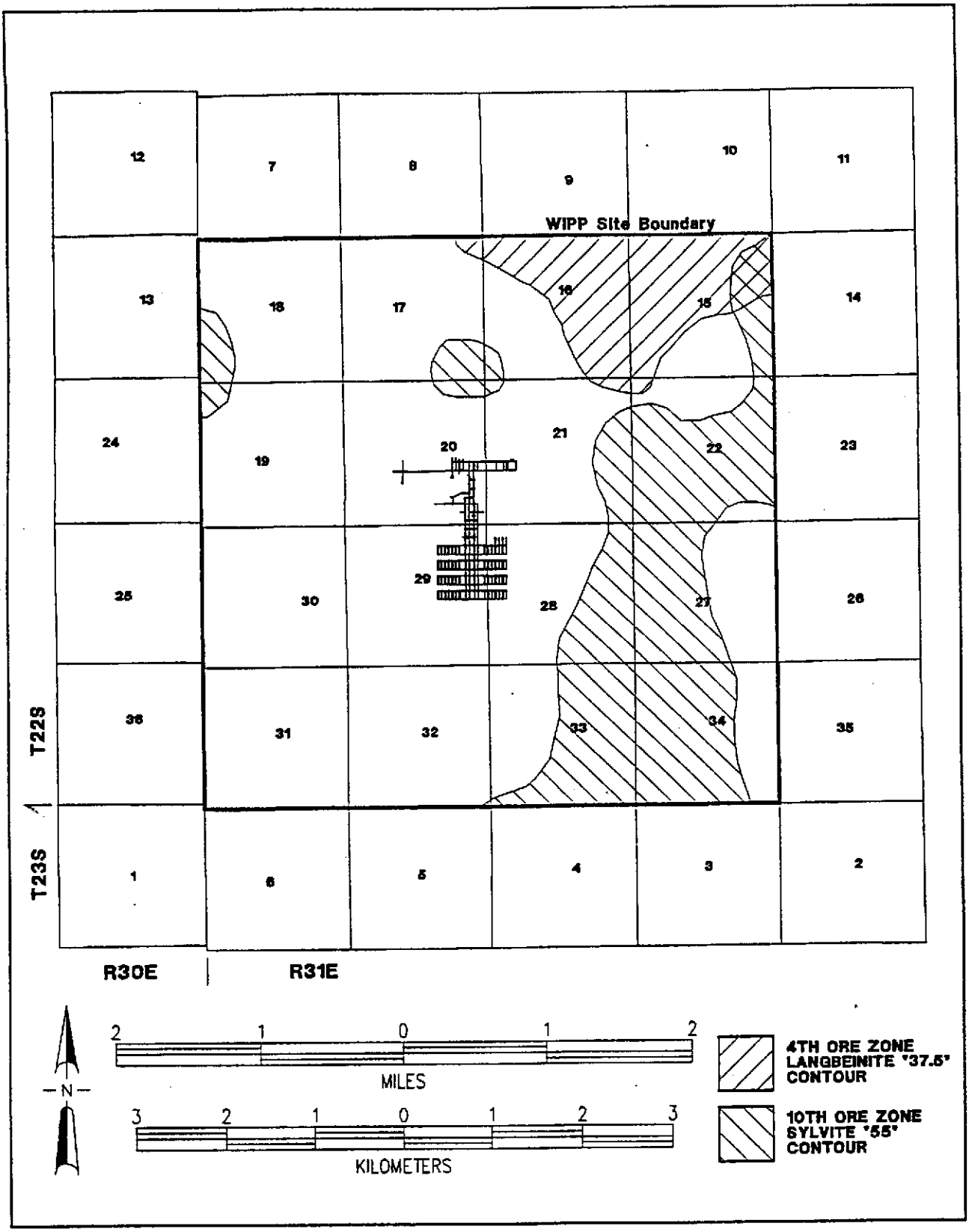

Figure 8
Extent of Mining of Economic Grade Ore Based on NMBMMR Report

BKPP4

FIGURE 3 reproduced from Westinghouse (96) ← (Howard, 96)

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expansion value used. First, the "Backfill Engineering Analysis Report" (IT Corp., 1994) includes a survey of angle of draw measurements for four major potash mines in the WIPP area. The measurements range from 25° to 58° (from vertical). Notably, on page 9-68 of the BID, EPA terms 58° "pessimistic". The midpoint of this range is 41.5°. Although the midpoint value would likely be acceptable, a more conservative value of 45° was chosen for the current analyses.

Second, work described in the EPA's "Background Information Document (BID) for 40CFR Part 194" (EPA, January, 1996, section 9.4) provides a basis for an alternative way of estimating an angle of draw. That study assumed a representative potash mine width of 3,000 ft, which, given the representative depth to the mines that they report as 1,543 ft., is assumed to be greater than or equal to W_c. W_c is defined as the minimum width (given a certain depth) of an excavation required to achieve maximum subsidence, according to the following equation:

$W_c = (2H)\tan(\delta)$

where:

H = depth from horizon of subsidence measurement to excavation
δ = angle of draw (from vertical axis)

Table 9-5 of the BID report lists depth to the Culebra as 714ft. Therefore, H = 1,543-714=829 ft. Then, assuming W_c = 3,000ft., the angle of draw is less than or equal to 44°.

Finally, on p. 11-10 of the BID, middle paragraph, an angle of draw of 40.7° is assumed by the EPA in a calculation of surface subsidence due to mining in the Salado. They assume that calculation to be "realistic".

Given our assumption of a 45° angle of draw, and assuming that H=829ft. (=253m) everywhere, a constant 253m wide 'collar' was added around the previously developed mining-impacted area maps. Because of this addition, in the partial-mining map, parts of the CA are now included for present and near future performance. That is because in certain areas, notably the southeast corner of the LWB, outside mining extends up to the very boundary. The extra collar extends the effect 253 meters into the CA.

Figures 4 and 5 show the completed maps for partial-mining and full-mining respectively.

<u>Reconsideration of Culebra flow model geometry and boundary conditions, in light of mining issues</u>.

Mining effects are only a few of the myriad issues that must be accounted for in the development of the geometry and boundary conditions for the Culebra regional flow model. The mining effects pose challenges regarding model boundary development,

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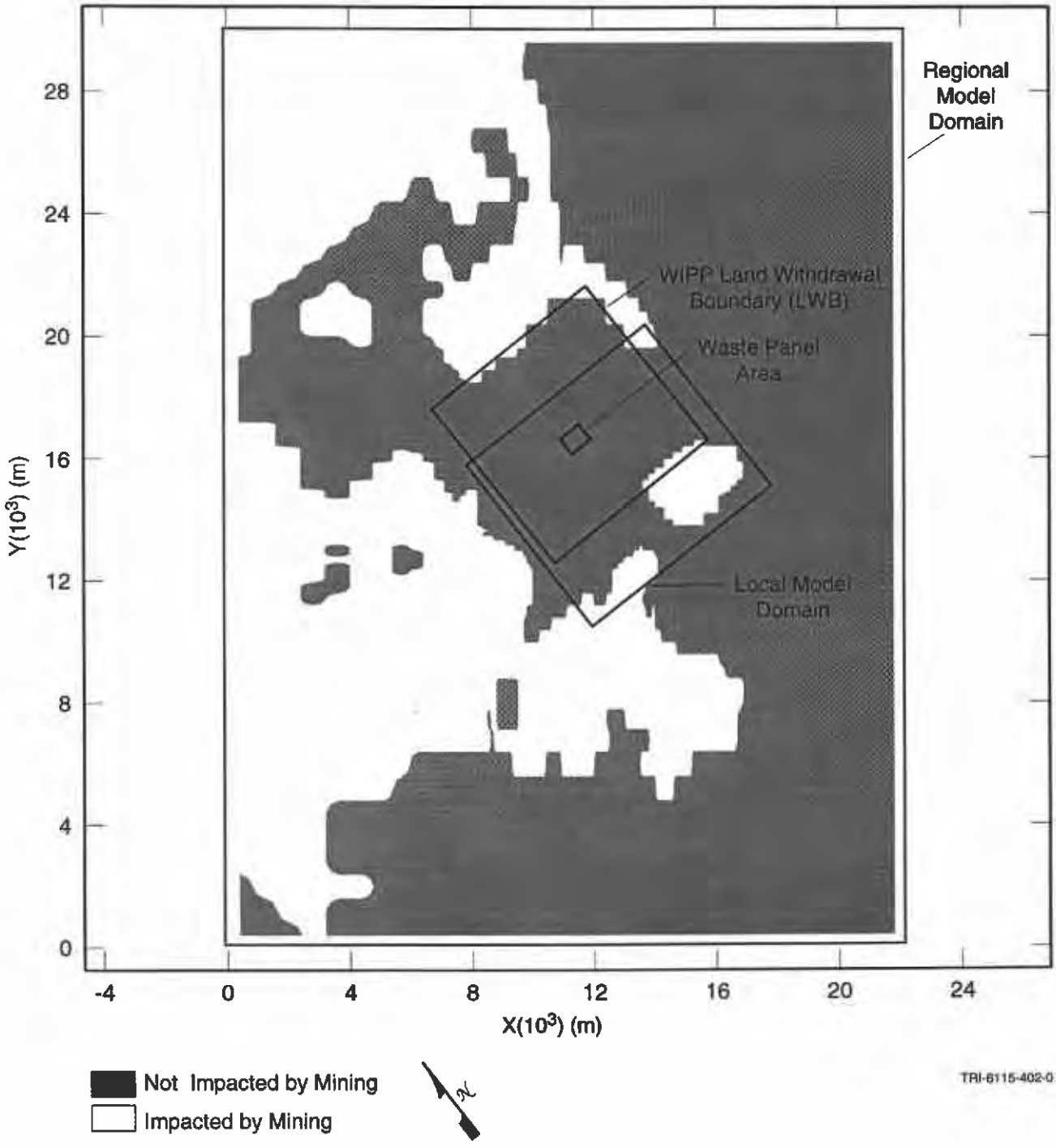

Figure 4. Extent of Impacted Area in the Culebra from Mining in the McNutt for Undisturbed Performance

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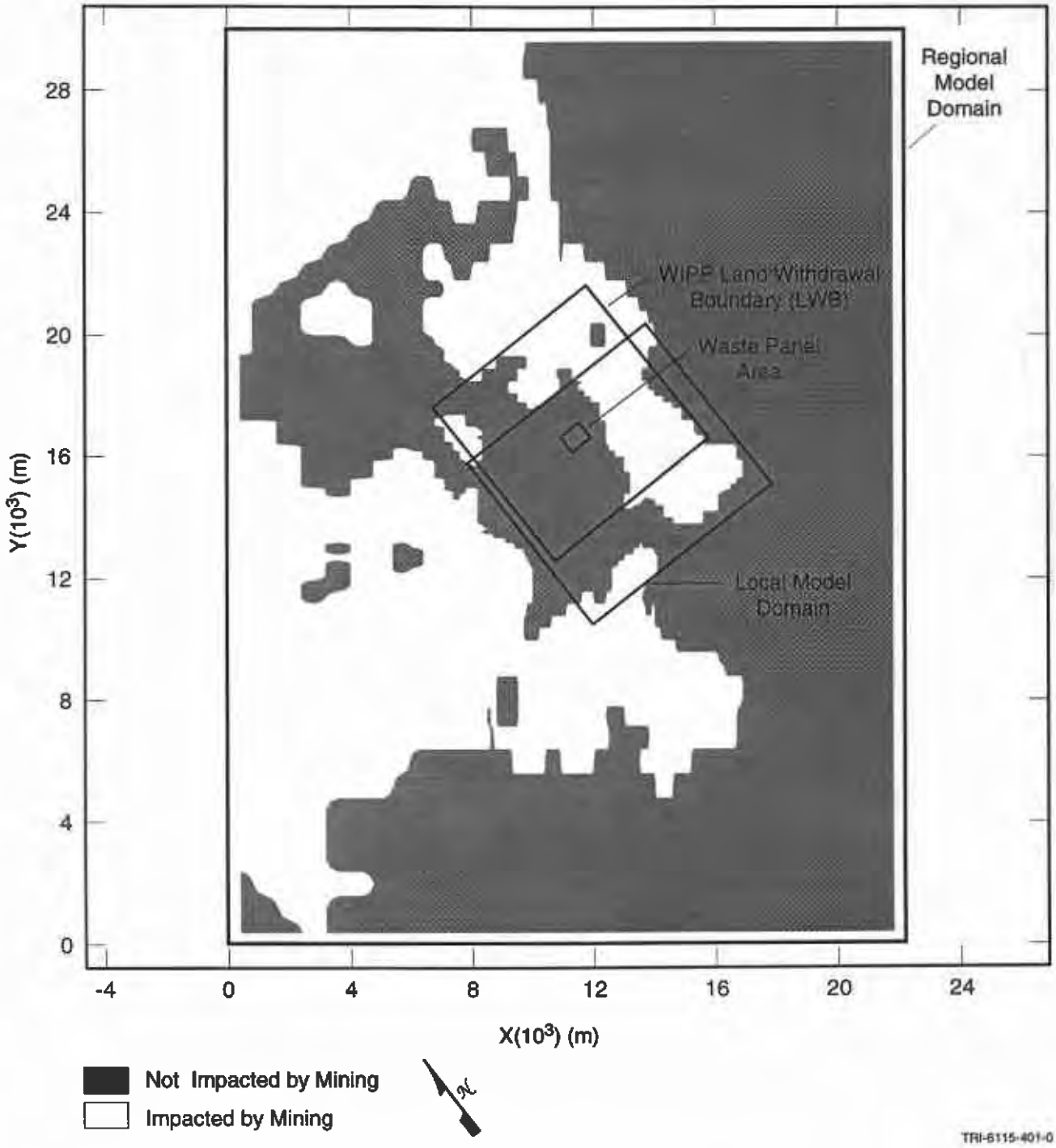

Figure 5. Extent of Impacted Area in the Culebra for Disturbed Performance if Mining Occurs in the Future within the Disposal System

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since, for example, the potash zones extend well beyond the original PA regional flow model boundaries. In fact, the zones extend well beyond the Delaware Basin.

Reference was made to the 3-D Regional Groundwater Flow Model (Corbet, 95) and its conceptualization of the regional groundwater basin of interest. In that study, as shown in Figure 6, the regional groundwater basin encompasses an area much larger than the 2-D PA regional flow model. This figure also shows the overlay of the potash-affected candidate areas and the topography. The groundwater basin can be conceptualized as a a 'complete' groundwater system (with possibly more than one saturated hydrogeologic unit) encompassed at its sides by effective vertical no-flow boundaries (vertical surfaces through which horizontal flow does not occur). Such boundaries, also known as groundwater divides, are often zones of flow symmetry, such as rivers or topographic ridges in many cases. Water cycles through such a basin by entering via precipitation/recharge processes and exiting via seepage faces / runoff processes.

Note that the PA regional model and the 3-D regional model share a boundary, namely the one corresponding to the perceived groundwater flow divide (via discharge symmetry) that underlies Nash Draw. As the conductivities are already quite high in that area (in fact, the Culebra is significantly broken up there), and given that regional and surface topographic effects in the area appear to have predominant control over the regional flow field, it was assumed that this region would continue to function as a groundwater divide, in spite of any mining effects. Therefore it was considered appropriate that one boundary of the new model still followed the Nash Draw axis.

Attention was focused on developing a model boundary for steady state flow purposes that did not underestimate flow rates in light of mining. In a steady state model, regional flow rates are controlled by the boundary conditions and the hydraulic conductivity distribution. All other things being equal, adjusting boundary conditions will cause a change in the regional hydraulic gradients which will lead to a change in flow rates.

The existing PA regional model was steady state, and was designed to apply the same constant head and no flow boundary conditions for all of its simulations. Those conditions consisted largely of the highest constant heads (~945m) assigned at the northern corner of the model and the lowest heads (~900m) assigned at the southern end of the model (Figure 7). The net hydraulic gradient applied over the existing model was therefore approximately 0.001 m/m. Examination of existing Culebra groundwater head maps (such as Brinster, 91, figure VI-2) shows that this is a representative gradient for the region, and that deliberately extending the model boundaries either further north or further south would not increase this overall gradient. Since the regional gradient is from north to south, extending the eastern boundary limits of the model would also not increase this overall gradient.

In the 3-D Regional Model study, Nash Draw is interpreted as a regional discharge area, draining the Rustler units to the east and north (and also by implication via discharge symmetry, to the west). It seems plausible that by increasing the hydraulic conductivities

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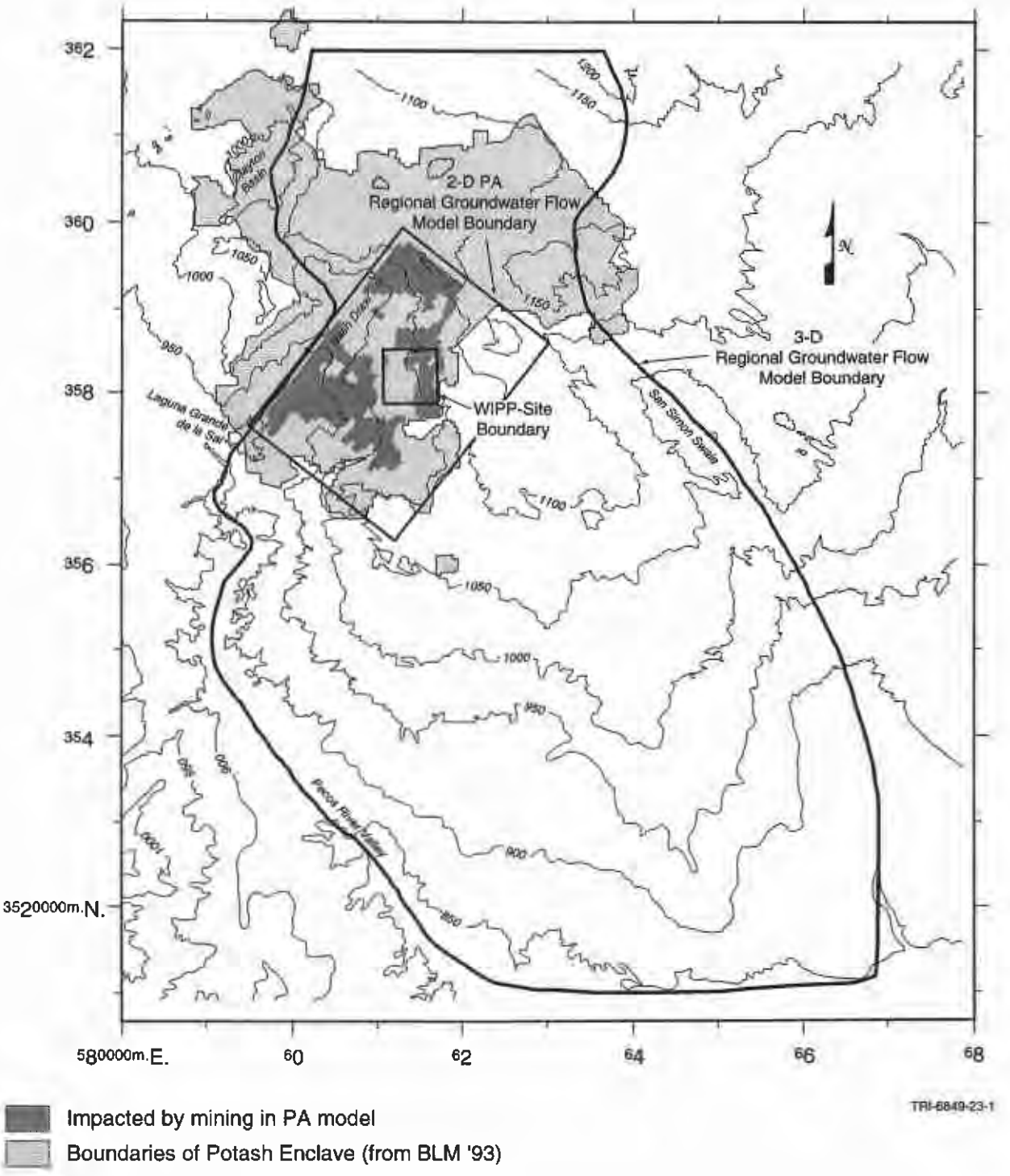

Figure 6. Overlay of Models and BLM Potash Map.

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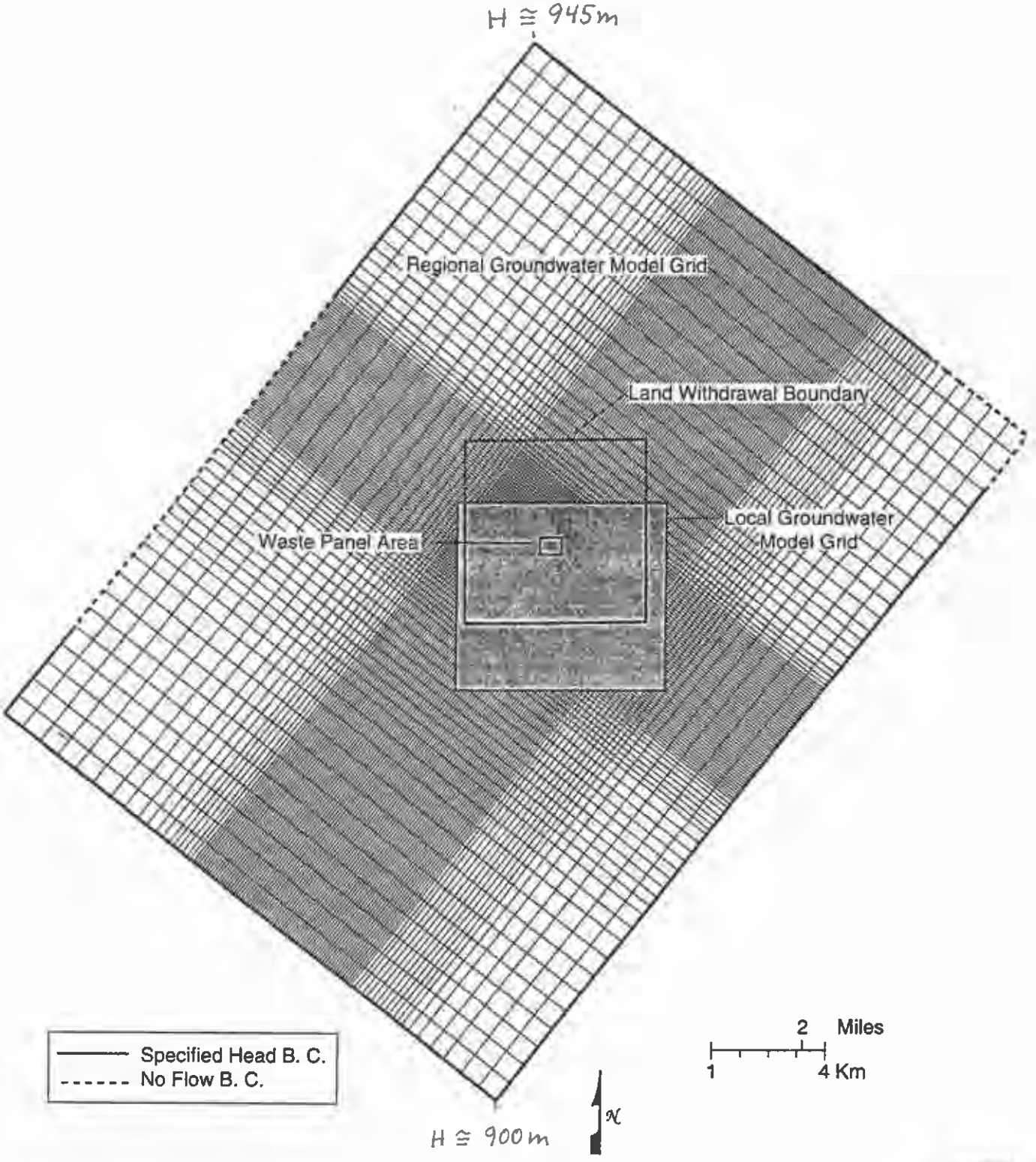

Figure 7. Regional Model Domain Spatial Discretization and Boundary Conditions

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of the Culebra (via mining effects), drainage to Nash Draw, including from the Culebra in the north, would increase dramatically and the water table would ultimately drop across the CA. As the water table drops in the north, Culebra heads would also lower, and the regional north to south head gradients would correspondingly lower to some degree. In other words, it is unlikely that Culebra regional gradients, especially those directing flow from the north to the south, would rise due to mining effects.

Given the information above, there were no reasons from a mining-effects standpoint to alter the existing PA regional model boundary positions. Nor was there any justification for changing the boundary conditions. In fact, it is conservative to maintain the existing boundary conditions in light of mining effects. Those conditions are likely to generate higher flow rates than what is expected via a drop in the water table. Also they maintain conditions that encourage a north to south flow direction, in line with the so-called high-T zone (which, in the case of mining would then be an extreme-T zone). As stated, it is more likely that the regional gradients would be directed to the west, towards Nash Draw, and thereby towards the low-T zone, significantly slowing down groundwater velocities within the CA.

Digitizing of mining-affected areas into the Culebra flow model(s).

Scaled maps of the mining areas (Figures 4 and 5) were overlain by identically scaled semi-transparent model grid maps (Figure 7). Model grid cells that lay within the mining-affected areas were identified and entered into ascii files for both the full-mining and the partial-mining cases. See other sections of this records package for detailed information.

Determination of multiplication factors to use for the hydraulic conductivity of mining-affected areas for each of the 100 base hydraulic conductivity fields.

As documented in the beginning of this report, the EPA guidance states that areas of the Culebra affected by mining will experience an increase in K of up to three orders of magnitude. In the PA implementation, a uniform random distribution of 100 mining multiplication factors is generated for each major replicate. The range is of course from a minimum of 1.0 to a maximum of 1000. Each multiplication factor (called minp_fac) is then paired with a Grasp-Inverse generated K-field for the regional model domain. The factor is only applied to the cells affected by mining.

Running of the Culebra ground water flow codes with the modified K-fields and integration of these flow results into the solute transport models, taking into account the regulatory criteria for probability of 'future' mining cases and the intrusion scenarios.

The regional and local Culebra ground water flow and transport codes are run as they normally would be, with the following exceptions. Two separate series of runs are made; one for the full-mining case and one for the partial mining case. The results of the

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runs are then adapted in subsequent activities that address, among other things, the times of occurrence of the full-mining condition.

A complete description of this process can be found in Helton, '96, and is beyond the scope of this document. However a brief summary is provided here for those familiar with the mechanics of PA CCDF generation. Ultimately, one hundred individual CCDFs are constructed, each with a different base set of parameter values. Each CCDF is constucted from 10,000 possible different futures, using its assigned parameter set. Within each assigned parameter set are parameters about mining. For example, there will be two hydraulic conductivity fields in a parameter set; one for the partial mining case, and one for the full mining case. There will also be a mining-multiplier value, described earlier (ranges from 1 to 1,000) which was used to create those hydraulic conductivity fields.

The timing of the onset of full mining is not contained in that parameter set. Instead, it is incorporated into the Poisson process equations used to generate the 10,000 possible futures. As stated, only two contaminant transport runs are actually conducted for each CDF. Interpolation procedures are then used to approximate cumulative releases (based on the output from those two runs) for each future. The relationship between the time of full-mining onset and the times of intrusion (when a plume is introduced, if ever, into the Culebra) is such that interpolation requires simplifying assumptions.

In some cases, due to the probability of occurrence, full-mining never takes place, and the interpolation is straightforward. In the majority of cases, however, at some point in time within the total 10,000 year framework, full-mining does take place. In those cases, plumes which were already transporting according to a partial-mining velocity field, are assumed to continue to transport according to that field. Only plumes which are created after the onset of full-mining are assume to transport according to a full-mining velocity field.

Analysis and Results

As discussed previously, the PA implements mining by first assigning areas of the Culebra in the flow model domain that would be impacted, via subsidence, by mining from the McNutt Potash Zone in the Salado Formation. Flow model grid cells that fall within those areas are then given a higher hydraulic conductivity (K) than their original assignment. The increased K is determined by applying a multiplication factor to the original value. The scalar multiplier may range anywhere from 1 to 1000. Each of the 100 T-fields is paired with an individual scalar multiplier. Figures 4 and 5 depict the affected model grid cells for the cases of Partial Mining and Full Mining, respectively.

It would be natural to assume that raising Ks in a model (all other things being equal) would make velocities increase, and therefore travel times would decrease. It would follow that the greater the area of increased K, the greater the velocity increase. Yet, this has not been the case. In the system modeled for WIPP, the full mining case has the bulk

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of the slowest travel times. In fact, flow runs with particle tracking were performed for the 'no-mining' case, and they generated the fastest velocities of all.

The reason for this phenomenon is simple. Changes in Ks over such a wide area have caused refraction of the normal groundwater flow paths. This refraction has created a shift in flow directions in the LWB from the south to the southwest. Particles originating from the waste panel no longer go down the original so-called high-T zone southward to the LWB. Instead they travel more to the west. They need only be diverted slightly to the west for dramatic slowdowns to be realized, since the hydraulic conductivities in that direction are much lower than along the original path, and are unchanged by mining.

The cause for this refraction is equally simple. Examination of Figure 7 (boundary conditions) shows that for the regional groundwater flow model, the boundary conditions are such that there would be a regional tendency for flow to proceed from north to south, merely because the highest heads are prescribed at the northern boundary corner and the lowest heads are prescribed at the southern corner. Now consider Figures 4 and 5, where the areas of application of full and partial mining effects are delineated. Given that these areas effect an increase of K of up to 1,000 fold, it is no wonder that the resistance to flow is drastically reduced therein. As the resistance is reduced, the hydraulic gradient across those areas also drops. In other words, heads near the LWB (in mining areas) are now far more similar in magnitude to heads at the model boundaries (in connected mining areas) than they would be prior to any mining effect.

Consider the mining area that extends from the western model boundary region to the western/southwestern portion of the LWB. The mining effect now causes the heads near the LWB to be closer to values along the western model boundary (than they would have been prior to mining). Now consider the tongue of mining area that projects down to the northeastern/eastern section of the LWB (and inside of the LWB for the full mining case). That mining effect now causes the heads in those areas to be closer to values along the northern corner of the model (than they would have been prior to mining. Since the prescribed heads at the northern model corner are higher than the prescribed heads along the western boundary region, the heads along the northeastern/eastern portion of the Land Withdrawal Area (LWA) are now higher than the heads along the western/southwestern portion of the LWA. Therefore, the gradients are no longer directed to the south in the LWA. Instead, they tend to the southwest or even to the west. As the gradients go, so goes the flow.

Vector R040 of PA Replicate #1 is discussed here as an example. This vector includes T-field #53 from the Grasp-Inverse series of runs, subsequently modified for mining. Figure 8 shows the regional model hydraulic conductivity distribution for the no-mining case. The modification consisted of the mining-impacted cells having their original K values increased by a factor of 271.4. Figures 9 through 11 depict the local model K values for the cases of no-mining, partial-mining, and full-mining.

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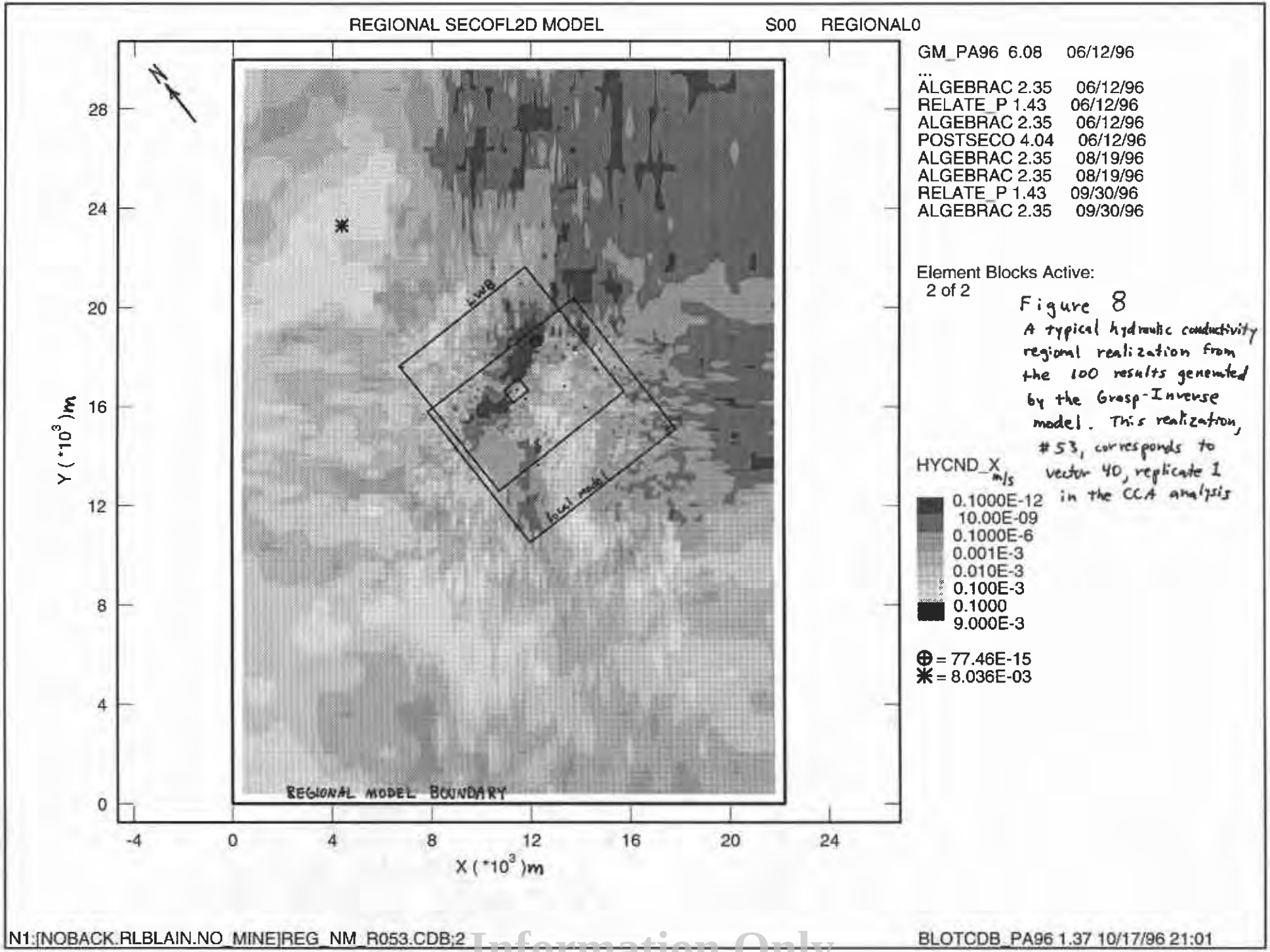

Figure 8
A typical hydraulic conductivity regional realization from the 100 results generated by the Grasp-Inverse model. This realization, #53, corresponds to vector 40, replicate 1 in the CCA analysis

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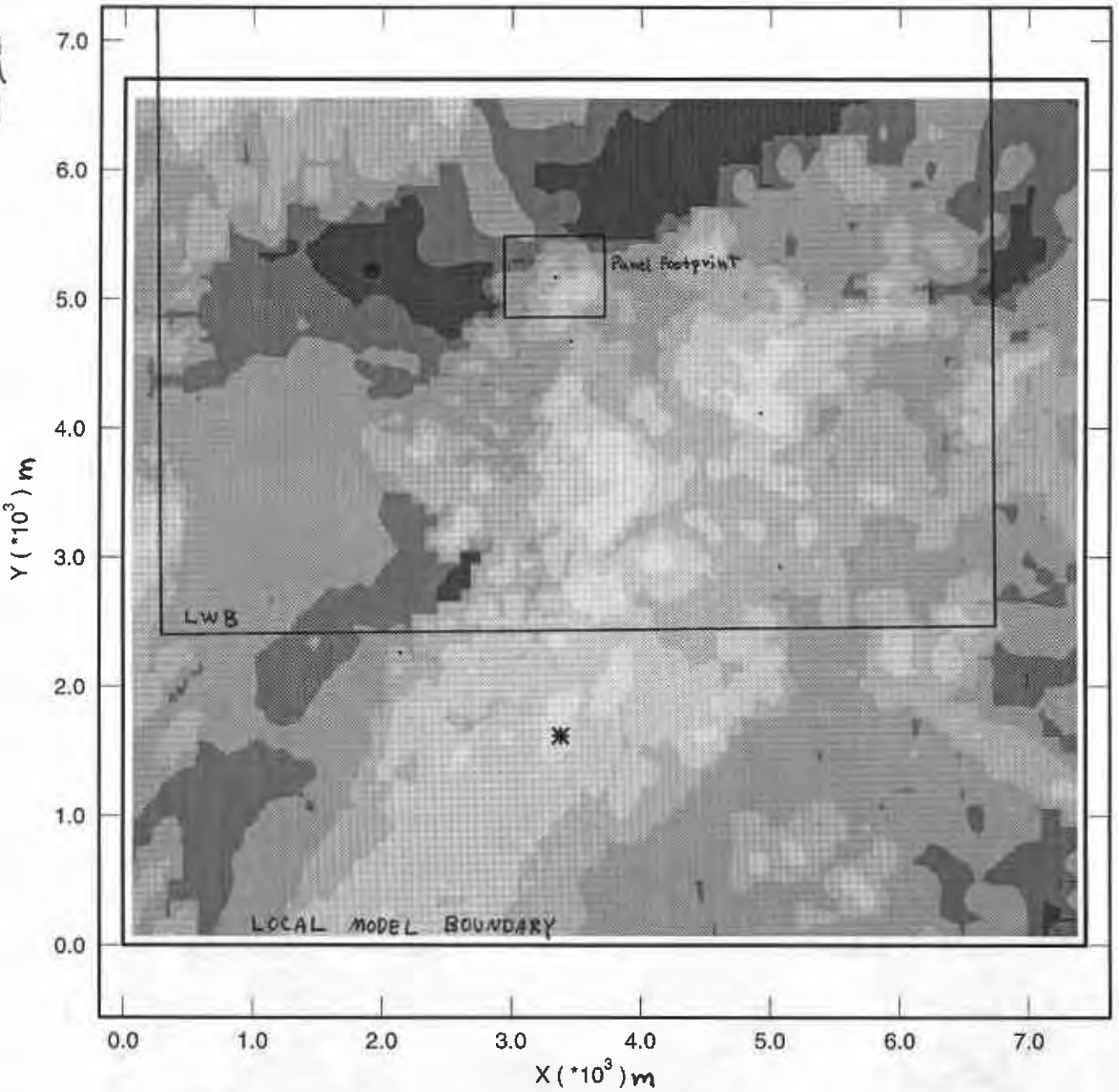

GM_PA96 6.08 06/12/96
POSTSECO 4.04 09/30/96

NO Deformation

Element Blocks Active:
1 of 1

Figure 9
Local hydraulic conductivity distribution for no-mining case: 6rasp-Inverse series #53 (corresponds to Replicate 1 vector 40)

HYCND_X m/s

0.1000E-12
10.00E-09
0.1000E-6
0.001E-3
0.010E-3
0.100E-3
2.000
2.550E-3

⊕ = 1.018E-12
✳ = 2.515E-03

Time = 0.0000

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BLOTCDB_PA96 1.37 10/17/96 20:59

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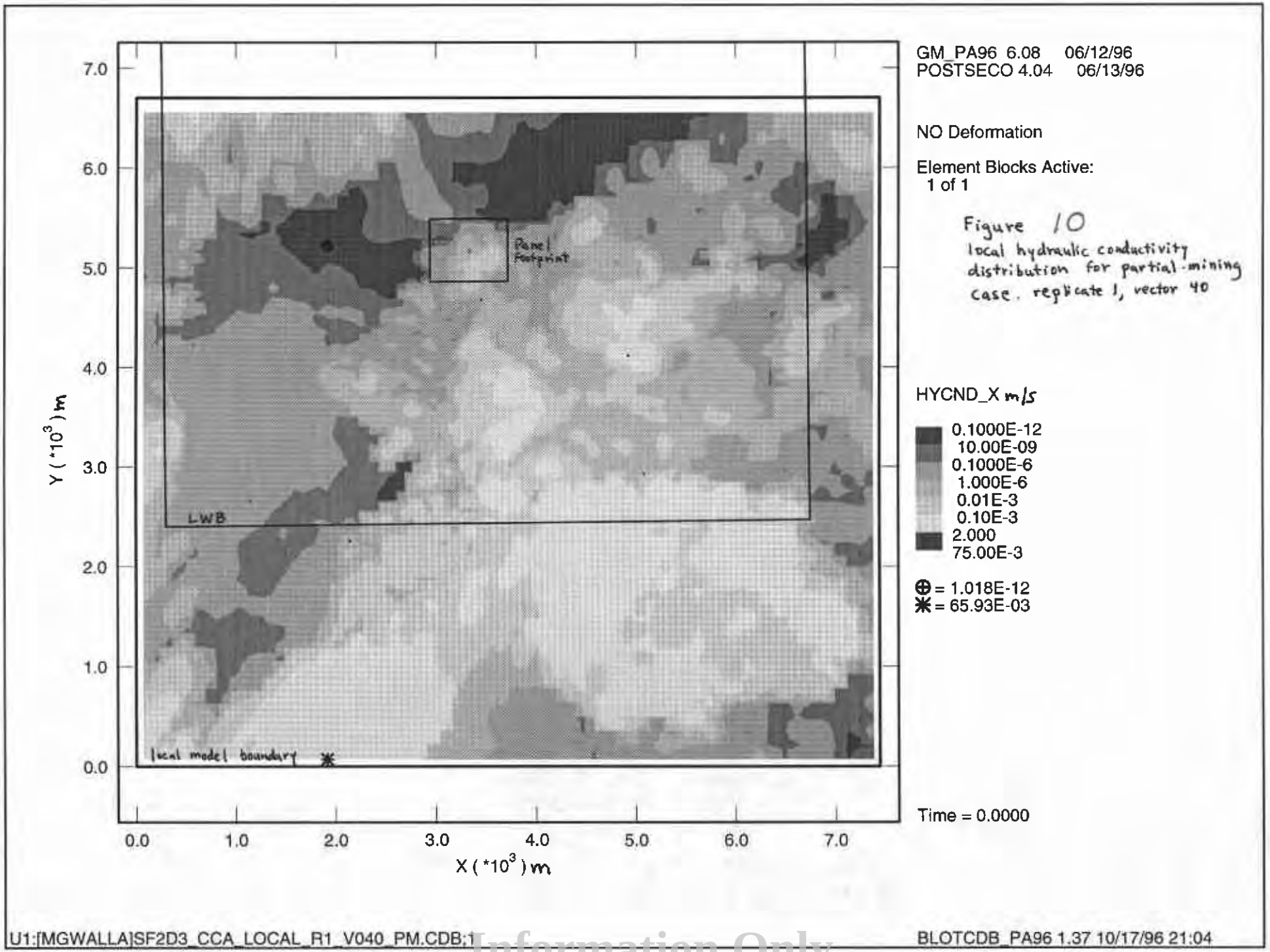

Figure 10
local hydraulic conductivity distribution for partial-mining case. replicate 1, vector 40

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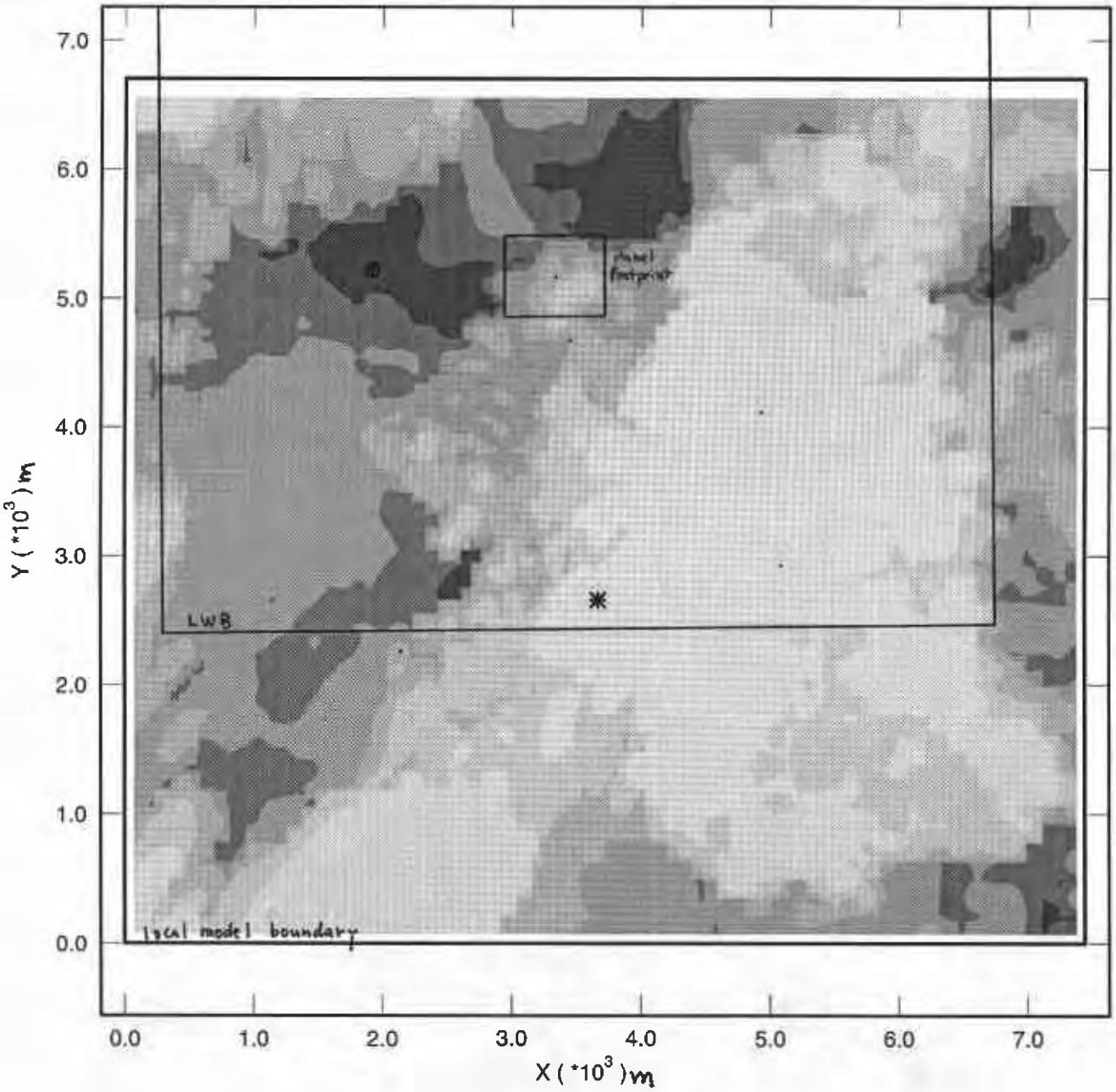

GM_PA96 6.08 06/12/96
POSTSECO 4.04 06/12/96

NO Deformation

Element Blocks Active:
1 of 1

Figure 11
local hydraulic conductivity distribution for full-mining case, replicate 1, vector 40

HYCND_X m/s

0.1000E-12
10.00E-09
0.1000E-6
1.000E-6
10.00E-6
0.1000E-3
2.000
0.2850

⊕ = 1.018E-12
✱ = 0.2709E+00

Time = 0.0000

U1:[MGWALLA]SF2D3_CCA_LOCAL_R1_V040_FM.CDB;1

BLOTCDB_PA96 1.37 10/17/96 21:07

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Figures 12 through 14 depict the local model hydraulic head contours for the cases of no-mining, partial mining, and full mining, respectively. For the case of no-mining, the contours depict a relatively steep gradient directed towards the southeast, followed by a flattened gradient heading more or less southwards. In the case of partial mining, the contours flatten somewhat and begin to separate into two distinct zones. The upper zone maintains a southeasterly direction, while the lower zone would direct flow to the south by southwest. In the full-mining case, this separation is more complete, and the lower zone directs flow to the southwest by west.

Appendix NS11.3 contains a complete discussion of the particle tracking analyses that were conducted in association with the Culebra flow model runs. That appendix details the methodology and rationale for tracking swarms of particles originating within the waste panel footprint. For the following discussion, only the particle originating from the center of the waste panel footprint is shown, for clarity.

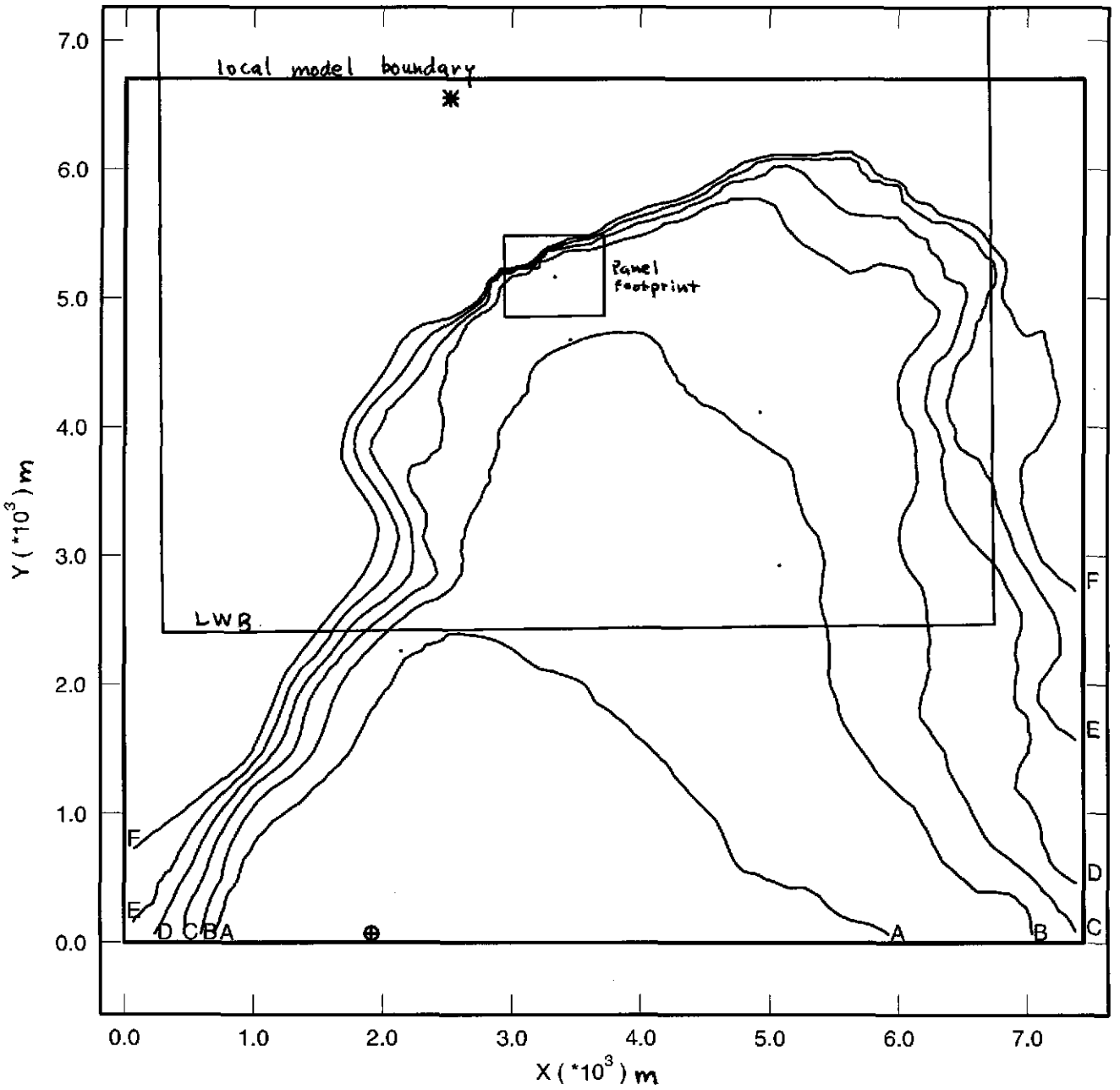
Figure 15 depicts the local model particle tracks for the same three cases. As expected, they are consistent with the hydraulic head contours. Table 1. shows particle travel times in years for the three cases, along with supporting information. As the table shows, the fastest velocities belong to the no-mining case, followed by the partial-mining case (more than 2 times slower), followed by the full-mining case (more than 7 times slower than the no-mining case).

Table 1. Particle travel times (from center of waste panel area to LWB) for a representative base hydraulic conductivity realization under nonmined, partially mined, and fully mined conditions.

Grasp-Inverse T-Field id #	Replicate 1 CCA vector #	scalar multiplier	travel time: no mining (years)	travel time: partial mining (years)	travel time: full mining (years)
53	40	271.4	3,581	8,461	27,790

This specific example of the no mining case being the fastest is but one of many cases in which this behavior is exhibited. In fact, this behavior is the norm for this system, as demonstrated in Figure 16. As that figure shows, in over 74% of the comparisons, velocities are greatest when mining effects are not applied to a T-Field. In addition the fastest velocity of all the cases is for a no-mining condition. Finally, it is notable that in 73% of the comparisons, velocities for partial mining are faster than velocities for full mining (Figure 17). This is an important justification for the manner in which the velocity fields are implemented into the PA. It shows that transporting plumes according to a partial-mining case velocity field (as opposed to a corresponding full-mining case velocitiy field) is conservative in the majority of cases. Furthermore, in the circumstances where partial-mining velocity fields are faster than full-mining velocity fields, the difference is often at an order of magnitude or greater. On the other hand, in the cases where full-mining velocity fields are faster than partial-mining velocity fields, the difference is never that great.

Information Only



GM_PA96 6.08 06/12/96
POSTSECO 4.04 09/30/96

NO Deformation

Element Blocks Active:
1 of 1

Figure 12
local hydraulic head contours for no-mining case.
Grasp Inverse series # 53
(for K distribution)

equivalent fresh water head
HEADEL m

A = 911.0
B = 911.5
C = 912.0
D = 912.5
E = 913.0
F = 913.5

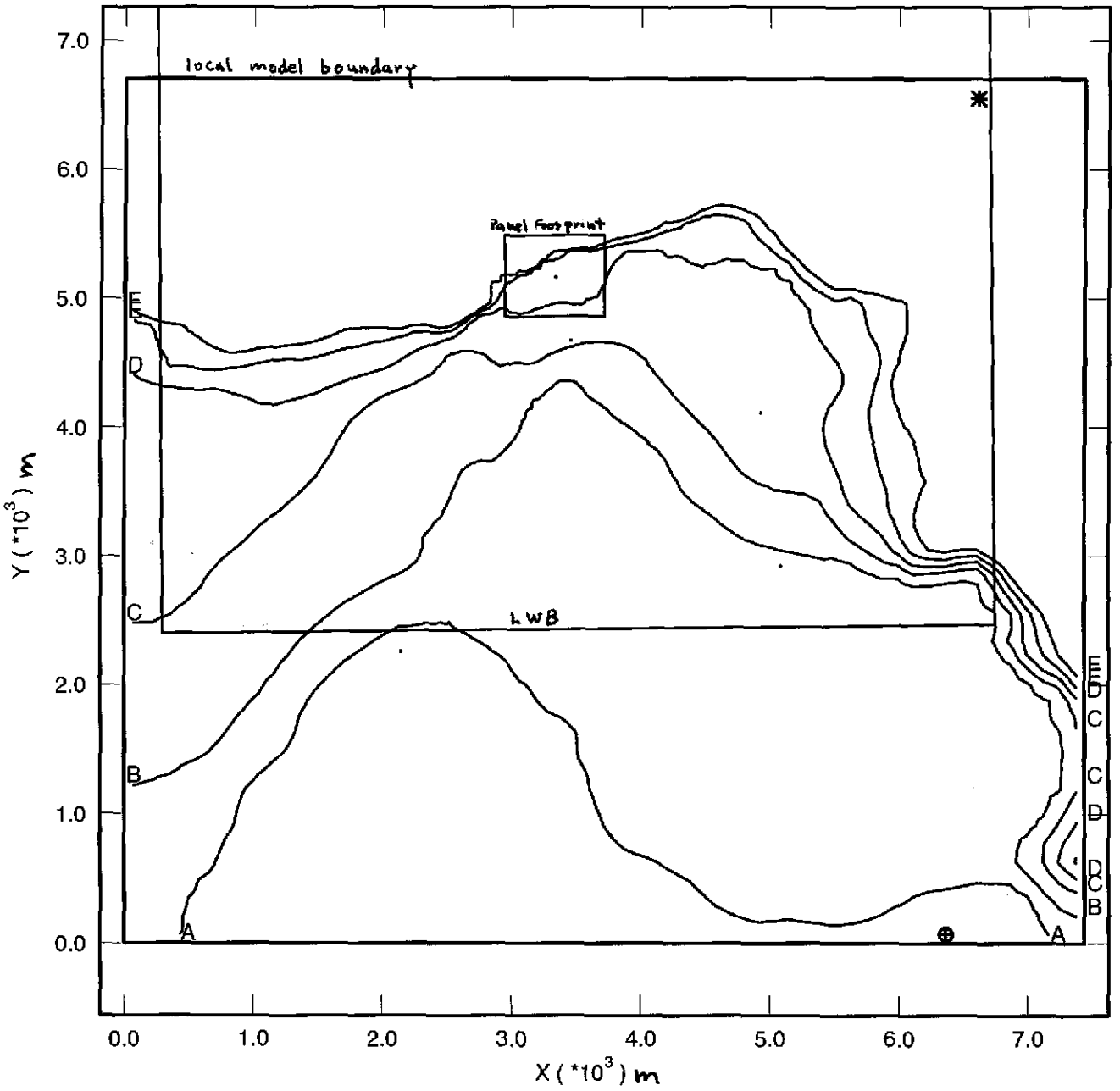
⊕ = 910.6
✱ = 930.7

Time = 0.0000

N1:[NOBACK.RLBLAIN.NO_MINE]SECOFL_NM_R053.CDB;2

BLOTCDB_PA96 1.37 10/17/96 21:57

Information Only



GM_PA96 6.08 06/12/96
POSTSECO 4.04 06/13/96

NO Deformation

Element Blocks Active:
1 of 1

Figure 13
local hydraulic head contours for partial-mining case, replicate 1, vector 40.

equivalent fresh water head

HEADEL m

A = 914.2
B = 914.4
C = 914.6
D = 914.8
E = 915.0
F = 915.2

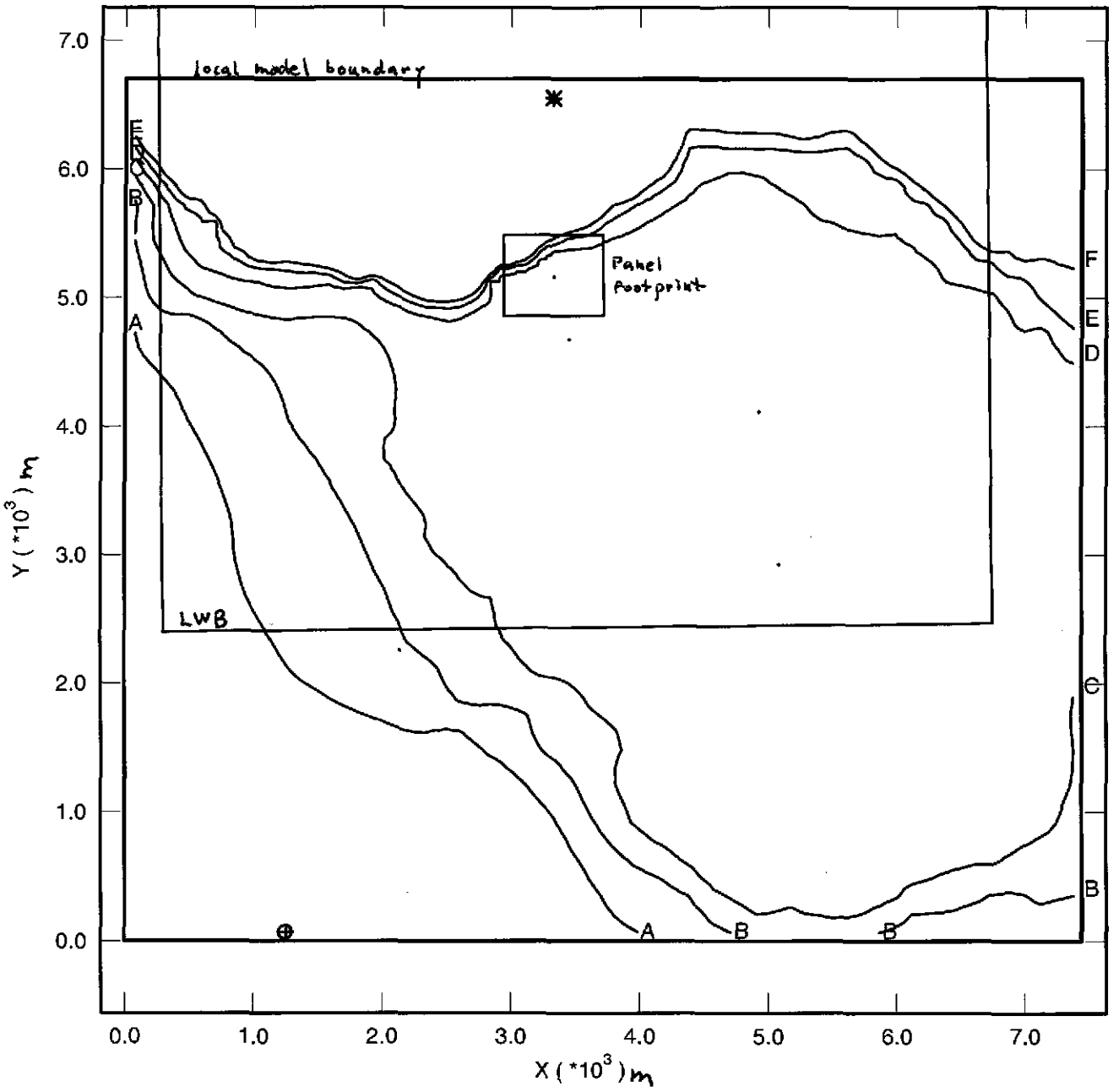
⊕ = 914.0
✱ = 932.9

Time = 0.0000

U1:[MGWALLA]SF2D3_CCA_LOCAL_R1_V040_PM.CDB;1

BLOTCDB_PA96 1.37 10/17/96 21:51

Information Only



GM_PA96 6.08 06/12/96
POSTSECO 4.04 06/12/96

NO Deformation

Element Blocks Active:
1 of 1

Figure 14
local hydraulic head contours for full-mining case. replicate 1, vector 40

equivalent fresh water head
HEADEL m

A = 915.0
B = 916.0
C = 917.0
D = 918.0
E = 919.0
F = 920.0

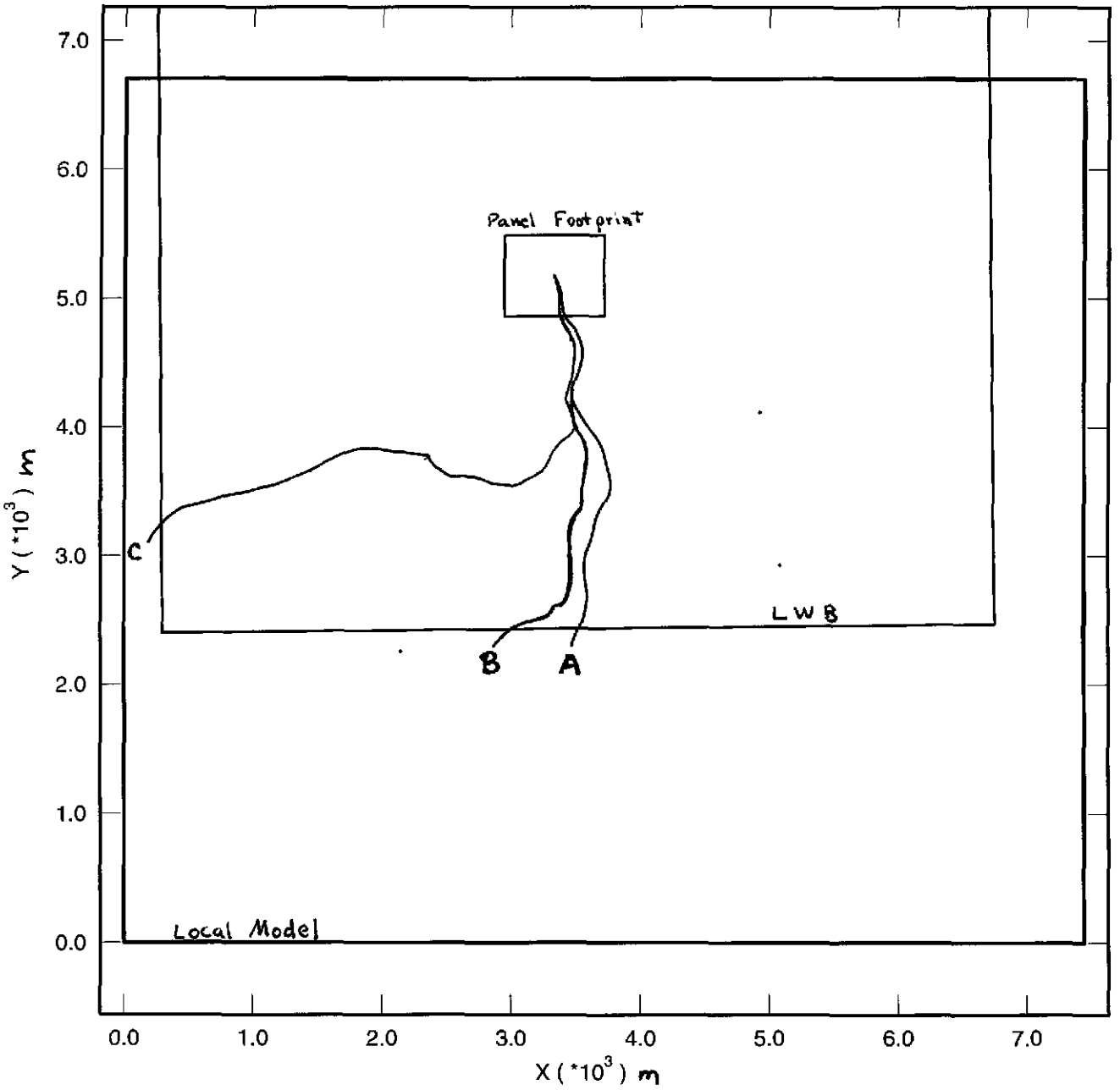
⊕ = 914.3
✱ = 931.7

Time = 0.0000

U1:[MGWALLA]SF2D3_CCA_LOCAL_R1_V040_FM.CDB;1

BLOTCDB_PA96 1.37 10/17/96 21:47

Information Only



GM_PA96 6.08 06/12/96
POSTSECO 4.04 09/30/96
TRACKER 10/01/96

Element Blocks Active:
1 of 1

case:

A : no-mining

B : partial mining

C : full mining

: particle track

X001 Y001

Times 0.0E+9
to 113.0E+9

Figure 15

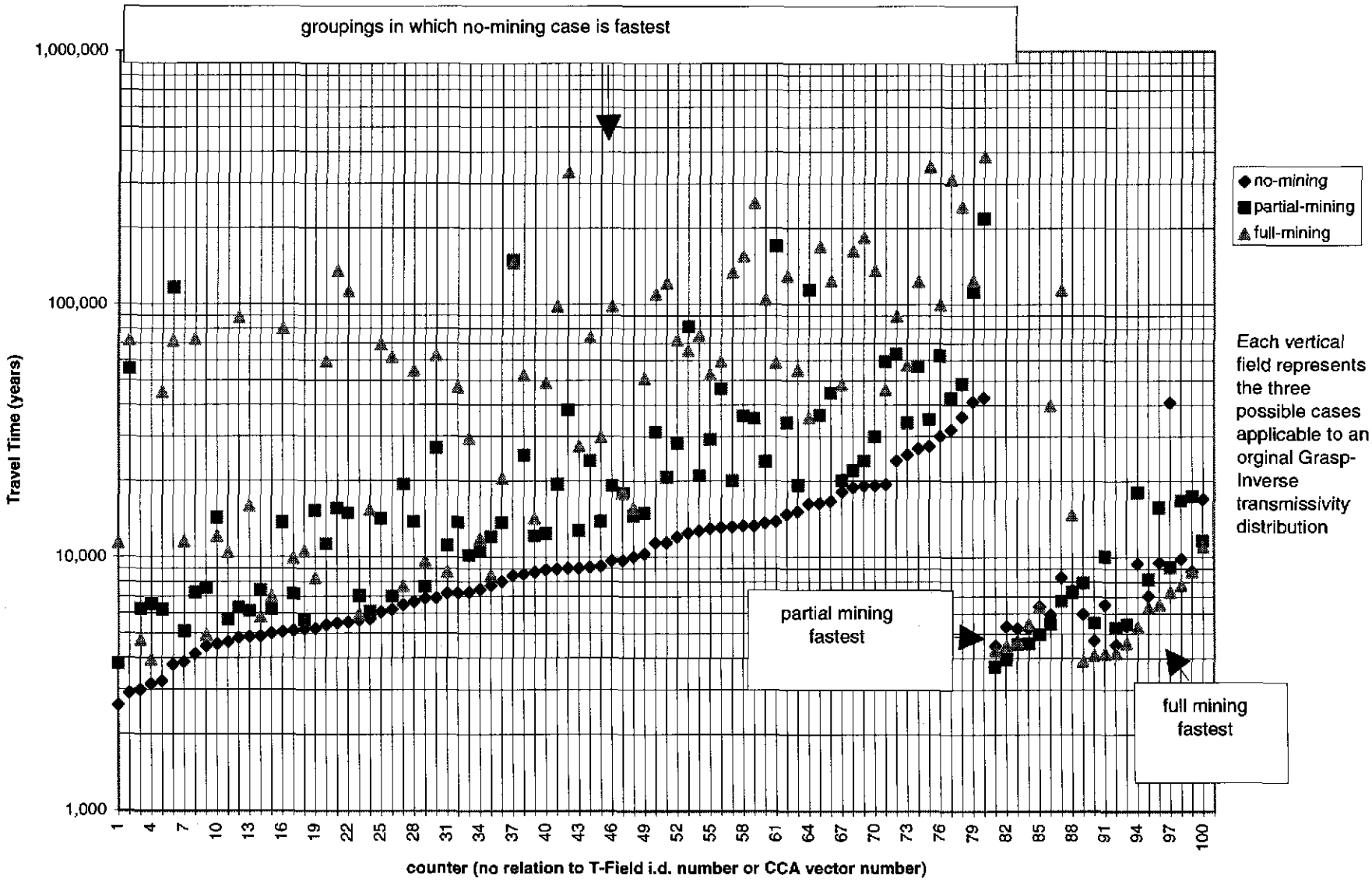
Directions of travel for a particle originating at the center of the waste panel footprint, for the cases of no-mining, partial mining, and full mining.

N1:[NOBACK.RLBLAIN.NO_MINE]TRACK_R053_7.CDB;1

BLOTCDB_PA96 1.37 10/17/96 20:38

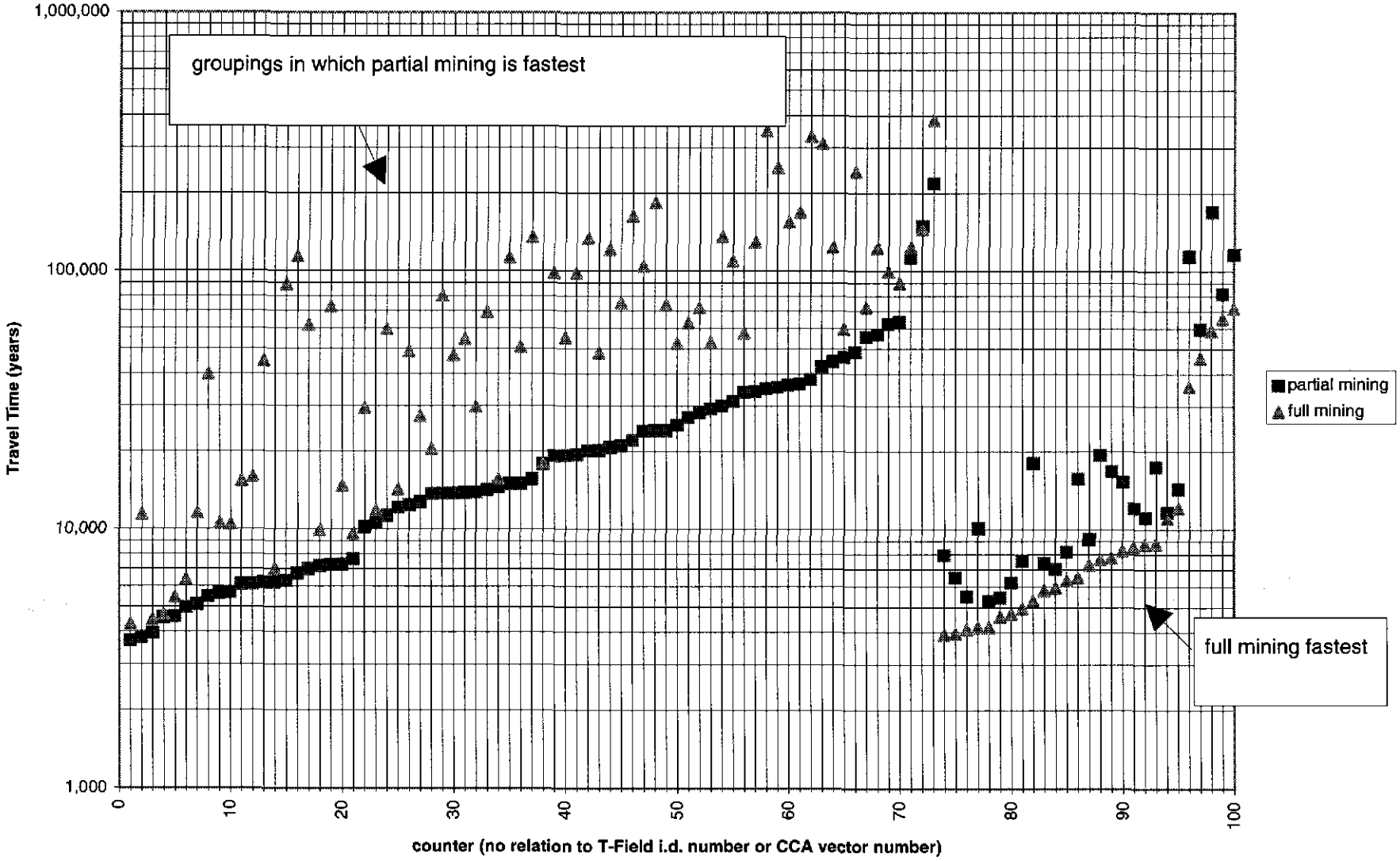
Information Only

Figure 16. Comparison of Mean Travel Times for the Three Flow Cases:



Information Only

Figure 17. Comparison of Mean Travel Times
Partial versus Full Mining Cases, Replicate 1



Information Only

Conclusions

The EPA guidance in 40CFR Part 194 and supporting documents has prescribed the manner in which effects of potash mining upon Performance Assessment are to be addressed. Their guidance involved treating the Culebra aquifer as impacted, via subsidence from mining, in such a manner that hydraulic conductivities (where impacted by subsidence) are raised by up to three orders of magnitude. Model studies were done utilizing the EPA guidance. Particle tracking was performed as a preliminary analysis tool by which to assess the relative impacts of the new mining guidance. It was determined that incorporation of mining effects into the PA, in the manner guided by EPA, would be advantageous, if anything, to compliance. The advantage would be gained by an overall slowdown in the groundwater velocities generated by the suite of groundwater flow calculations.

Information Only

Glossary

existing states, or *present states*; Physical conditions about the WIPP site, including the subsurface, as they currently exist. This includes conditions (such as hydraulic heads in the saturated zone) that may be currently influenced by human activities in the area, such as petroleum or potash resource development.

near future states; Physical conditions about the WIPP site, including the subsurface, as they are expected to evolve up to the completion of any resource-development activity initiated (i.e., for which a potash or petroleum lease exists and an application for a resource-development permit has been filed with the State and/or the BLM) as of the date of sealing of the WIPP shafts, if the activity could affect physical conditions important to performance of the WIPP. This definition does not include conditions resulting from any leases (and resulting development activities) that may be granted in the future.

> With regard to potash mining effects upon the Culebra, the so-called Partial-Mining Case encompasses the combined effects of existing and near future states.

future states: Physical conditions about the WIPP site, including the subsurface, as they are expected to evolve in the absence of resource extraction activities initiated subsequent to the date of sealing of the WIPP shafts, except potash mining. For the issue of potash mining, this definition includes conditions resulting from any potash mining in the future, if mining could affect physical conditions important to performance of the WIPP.

> With regard to potash mining effects upon the Culebra, the so-called Full-Mining Case encompasses the effects of all states; existing, near future, and future.

Information Only

References

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U.S. BLM, 1993, *Preliminary Map showing Distribution of Potash Resources, Carlsbad Mining District, Eddy and Lea Counties, New Mexico*, 1993, Roswell District, U. S. Bureau of Land Management (BLM).

U.S. EPA, 1996, *40 CFR 194, Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations*; Final Rule, Friday, February 9, 1996, Federal Register/vol. 61, No. 28, Rules and Regulations

U.S. EPA, 1996, *Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations, Background Information Document (BID)* for 40CFR Part 194 EPA, January, 1996, section 9.4

Wallace, M.G., 1996, *Mining Transmissivity Multiplier*, Records Package WPO#36489, Sandia National Laboratories, Albuquerque, NM 87185

Information Only

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:

Three ground water flow model sets (no-mining case, partial-mining case, and full-mining case), 100 runs each, 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 from 1996 PA Culebra local flow model

Original transmissivity fields (Lavanue, 96) were modified. First, in the conventional manner for normal PA analysis to correct for a different aquifer thickness and thereby to obtain hydraulic conductivity. Second, by applying the mining multiplication factor to the affected areas (for two of the cases), according to the means summarized in the attached Summary Memo of Record.

Names of Participants:

Michael Wallace, Dept. 6849 (RE/SPEC, Inc.) MS 1328
Rebecca Blaine, Dept. 6849 (Ecodynamics, Inc.) MS 1328

Dates Analysis Conducted:

Summer, Fall, 1996

Information Only

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 Ns11: Subsidence Associated with Mining Inside or Outside the Controlled Area

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:

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

Documentation of Changes from Work Analysis Plan:

The Work Analysis Plan, also known as the Planning Memo of Record, was superceded as a result of newer regulatory guidance (40 CFR 194). That guidance is included here as Appendix NS11.1, and constitutes the new plan, spelled out in detail in the attached Summary Memo of Record. The original plan was written in 1995 using older regulatory guidance (40 CFR 191 and a proposed but not official 40 CFR 194).

Information Only

WPO 22521

NS-11: SUBSIDENCE ASOCIATED WITH MINING INSIDE OR OUTSIDE OF THE CONTROLLED AREA
Planning Memo of Record

TO: D. R. Anderson

FROM: T. Corbet

INFORMATION ONLY

SUBJECT: FEP Screening Issue NS-11

STATEMENT OF SCREENING ISSUE

Subsidence over future potash mines could modify groundwater flow in strata overlying the Salado Formation. The most important potential impact of future mining would be fracturing of hydraulically tight units within the Rustler Formation. Such fracturing could increase the vertical hydraulic conductivity of these units and thereby increase vertical leakage. It has also been proposed that depressions on the surface caused by subsidence could collect surface runoff and consequently increase the amount of recharge to the groundwater system.

The region of potential potash reserves in the upper Salado is more extensive than the controlled area. This area, however, would never be mined in one pass. Instead, mine working would follow trends of the highest grade ore. This pattern of mining would generate a complex and changing stress field in the overlying rocks. The nature of the stress field, and its affect on rock properties, could not be predicted in the absence of knowledge about the mining pattern. For the purposes of this FEP screening issue, it is necessary, and probably sufficient, to assume as a limiting case that future mining would uniformly impact rock properties in the entire region overlying potential reserves.

APPROACH
Calculation Design

Approximately 8 3D transient calculations will be performed as part of FEP screening issue NS-8. For this side effort, several of those simulations will be repeated with temporally varying rock properties in the area overlying potash reserves. Specifically, the vertical conductivity and specific storage of the anhydrite layers will be increased at the simulated present time. The simulated impact of the rock property changes on flow in the Rustler over the following 10,000 years will be used as a criteria to aid in making a screening decision about this FEP issue. It would also be possible to increase the recharge rate over the mined area to simulate the possible impact of surface depressions.

INFORMATION ONLY

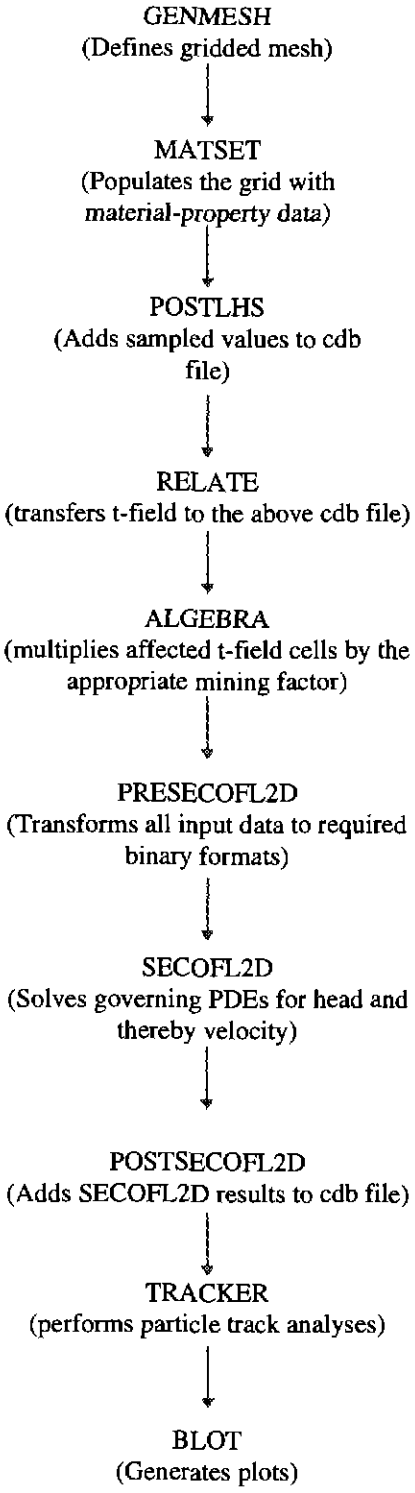
OLD → SWCF-A: 1.1.6.3: PA: NS: TSK: NS, FEP-SCRN (2 cy)

Information Only

SWCF-A: 1.2.07.3: PA: QA: TSK: NS11 QA DKM 9/25/96 page 33

General Schematic of Data Flow for NS11:

case-specific modifications to this general data flow are detailed in subsequent sections



Information Only

Software:
Title and version of software used:

For partial-mining and full-mining cases, the TRACKER code was run directly on the output from the CCA runs. Therefore only TRACKER and other downstream software are listed here for these cases. For the no-mining case, RELATE and ALGEBRA were applied to existing CCA files. Therefore, only those and downstream software codes are listed for that table.The pertinent output from CCA is identified in a following section of this records package (*Data set and information files used, including name and version of all databases, libraries, and data files:).*

Partial-Mining and Full-Mining Cases

software	NS11 Calc partial-mining run dates	NS11 Calc full-mining run dates	pointer to SWCF records
TRACKER, Ver. 5.01Z0 3-8-94	10-14-96 to 10-15-96	10-14-96 to 10-15-96	WPO7483 also see WPO40516
Spreadsheets			
Microsoft Excel Ver. 5.0c	various dates summer, fall, 96	various dates summer,fall, 96	na
Plotting and Data Presentation Packages			
BLOTCDB Ver. 1.37 6-4-96	various dates summer,fall, 96	various dates summer,fall, 96	WPO21260

Information Only

Software: (cont.)

No-Mining Case

Pre-Processor	Ns11 Calc no mining run dates	pointer to SWCF records
RELATE, Ver 1.43 3-6-96	9-30-96	WPO22267
ALGEBRA, Ver 2.35 1-31-96	9-30-96	WPO21247
PRESECOFL2D, Ver. 4.05, 6-11-96	9-30-96	WPO32397
Analysis		
SECOFL2D, Ver. 3.03 5-7-96	9-30-96	WPO37271
Post Processor		
POSTSECOFL2D, Ver. 4.04, 4-23-96	9-30-96	WPO23298
TRACKER, Ver. 5.01Z0 3-8-94	10-14-96	WPO7483 also see WPO40516
Spreadsheets		
Microsoft Excel Ver. 5.0c	various dates summer, fall, 96	na
Plotting and Data Presentation Packages		
BLOTCDB Ver. 1.37 6-4-96	various dates summer, fall, 96	WPO21260

Information Only

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

Data Development; creation of modified hydraulic conductivity fields for use in the CCA

Data files that contain the results of the digitization of the mining-affected areas are part of the CMS system. The initial files that were developed for that process are stored in the Gateway 2000 computer at the desk of Michael Wallace, Dept. 6849, SNL (as of 11-19-96) in C:/data/pish/

cells_in.dat *cells affected by mining from inside the LWB*
cells_pm.dat *cells affected by mining from outside the LWB*

The above files are merely long lists of each regional model grid cell number, followed by an identifer: 0.0 = no mining effect, 1.0 = mining effect

Those files were converted to ALGEBRA input files for application to the regional model. They can be 'fetched' from the Configuration Management System (CMS) by entering the following commands:
(for partial mining)
$ libalg
$ cfe alg_sf2d_cca_ pm.inp
(for full mining)
$ libalg
$ cfe alg_sf2d_cca_ fm.inp

Information Only

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

SECOFLO2D runs; Partial-Mining and Full-Mining Cases

Most files are located currently in the WIPP Alpha Cluster in the following directories:

Partial Mining Case: F1:[FEP.RLBLAIN.NS11.P_MINE]
Full Mining Case: F1:[FEP.RLBLAIN.NS11.F_MINE]

File Characteristic	*Full Mining Case*	*Partial Mining Case*
starting CCA data	*see note #1*	*see note #1*
com procedure	track_13.com	track_13.com
travel time ascii data, local	tt_r###_x.dat (x=1 to 13) track_x.inp	tt_r###_x.dat (x=1 to 13) track_x.inp
particle tracks, local	track_r###_x.cdb (x=1 to 13) see note #2, this page	track_r###_x.cdb (x=1 to 13) see note #2, this page

Note #1. For the partial-mining and full-mining cases, TRACKER was run directly on the output from the CCA runs. The output used can be 'fetched' from the Configuration Management System (CMS) by entering the following commands:

(for partial mining)
$ libsf2d
$ cfe sf2d3_cca_local_r1_v*_pm.cdb

(for full mining)
$ libsf2d
$ cfe sf2d3_cca_local_r1_v*_fm.cdb

Note #2. For all cases, the TRACKER output .cdb files were too large to be stored. They can easily be recreated by running the track_13.com procedure (assuming the .cdb file has first been fetched, if necessary, from CMS, see Note #1).

Information Only

Data Set . . . cont. SECOFLO2D runs; No-Mining Case

Most files are located currently in the WIPP Alpha Cluster in the following directories:
No Mining Case: F1:[FEP.RLBLAIN.NS11.NO_MINE]

File Characteristic	*No Mining Case*
RELATE input files output files com procedure	 gri_cca_rxxx.cdb *see note #3.* reg.cdb, relate.inp reg_nm_rxxx.cdb relate.com
ALGEBRA input files output files com procedure	 reg_nm_rxxx.cdb algd.inp reg_nm_rxxx.cdb alg.com
PRESECOFLO2D input files cdb input ascii input	 reg_nm_r###.cdb, loc.cdb sf2d1_cca.inp
general output data	secofl_nm_r###.cdb
com procedure	secofl.com, track_13.com
travel time ascii data, local	tt_r###_x.dat (x=1 to 13) track_x.inp
particle tracks, local	track_r###_x.cdb (x=1 to 13) see note #2

Note #2. The TRACKER output .cdb files were too large to be stored. They can easily be recreated by running the track_13.com procedure.

Note #3. For the no-mining case, RELATE was used to adopt an existing model grid setup from the CCA. That setup was 'fetched' from the CMS by entering the following commands:
$ libgri
$ cfe gri_*.cdb

The partial mining or full mining hydraulic conductivity distribution was then replaced with the original Grasp-Inverse generated T field. Then, ALBEBRA was used to modify that T-field to a hydraulic conductivity field consistent with the proper CCA Culebra parameter thickness of 4.0m.

Information Only

Computer platform:

All codes other than the *Spreadsheets* and *Plotting and Data Presentation Packages* were run on the WIPP Alpha Cluster, open VMS Ver. 6.1.

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

Source Listing of Macros and Other Application Software Codes:

see attachments of macros from Microsoft Excel spreadsheets used for SMOR Appendix Ns11.3. appropriate pages follow.

These two macros are stored in the Gateway 2000 computer at the desk of Michael Wallace, Dept. 6849, SNL (as of 11-19-96) in C:/data/paramete, as virgin4.xls, parmin3.xls, and fulmin3.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 a no-mining case, and 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.

Macro for No-Mining Case

```
" Macro1 Macro
' Macro recorded 10/13/96 by Authorized Gateway Customer
Sub Macro1()
Counter = 0
   Do While Counter < 9   'Loop.
      Counter = Counter + 1   ' Increment Counter.
   Workbooks.OpenText Filename:= _
      "C:\DATA\PARAMETE\MINP_FAC\VIRTIMES\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("virgin4.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 = 98
   Do While Counter < 99   'Loop.
      Counter = Counter + 1   ' Increment Counter.
```


Information Only

```
    Workbooks.OpenText Filename:= _
      "C:\DATA\PARAMETE\MINP_FAC\VIRTIMES\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("virgin4.XLS").Activate
    ActiveSheet.Paste
    Range("A" & Counter + 1).Select
     Loop
End Sub
```

Macro for Partial-Mining Case

```
' 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
```

Macro for Full-Mining Case

```
' 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.
```


Information Only

```
    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
```

Documentation of deviations from baseline data set, including rationale:

No deviations. This FEP analysis uses only data from the baseline data set.

Information Only

Appendix NS11.1

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federal register

Friday
February 9, 1996

Part VI

Environmental Protection Agency

40 CFR Part 194

Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the 40 CFR Part 191 Disposal Regulations; Final Rule

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ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 194

[FRL–5418–5]

RIN 2060–AE30

Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance With the 40 CFR Part 191 Disposal Regulations

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: The Environmental Protection Agency (EPA) is promulgating criteria for determining if the Waste Isolation Pilot Plant (WIPP) will comply with EPA's environmental radiation protection standards for the disposal of radioactive waste. If the Administrator of EPA determines that the WIPP will comply with the standards for disposal, then the Administrator will issue to the Secretary of Energy a certification of compliance which will allow the emplacement of transuranic waste in the WIPP to begin, provided that all other statutory requirements have been met. If a certification is issued, EPA will also use this final rule to determine if the WIPP has remained in compliance with EPA's environmental radiation protection standards, once every five years after the initial receipt of waste for disposal at the WIPP. This rulemaking was mandated by the WIPP Land Withdrawal Act of 1992.

EFFECTIVE DATE: These regulations are effective April 9, 1996. The incorporation of certain publications listed in the regulations is approved by the Director of the Office of the Federal Register as of April 9, 1996. A petition for judicial review of this final action must be filed no later than April 9, 1996 pursuant to section 18 of the WIPP Land Withdrawal Act of 1992 (Pub. L. 102–579).

FOR FURTHER INFORMATION CONTACT: Betsy Forinash, Mary Kruger or Martin Offutt; telephone number (202)–233–9310; address: Radiation Protection Division, Mail Code 6602J, U.S. Environmental Protection Agency, Washington, DC 20460. Copies of the Background Information Document and Economic Impact Analysis which accompany today's action may be obtained at this address. The Agency has also published a document, accompanying today's action, which responds in detail to significant public comments that were received on the proposed rule. This document, entitled "Response to Comments" may be obtained by contacting Betsy Forinash.

SUPPLEMENTARY INFORMATION:

Introduction

Purpose of Today's Action

Today's action implements the Environmental Protection Agency's (EPA) environmental radiation protection standards, 40 CFR part 191, by applying them to the proposed disposal of transuranic radioactive waste in the Waste Isolation Pilot Plant (WIPP). The EPA previously promulgated 40 CFR part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," to provide standards that will apply to all sites (except Yucca Mountain) for the deep geologic disposal of highly radioactive waste. Complete descriptions of 40 CFR part 191 were published in the Federal Register in 1985 (50 FR 38066–38089, Sep. 19, 1985) and 1993 (58 Fed. Reg. 66398–66416, Dec. 20, 1993). The WIPP is subject to 40 CFR part 191, and is being constructed by the Department of Energy (DOE) near Carlsbad, New Mexico, as a potential repository for the safe disposal of transuranic radioactive waste. The EPA is required by the WIPP Land Withdrawal Act of 1992 (Pub. L. 102–579) to evaluate whether the WIPP will comply with subparts B and C of 40 CFR Part 191—known as the "disposal regulations"—and to issue or deny a certification of compliance. The Department of Energy is required to submit an application to EPA that will be the basis of EPA's evaluation of whether a certification of the WIPP's compliance with the disposal regulations should be issued. The Department of Energy may not begin to emplace transuranic waste underground for disposal at the WIPP until such time as a certification of compliance has been issued and all other requirements of section 7(b) of the WIPP Land Withdrawal Act have been satisfied. With today's rulemaking, the Agency establishes criteria by which to judge whether the WIPP is in compliance with the "disposal regulations" and sets forth procedural requirements for this determination.

Today's action, 40 CFR part 194, also applies to the periodic re-certification of the WIPP's compliance with the disposal regulations. The process of periodic re-certification, established by section 8(f) of the WIPP Land Withdrawal Act, calls for EPA to determine whether the WIPP continues to be in compliance with the disposal regulations, assuming that an initial certification of compliance has been issued. The Secretary of Energy must submit to the Administrator of EPA documentation of the WIPP's continued compliance with the disposal regulations, every five years after the initial receipt of transuranic waste for disposal at the WIPP, until the end of the decommissioning phase. The Agency will use the criteria set forth in today's rulemaking in determining whether or not the WIPP will have continued to be in compliance.

The WIPP was authorized in 1980, under section 213 of the Department of Energy National Security and Military Applications of the Nuclear Energy Authorization Act of 1980 (Pub. L. 96–164, 93 Stat. 1259, 1265), "for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States." The waste proposed for disposal in the WIPP, transuranic radioactive waste (TRU waste), is waste consisting of materials such as rags, equipment, tools, protective gear and sludges which have become contaminated during atomic energy defense activities. The WIPP Land Withdrawal Act defines transuranic waste to be waste containing more than 100 nano-curies per gram of alpha-emitting radio-isotopes, with half-lives greater than twenty years and atomic number greater than 92, per gram of waste. The Act further stipulates that radioactive waste shall not be transuranic waste if such waste also meets the definition of high-level radioactive waste, has been specifically exempted from the disposal regulations with the concurrence of the Administrator, or has been approved for an alternate method of disposal by the Nuclear Regulatory Commission. The radioactive component of transuranic waste consists of man-made elements created during the process of nuclear fission, chiefly isotopes of plutonium.

Statutory and Regulatory Basis

Today's action, 40 CFR part 194, was mandated by Congress in section 8(c) of the WIPP Land Withdrawal Act. The criteria promulgated in this action implement only those subparts of 40 CFR part 191 that apply to the disposal of transuranic radioactive waste. As stated in the Code of Federal Regulations, Appendix C of 40 CFR part 191 is guidance for the implementation of the regulations contained in 40 CFR part 191 that is not binding on the implementing agency, which is EPA with respect to the WIPP. Appendix C was designed to apply to all geologic

Information Only

repositories for the disposal of highly radioactive wastes, not necessarily to the specific site characteristics of the WIPP and not only to transuranic waste. As a result, the Agency found in developing today's action that only some of the guidance contained in Appendix C had specific relevance to the WIPP. Today's action has been guided by only those aspects of Appendix C that the Agency has determined, based on technical and policy considerations, to be applicable to the WIPP.

Today's action, 40 CFR part 194, does not amend 40 CFR part 191. With the Energy Policy Act of 1992, Congress mandated the development of regulations to replace 40 CFR part 191 for the Yucca Mountain site only, but the entire standard, 40 CFR part 191, remains applicable to the WIPP. See 106 Stat. 2921, section 801(a)(1). Subpart A of 40 CFR part 191 applies to the management of spent nuclear fuel, high-level and transuranic radioactive wastes at sites designated for the disposal of these wastes. Section 9(a) of the WIPP Land Withdrawal Act stipulates that the Secretary of Energy shall comply with respect to the WIPP with Subpart a of 40 CFR part 191. The Agency has not implemented these requirements in today's action; 40 CFR part 194, but intends to issue guidance for their application to the WIPP at a future date.

Compliance With Other Environmental Laws and Regulations

The WIPP is regulated under the Resource Conservation and Recovery Act (RCRA) and is subject to both the Part B licensing requirements and the land disposal restrictions of that statute. The WIPP must comply with other environmental laws, including, among other statutes, the Clean Air Act (40 U.S.C. 7401 *et seq.*), the Toxic Substances Control Act (15 U.S.C. 2601 et seq.) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.). This action does not affect the need for DOE to comply with these and all other applicable environmental laws with respect to the WIPP.

Public Involvement in Today's Rulemaking

The Agency has taken significant steps to involve the public in the rulemaking for today's action. The EPA published an Advanced Notice of Proposed Rulemaking (ANPR) in February, 1993 (58 FR 8029) which solicited public comment on eight issues central to the development of this final rule. The EPA again solicited public comment on a preliminary draft of the proposed rule, in January, 1994. The Agency published a notice of proposed rule on January 30, 1995, which announced the start of a public comment period of 90 days (60 FR 5766). The Agency convened a technical workshop in February, 1995, for the express purpose of soliciting the views of both scientific experts and the public on issues germane to the rulemaking. In March, 1995, the Agency held public hearings in three cities in New Mexico to solicit public input on the notice of proposed rule. On August 1, 1995, the Agency re-opened the comment period on the notice of proposed rule for an additional 45 days (60 FR 39131). During the entire comment period on the proposed rule, the Agency received over 100 written public comments. The Agency has responded to significant comments received on the notice of proposed rule from both written submissions and from testimony at the public hearings, including late written comments received soon after the close of the second part of the comment period, in a document published concurrently with today's action. In September, 1995, EPA conducted a public meeting of the WIPP Review Committee of the National Advisory Council for Environmental Policy and Technology (NACEPT) on three issues relevant to today's action. During this meeting, members of the public provided formal presentations and oral comments to the committee. See 60 FR 43470–43471 (Aug. 21, 1995).

Summary of the Final Rule

The supporting rationale for today's action, found in the following summary and discussion of principal changes, is further explained in the Background Information Document and the Response to Comments which accompany today's action, copies of which may be obtained as described in the start of this notice. Those sections of the final rule which have remained unchanged since the rule's proposal are also further explained in the notice of proposed rule (60 FR 5766–5791).

Subpart A: General Provisions

Subpart A of the final rule establishes provisions related to the structure of the final rule itself, including: Purpose, scope and applicability; definitions; substitution of alternative provisions for those promulgated in today's final rule; and procedures which shall be followed in communications and written reports submitted by the Secretary of Energy to the Administrator. Further provisions are set forth which incorporate by reference several publications. Publications so incorporated shall have the same legal force and effect as the other requirements of the final rule.

Section 194.4 of subpart A permits the Agency to specify conditions on the issuance of a certification and to issue a modification, suspension or revocation of a certification. The Agency would, for example, specify conditions in the event that the necessary confidence in the WIPP's compliance could be achieved by the implementation of additional measures, or if EPA determines that the WIPP will comply with the disposal regulations if certain terms of the application were to be changed.

The Agency would consider issuing a modification, suspension or revocation whenever the disposal activities or disposal system change such that significant information contained in the most recent compliance application were no longer to remain true. Such a situation may occur if (1) DOE plans to make a significant change to the disposal system or disposal activities, or (2) DOE discovers that a significant change has occurred in the disposal system or disposal activities; in either case DOE must inform the Administrator in writing. If DOE finds the latter condition to be true, then DOE must determine if a release of waste from the disposal system has occurred or is expected to occur that would cause the numerical requirements of the disposal regulations to be exceeded. Releases which might occur during management operations, covered under subpart A of 40 CFR part 191, which do not relate to compliance with the disposal regulations would not necessitate this investigation. However, if DOE conducts this investigation and determines that such a release has occurred or is likely to occur, then DOE shall notify the Administrator of this fact and immediately cease emplacing waste in the WIPP. In such situations, the Administrator will determine which of three actions—modification, suspension or revocation—will be appropriate. Any modifications and revocations issued by EPA would affect the certification issued pursuant to section 8(d)(1) of the WIPP Land Withdrawal Act and must be conducted by rulemaking under section 553 of the Administrative Procedure Act. See 5 U.S.C. 553. A suspension may be issued at any time at the Administrator's discretion so as to promptly address any potential threat to public health. A suspension shall remain in place until such time as DOE shall have effected remediations as necessary to re-establish the WIPP's compliance with the disposal regulations or until EPA will

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK:NS11 46

have modified or revoked the certification. DOE shall not restart emplacing waste in the WIPP until the Administrator notifies DOE in writing that the suspension has been lifted.

Subpart B: Compliance Certification and Re-certification Applications

Subpart B of the final rule sets forth requirements for the format and content of compliance applications. Section 194.11 of the final rule stipulates that DOE must submit a complete compliance application before the one-year, statutory review period shall commence. See Pub. L. 102-579, section 8(d)(1). Should DOE's initial submission be incomplete, the Administrator will explain the nature of the deficiency and will request DOE to submit further information until the Administrator has notified the Secretary that all materials necessary for a complete application have been received. This process will ensure that the Agency's one-year period will be devoted exclusively to a substantive, meaningful review. This provision applies as well to the compliance applications periodically submitted by DOE for re-certification of compliance. Once the Administrator has notified the Secretary of Energy that a complete compliance application for re-certification has been received, the Agency will commence the six month review period as provided for in section 8(f) of the WIPP Land Withdrawal Act. Section 194.12 requires that 30 copies of the compliance applications and any accompanying materials shall be submitted to the Administrator. Section 194.13 requires that compliance applications be accompanied by any referenced materials, unless such materials are generally available.

Section 194.14 of the final rule lists those elements which the Agency requires to be in a complete compliance application. In general, compliance applications must include information relevant to demonstrating compliance with each of the individual sections of the final rule. The Agency intends to publish the final version of the Compliance Application Guidance (CAG) at a later date to provide detailed guidance on the submission of a complete compliance application.

Section 194.15 of the final rule specifies that DOE must submit any additional information that will have been gathered during the elapsed five-year period and that is relevant to compliance with the disposal regulations. To facilitate the Agency's review of compliance applications for re-certification, today's final rule stipulates that DOE will not have to re-submit information that will have been included in previous compliance applications, provided that the information will have remained true and accurate. The current compliance application should clearly reference such information so that the Agency's review of the section in question can be accomplished expeditiously.

Subpart C: Compliance Certification and Re-certification

Subpart C establishes the requirements that apply to the performance assessments and compliance assessments that will be used to demonstrate compliance with the numerical requirements of the disposal regulations. In addition, subpart C implements the six assurance requirements of the disposal regulations and also establishes seven general requirements in §§ 194.21 through 194.27 which must be met by all portions of and all activities associated with compliance applications.

Section 194.21, inspections, provides EPA with right of inspection of all activities at the WIPP and all activities located off-site which provide information included in compliance applications. The Agency will conduct periodic inspections, both announced and unannounced, to verify the adequacy of information included in the compliance applications. The Agency may conduct its own laboratory tests, in parallel with those conducted by DOE, so as to confirm the adequacy of the techniques employed at those facilities. The Agency may also inspect any relevant records kept by DOE, including those records required to be generated pursuant to today's action.

Section 194.22, quality assurance (QA), sets requirements that apply to data and information collected as part of the WIPP program. The Agency requires quality assurance programs to be implemented, as soon as practicable after April 9, 1996, that meet the requirements of the American Society of Mechanical Engineers (ASME) "Quality Assurance Program Requirements for Nuclear Facilities" (NQA-1-1989), ASME's "Quality Assurance Requirements of Computer Software for Nuclear Facility Applications" (part 2.7 of NQA-2a-1990 addendum to ASME NQA-2-1989), and ASME's "Quality Assurance Requirements for the Collection of Scientific and Technical Information on Site Characterization of High-Level Nuclear Waste Repositories," (NQA-3-1989 edition), excluding sections 2.1(b), 2.1(c) and 17.1. Section 194.5 of the final rule incorporates these three publications by reference. The Agency believes that ASME's standards offer the most comprehensive and specific set of requirements for nuclear facilities and has therefore used these standards in place of establishing new requirements. Paragraph (a)(2) of § 194.22 requires that DOE must implement a quality assurance program that meets the above three sets of ASME's requirements for seven specific program elements of the WIPP and for any other system, structure, component, or activity important to the containment of waste in the disposal system.

Data that were collected prior to the implementation of the above programs must also satisfy quality assurance requirements. Any compliance application must demonstrate, subject to the approval of the Administrator or the Administrator's authorized representative, that such data were qualified using one or more of the following four methodologies: (1) Use of a methodology that is substantially equivalent in effect to the three sets of ASME's requirements; (2) peer review that is compatible with NUREG-1297; (3) corroborating data; or (4) confirmatory testing. The Agency believes that each of these latter three methods provides a means of inferring the quality of the existing data by subjecting some aspect of that data to additional scrutiny. Peer review involves a critical evaluation by an independent review group of the adequacy with which the experiments used to acquire this data were planned and conducted. The use of corroborating data evaluates the degree to which the existing data agree with data generated from similar work that has already been published in scientific journals, along with an appraisal of the latter's quality. Confirmatory testing involves repeating a small portion of the experiments, using quality assurance methods that meet the requirements of ASME's standards, and comparing the resulting data to the data in question. In the last two alternate methodologies, the level of agreement between the existing data and the corroborating or confirmatory data provides an objective measure to assess the quality of the existing data, if only in part. All quality assurance programs, both for existing data and data that has yet to be collected, must assess the accuracy, precision, representativeness, completeness and comparability of data. To verify that the quality assurance programs satisfy the requirements of this section, the Administrator will conduct inspections which may include surveillance, audits and management systems reviews.

Section 194.23, models and computer codes, sets requirements for the models and computer codes used in

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK:NS11 47

performance assessments and compliance assessments. Compliance applications must demonstrate that performance assessments and compliance assessments make a logical progression from conceptual models to mathematical models to numerical models and finally to computer models and codes. Compliance applications must provide information on and descriptions of models and computer codes which will permit the Agency to conduct a review of the modeling approach, theoretical bases, and the methodology employed in developing the list of processes and events used to support the compliance application. Compliance applications must include evidence that all computer codes comply with the requirements of part 2.7 of ASME's NQA–2a-1990 addendum.

The Agency intends to conduct detailed reviews of the computer codes used in performance and compliance assessments, since it is the results of computer codes themselves that will be compared to the numerical requirements found at section 13 of 40 CFR part 191. Compliance applications must provide: Descriptions of the theoretical backgrounds for each model and the method of analysis or assessment; a line-by-line listing of codes, which may be submitted in electronic format; a discussion of the treatment of correlation between parameters; and other information necessary to permit the Agency to conduct its review. Upon request, DOE must provide the Agency with the means to conduct its own simulations. The final rule requires that any computer files and hardware that will be necessary for performing simulations shall be made available within 30 days of a request from the Administrator or the Administrator's authorized representative.

Section 194.24, waste characterization, has been revised in the final rule. A discussion of the rationale for the changes is contained below in the section of the supplementary information, "Principal changes in the final rule." The final rule requires DOE to identify and describe quantitative information on those physical, chemical and radiologic characteristics of the waste that can influence disposal system performance. The Agency does not expect or require that every drum of transuranic waste be opened in an effort to provide an exhaustive characterization of the contents. Rather, the Agency expects that DOE will sample drums of waste to the extent necessary and will combine the results with other information such as process knowledge to determine the waste characteristics. The level of accuracy needed in waste characterization is determined by the degree of accuracy assumed in the compliance application. A waste characteristic, as defined in the final rule, is a physical or chemical parameter that serves as a quantitative input to performance assessments or compliance assessments, examples of which are solubility and compactibility. DOE must conduct an analysis to identify and assess the impact on long-term performance of those waste characteristics which influence the containment of waste in the disposal system. This section of the final rule lists specific characteristics which must, at a minimum, be included in the analysis.

The final rule requires DOE to establish limits on the quantities of different "waste components," such as cellulosics, metals or activity in curies, that may be proposed for disposal and emplaced in the WIPP. A waste component is distinguished from a waste characteristic in that the former is an amount of a type of waste present in the total inventory— expressed as a volume, mass or weight (or curies, in the case of activity)—whereas the latter is any parameter that describes the physical, chemical or radiologic properties and behavior of some or all of the containers of waste. For example, a container of waste might contain a given quantity of chelating agents, which are a waste component. An example of a corresponding waste characteristic is the solubility in brine of the radionuclides in a container. The final rule requires that DOE establish upper or lower limits, as appropriate, on the total amount of each waste component that may be emplaced for disposal in the WIPP. A lower limit might be specified for gas-gettering waste components, and an upper limit might be specified for cellulosics. The final rule requires that these upper and lower limits be established based on the total inventory proposed for disposal such that the results of a performance assessment will comply with the containment requirements of 40 CFR 191.13 when these values are used.

Performance assessments and compliance assessments must use the values for each waste characteristic as each would exist in the disposal system assuming that an amount of each waste component, equal to that component's upper or lower limit, as appropriate, were emplaced in the WIPP. As waste is emplaced in the WIPP, a running total must be kept of each waste component. The final rule requires that the quantity of each waste component that has been emplaced in the repository shall not cause the upper limits to be exceeded or, as appropriate, shall not preclude the total emplaced quantity of any waste component from eventually reaching its lower limit. Compliance with the lower limits shall be demonstrated by DOE using information on the waste loading scheme, the total amount of that waste component that has been emplaced in the disposal system to date, the total amount of that waste component listed in the total waste inventory described in the current compliance application, and the amount of that waste component that still has yet to be generated. DOE must establish a system of controls to verify that this requirement will be met and shall submit documentation demonstrating this with any compliance application.

Section 194.24 also requires that performance assessments and compliance assessments shall be conducted in accordance with the waste loading procedures and schemes that will be employed. If a waste loading scheme is not included in the compliance application, the performance assessments and compliance assessments must assume that the containers of waste are randomly emplaced in the WIPP. Thus, for example, DOE shall not assume that the waste components and characteristics are evenly distributed throughout the repository unless a proposed loading scheme that would cause this to occur has been included in the current compliance application.

The final rule extends the requirements of § 194.22, on quality assurance, to process knowledge acquired and used during waste characterization activities. The final rule specifies that the total inventory of waste proposed for disposal in the WIPP must comply with the limitations on transuranic waste found in the WIPP Land Withdrawal Act. The final rule enables the Administrator to use audits and inspections to verify compliance with the waste characterization section.

Section 194.25 of the final rule specifies requirements on future state assumptions. The Agency recognizes the inherently conjectural nature of specifications on future states and wishes to minimize such speculation in compliance applications. The Agency has found no acceptable methodology that could make reliable predictions of the future state of society, science, languages or other characteristics of future mankind. The Agency does believe that established scientific methods could make plausible predictions regarding the future state of three classes of natural processes,

Information Only

SWCF-A 1.2.07.3:PA:DA:TSK. NSII 48

namely geologic, hydrogeologic and climatic conditions. Hence, the final rule requires that performance assessments and compliance assessments shall include dynamic analyses of geologic, hydrogeologic and climatic processes and events that will evolve over the 10,000-year regulatory time frame. DOE shall assume that all other present day conditions will exist in their present state for the entire 10,000-year regulatory time frame.

Section 194.26 sets requirements that apply to expert judgment. Typically, expert judgment is used to elicit two types of information: (1) Numerical values for parameters (variables) which are measurable only by experiments that cannot be conducted due to limitations of time, money and physical situation; and (2) essentially unknowable information, such as which features should be incorporated into passive institutional controls that will deter human intrusion into the repository. Quality assurance must be applied to expert judgment to verify that the procedures for conducting and documenting the expert elicitation have been followed. The final rule prohibits expert judgment from being used in place of experimental data unless DOE can provide a justification explaining why the necessary experiments could not be conducted. Expert judgment may substitute for experimental data in those instances where limitations of time, resources or physical setting would have precluded the successful and timely collection of data.

The compliance application must provide documentation which demonstrates that the experts have the necessary qualifications for addressing the questions and issues put before them. Compliance applications must explain the connection between the question posed to the expert panel and the manner in which the final report of the panel is used in the compliance application. These requirements have been included to prevent any misuse of expert judgment as might result from the use of the results of one elicitation process in answer to a new and separate question that was not posed to the experts and for which, if asked, the experts might have provided a different answer.

The final rule places requirements on the composition of the expert panel, including the fraction of panel members who are not employed by DOE. At least two-thirds of the experts sitting on an expert panel shall not be employed directly by DOE or its contractors. University professors with grants from DOE for research not related to the WIPP will not be considered employees or contractors of DOE, nor will the New Mexico Environmental Evaluation Group and the National Academy of Sciences' Board on Radioactive Waste Management and WIPP Panel. In exceptional instances, DOE may use as few as one-third non-DOE employees if a sufficient number of non-DOE employees cannot be found. DOE must submit documentation which demonstrates that a sufficient number of non-DOE experts were not available. In the proposed rule, the Agency had set this minimum at one-half of the expert panel's membership. However, because of the pervasive effort of DOE in the fields of highly radioactive waste disposal and actinide chemistry, the Agency has lessened this requirement in the final rule in striving to balance the importance of technical expertise with the need for the advice to be impartial.

The section on expert judgment requires that the public be given the opportunity to present information to the expert panel to allow the public's views to be incorporated in the expert judgment process. This requirement will help prevent an inappropriately narrow spectrum of background information from being presented to the experts which might have slanted the outcome of the elicitation process. This section also requires that the elicitation process be well documented so as to demonstrate a logical progression from the first statement of the issue given to the panel members to the combination and presentation in the final report of the elicited results.

Section 194.27, peer review, has been revised in the final rule. The rationale for these changes is discussed in the section of the SUPPLEMENTARY INFORMATION, "Principal changes in the final rule." Given that decisions in the field of highly radioactive waste disposal are inherently first-of-a-kind, the Agency is requiring peer review so that others working in the field can confirm the adequacy of these decisions and interpretations. The final rule requires DOE to conduct peer review of three specific elements of the WIPP program. In specific, the Agency has required peer review of the conceptual models that DOE selects and develops, waste characterization assessments and the study of engineered barriers. The requirement for peer review of conceptual models will enrich DOE's process of selecting and developing conceptual models with a broad spectrum of scientific viewpoints. Waste characterization is a field in which many new and precedent-setting techniques will be employed in areas in which no standardized practice exists. Peer review of waste characterization is indicated due to the importance of a knowledge of the physical, chemical and radiological state of the waste in predictions of the long term performance of the disposal system. This section, § 194.27, requires peer review to be conducted of the study of engineered barriers so as to ensure that the best possible information is provided to DOE on the selection of engineered barriers. Additionally, this section requires compliance applications to include documentation of any peer review activities that DOE may have conducted apart from those required by this rule, including those activities which are similar to peer review, such as the reviews conducted by the WIPP Panel of the National Academy of Sciences.

The Agency is requiring that peer review which occurs subsequent to the promulgation of today's action must be conducted according to the guidelines of NUREG–1297. The final rule incorporates this publication by reference, as specified in § 194.5. The specific requirements in NUREG–1297 that discuss for which activities peer review should be conducted do not apply, nor do they supersede the requirements of the final rule. Peer review which has been conducted prior to today's action must be documented in compliance applications. Such past peer review activities must conform to either NUREG–1297 or to an alternate set of criterion which are substantially equivalent in effect to NUREG–1297 and which have been approved by the Administrator.

Sections 194.31 through 194.34 of the final rule implement the numerical containment requirements of 40 CFR 191.13. Section 194.31, which provides instructions for setting the release limits of appendix A of 40 CFR part 191, has been revised from the proposed rule. The rationale for this change is explained in the section, "Principal changes in the final rule." Section 194.31 now specifies that the release limits are to be determined based on the total activity, in curies, of transuranic waste present at the time of disposal (as defined in 40 CFR 191.2). If the activity of a waste container is assayed prior to this time, then the known rates of decay for the radionuclides in the container should be used to calculate the activity of the waste as it will exist at the anticipated time of disposal.

Section 194.32 stipulates that performance assessments shall include both natural and man-made processes and events which can have an effect on the disposal system. Performance assessments need not include those processes and events which have a

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSII 49

probability of less than 1 in 10,000 of occurring during the 10,000-year regulatory time frame. For the purposes of this screening requirement, processes and events must be analyzed in the most general formulation possible; for example, the probability of dissolution must be set equal to the probability of all types of dissolution occurring anywhere in the Delaware Basin during the regulatory time frame. Performance assessments should, however, conduct separate analyses of the different dissolution fronts which occur in the Delaware Basin so as to account for the different hydrogeologic characteristics of each.

With respect to man-made processes and events, performance assessments must include the effects of drilling events and excavation mining. Some natural resources in the vicinity of the WIPP can be extracted by mining. These natural resources lie within the geologic formations found at shallower depths than the tunnels and shafts of the repository and do not lie vertically above the repository. Were mining of these resources to occur, this could alter the hydrologic properties of overlying formations—including the most transmissive layer in the disposal system, the Culebra dolomite—so as to either increase or decrease ground-water travel times to the accessible environment. For the purposes of modeling these hydrologic properties, this change can be well represented by making corresponding changes in the values for the hydraulic conductivity. The Agency has conducted a review of the data and scientific literature discussing the effects mining can induce in the hydrologic properties of a formation. Based on its review of available information, the Agency expects that mining can, in some instances, increase the hydraulic conductivity of overlying formations by as much as a factor of 1,000, although smaller or even negligible changes can also be expected to occur. Thus, the final rule requires DOE to consider the effects of mining in performance assessments. In order to consider the effects of mining in performance assessments, DOE may use the location-specific values of hydraulic conductivity, established for the different spatial locations within the Culebra dolomite, and treat them as sampled parameters with each having a range of values varying between unchanged and increased 1,000-fold relative to the value that would exist in the absence of mining.

The Agency recognizes that other numerical changes to the hydraulic conductivity values may be more appropriate for use in representing the effects of mining. Compliance applications must include a discussion of the rationale and experimental data which support the hydraulic conductivity values chosen and the effects of mining on the range of these values. The Agency further recognizes that some parameter other than hydraulic conductivity might be demonstrated to incorporate, equally or perhaps better, the potential effects of mining in performance assessments. DOE may elect to use another parameter, provided that DOE can demonstrate that the use of this other parameter is equally or more appropriate than hydraulic conductivity in reflecting the potential effects of mining on the disposal system. Pursuant to § 194.34 of the final rule, performance assessments must randomly sample across the full range of values that have been established for all uncertain variables, including the hydraulic conductivity of the Culebra dolomite established as discussed above.

The final rule specifies those assumptions and methods that shall be used in performance assessments to account for the effects of mining. As with drilling, the historical record of the past 100 years' mining activity in the Delaware Basin provides a reasonable basis for predicting the nature of future mining activity. Accordingly, the Agency examined the records of past mining of mineral resources in the Delaware Basin, using data supplied by the U.S. Bureau of Land Management. The Agency found that the areal extent of mining in the immediate vicinity of WIPP over the past 100 years covered roughly one percent of the land area of the entire Delaware Basin and used this information to predict the likelihood that a mining event would occur in succeeding centuries. Accordingly, the final rule requires performance assessments to assume that, in each century after closure of the repository, there will be a 1 in 100 chance that a single mining event will occur within the controlled area. As explained later in this section, the assumed mining event would remove all of the existing mineral deposits lying within the controlled area that are of similar quality and type to those minerals currently extracted in the Delaware Basin. For each century during the regulatory time frame, performance assessments should determine whether this mining event will occur, based on the 1 in 100 probability, proceeding one century at a time from the start of the 10,000-year period. If a positive determination is made, then performance assessments must assume that the single mining event occurs at the start of that century and further assume that no mining will occur thereafter. The Department may elect to use an alternate method for calculating the point in time at which mining will occur, provided that such method would not, on average, predict that mining will occur at times later than those calculated using the method in the final rule.

The final rule specifies that mining should be assumed to occur within the controlled area, with the size and shape of the mine conforming to existing mineral deposits that are similar in type and quality to those extracted in the Delaware Basin. The Agency based this requirement on a consideration of the physical nature of mining activities. First, the Agency assumed that the size and shape of a mine will be dictated by the size and shape of the mineral deposits that are to be extracted with no two mines being alike. The mineral deposits that will be mined in the future may consist of minerals of current economic interest, or of materials not useful or valuable in present-day terms. Without knowledge of what these future resources might be, any attempt to predict the size and shape of the associated mineral deposits would be speculative, as would any attempt to determine the size and shape of the mines used to extract them. The Agency further recognized that individual mines are of highly irregular shape and there is every reason to believe that deposits of minerals that are mined in the future will also vary in size and be highly irregular in shape. The Agency believes that no logical mathematical scheme exists that could be used to predict the potentially wide variety of sizes and highly irregular shapes. In light of the speculativeness and mathematical difficulty, the Agency has chosen to use existing mineral deposits as "stand-ins" to be used to determine the size and shape of the unknown mineral deposits that might be mined in the future. Thus, the final rule requires performance assessments to assume that all the presently known mineral resources lying within the controlled area will be extracted at the single point in time determined by the method in the final rule, discussed above. No further mining will be assumed to occur, since the available mineral deposits will have been depleted. The type of minerals that shall be assumed to be extracted are those mineral deposits that are similar in quality and type to those that are currently extracted in the Delaware Basin.

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NS11 50

Performance assessments may assume that the likelihood of mining may be decreased by PICs and active institutional controls, to the extent that can be justified in the compliance application and to a degree identical to that assumed for drilling. The requirements of sections 41 and 43 of the final rule therefore will apply to the consideration of mining in performance assessments.

Section 194.33, consideration of drilling events, has been revised since the proposed rule. The rationale for the new provisions is explained in the section below, entitled "Principle changes in the final rule." Section 194.2 includes two definitions relevant to the consideration of drilling events. "Deep drilling" denotes those drilling events that reach or exceed a depth 2150 feet below the surface where such drilling occurred. "Shallow drilling" denotes those drilling events that do not reach to a depth 2150 feet below the surface where such drilling occurred. Sections 194.32 and 194.33 of the final rule require that performance assessments include the effects of both deep drilling and shallow drilling, whether such drilling has occurred prior to the time at which the compliance application is prepared, can be reasonably expected to occur in the near future based on existing leases, or can be expected to occur in the future during the 10,000-year regulatory time frame.

The future rates of both deep drilling and shallow drilling shall each be set equal to the rate at which deep drilling and shallow drilling, respectively, have occurred in the Delaware Basin during the 100-year period immediately prior to the time the current compliance application is prepared. The Delaware Basin is defined, in § 194.2, to be the surface and subsurface features which lie inside the innermost edge of the Capitan Reef and, where the Capitan Reef is absent to the south, the features which lie to the north of a straight line connecting the southeastern point of the Davis Mountains and the southwestern point of the Glass Mountains.

Performance assessments must add together all releases of radionuclides which are predicted to occur during the 10,000-year regulatory time frame to arrive at the cumulative releases from the disposal systems; the containment requirements of 40 CFR 191.13 apply to cumulative releases of waste and not the individual events which cause the releases. Further, boreholes drilled after closure of the repository shall be assumed to affect the properties of the disposal system for the remainder of the 10,000-year regulatory time frame. When analyzing the effects of all later boreholes, performance assessments must account for the effect that these existing boreholes will have had on the hydrogeologic properties of the disposal system and on the creation of new pathways for releases. In today's final rule, the Agency requires that performance assessments and compliance assessments must include—among other processes and events—the effects on the disposal system of drilling and all types of resource extraction activities, including *inter alia* solution mining and fluid injection, that will have occurred prior to the time at which the compliance application is prepared or that may be expected to occur soon afterward based on existing plans and leases for drilling.

In the case of shallow drilling only, DOE may, if justified, derive the drilling rate from the historical rates of shallow drilling for only those resources in the Delaware Basin which are of similar quality and type to those found in the controlled area. For example, if only non-potable water can be found within the controlled area, then the rate of drilling for water may be set equal to the historical rate of drilling for non-potable water in the Delaware Basin over the past 100 years.

Section 194.33 requires performance assessments to make several specific assumptions about future deep drilling and shallow drilling. These assumptions include that drilling will occur randomly in space and time and may occur at different rates for each resource, and that drilling practices will remain as those of today and may vary depending on the resource. Performance assessments should assume that the permeability of sealed boreholes will be affected by natural processes, and should assume that the fraction of boreholes that will be sealed by man equals the fraction of boreholes which are currently sealed in the Delaware Basin.

The Agency recognizes that drill operators currently employ different techniques in the exploration and development of each resource. Hence, performance assessments shall conduct a separate analysis of the effects that future drilling for each different resource—the act creating a borehole—will have on the disposal system. Each separate analysis should set the future rate of drilling for the particular resource equal to the historical rate at which that resource has been drilled for in the Delaware Basin during the past 100 years. The analyses of the consequences of each type of drilling might remain conceptually similar, but vary with regard to assumptions made on size and depth of boreholes, quantity of drilling fluid used, or any other characteristic specific to that type of resource. Analyses of the consequences of future drilling events may be confined only to the drilling activity and the subsequent effect of the borehole's presence and need not include an analysis of extraction and recovery activities which would occur subsequently.

In determining the drilling rate or the amount of waste released from such drilling, performance assessments should not assume that drill operators would detect the waste and then cease the current drilling operations or otherwise mitigate the consequences of their actions. Similarly, drill operators should not be assumed to cease further exploration and development of resources as a result of the driller's detecting the waste.

Section 194.34 requires that the results of performance assessments be expressed as complementary, cumulative distributions functions (CCDFs). The CCDFs shall be generated using random sampling techniques which draw upon the full range of values established for each uncertain parameter, which may include physical and chemical waste characteristics. Parameters of lesser sensitivity in performance assessments may be held constant, provided that such constant values can be justified as sufficiently conservative. The quantitative requirements of this section state that there must be a 0.95 probability that, at values of cumulative release of 1 and 10, the maximum CCDF generated exceeds the 99th percentile of the population of CCDFs. The values of cumulative release are calculated according to Note 6 of Table 1, Appendix A of 40 CFR part 191. Additionally, the mean of the population of CCDFs must meet the requirements of section 13 of 40 CFR part 191 with at least a 95 percent level of statistical confidence. In demonstrating compliance with these standards, the infinite number of CCDFs denoted by the term, population of CCDFs, need not be generated. By generating only a finite number of CCDFs and applying statistical theory, the relationships between the finite group of computer-generated CCDFs, the population of CCDFs and the numerical requirements of this section can be established.

Subpart C of today's action also implements the six assurance requirements of section 14 of 40 CFR part 191. The assurance requirements were included in the disposal regulations to provide the confidence needed for long-term compliance with

Information Only

the containment requirements of section 13 of 40 CFR part 191.

Section 194.41 of today's final rule requires a description of the active institutional controls that will be implemented at the WIPP. This description shall be sufficient to support any assumptions made on their effectiveness in performance assessments and compliance assessments. However, in no case shall active institutional controls be assumed to be in effect for more than 100 years after the time of disposal.

Section 194.42 of the final rule, monitoring, has been revised from the proposed rule. The rationale for these changes is provided below, in "Principal changes in the final rule." Any unpredicted detection of movement of radionuclides toward the accessible environment would be cause for concern that a release of waste in excess of what is permitted under the disposal regulations is likely to occur. This section specifies requirements for monitoring in both the pre-closure and post-closure periods, as necessary to verify that the WIPP complies with the disposal regulations. In the event that an initial certification has been granted, the results of monitoring during the pre-closure period will be used by the Agency to verify that the information contained in the initial compliance application has remained true and accurate; this information would be used by the Agency during both the initial five-year period after the start of emplacement of waste and during the reviews made for the periodic re-certifications of compliance. The final rule has included a provision which requires DOE to conduct an analysis of parameters that will be used in the development of pre-closure and post-closure monitoring plans. The analysis should consider the importance of the parameter with respect to both the containment of waste in the disposal system and the practicability of performing such monitoring, including its technical feasibility and the cost.

Section 194.43 implements the assurance requirements on passive institutional controls (PICs). The final rule specifies that DOE must include a detailed description of the PICs that will be employed and lists the information that the PICs are required, at a minimum, to convey. Additionally, the final rule allows the Department to reduce the likelihood of future human intrusion that is used in performance assessments by a proposed amount corresponding to the predicted effect of PICs. See generally 47 FR 58196, 58201 (Dec. 29, 1982); 50 FR 38066, 38080 (Sept. 19, 1985). Thus, DOE may propose in its compliance application to reduce the rate of human intrusion by a fractional amount, extending over a technically supportable period of time, and must justify this using the plans for the implementation for PICs and associated evidence of their effectiveness. This credit may take the form of a constant reduction in the rate of human intrusion lasting several hundred years or may be a reduction in the rate which tapers off in size over several hundred years. Such credit cannot be assumed to eliminate completely the possibility of human intrusion, even for a short period of time after the active institutional controls at the WIPP are assumed to be ineffective. During the rulemaking on certification, the Agency could determine that the description of the PICs does not adequately justify the degree of proposed credit assumed by DOE and therefore disallow some or all of the credit proposed by DOE in the compliance application.

Having considered the public comments regarding PICs, the Agency believes that such credit could be no more than approximately 700 years past the time of disposal. Thus, the final rule limits to several hundred years the amount of credit that EPA may grant for PICs. Any determination that a specific numerical credit would be appropriate for a much longer period of time would be unduly speculative and therefore inappropriate.

Today's action should not be construed to approve or award any amount of credit for PICs, as such a determination cannot be made in advance of the rulemaking on certification of compliance. The Agency is deferring any decisions on credit for PICs planned for the WIPP until such time as the compliance application has been received and a rulemaking for certification has been completed. This restates the Agency's prior assertion, made in the promulgation of the final disposal regulations in 1985:

> Specific judgments about the chances and consequences of intrusion should be made by the implementing agencies (EPA for the WIPP) when more information about particular disposal sites and passive control systems is available. See 50 FR 38080.

In developing this section of the final rule, 40 CFR 194.43, the Agency considered the treatment of PICs in the disposal regulations, the input received in public forums and the public comments received on the proposed rule. The disposal regulations established the foundation of today's action on the role of passive institutional controls. Section 191.14(c) of the disposal regulations require that disposal sites be designated by the most permanent markers, records, and other passive institutional controls practicable to indicate the dangers of the wastes and their location. In adopting these provisions of the disposal regulations, the Agency expressly assumed that passive institutional controls "should reduce the chance of inadvertent intrusion compared to the likelihood if no markers and records were in place." See 50 FR 38080. With respect to performance assessments, the Agency examined whether PICs should be taken into account to some degree when estimating the likelihood of inadvertent human intrusion and concluded that "a limited role for passive institutional controls would be appropriate when projecting the long-term performance of mined geologic repositories to judge compliance with (the containment requirements of 40 CFR part 191)." At the same time, the Agency explicitly determined that PICs should not be assumed to completely prevent the possibility of inadvertent human intrusion. See 50 FR 38080.

In the proposed rule, 40 CFR part 194, the Agency specifically requested comment on the requirements on PICs. The Agency conducted a public discussion of PICs in a technical workshop in Washington, DC, in February, 1995. In September, 1995, EPA consulted the WIPP Review Committee of the National Advisory Council for Environmental Policy and Technology (NACEPT) on three issues, including PICs, in a public meeting in New Mexico. See 60 FR 43470–43471 (Aug. 21, 1995). The Committee agreed that PICs would be likely to decrease the likelihood of inadvertent intrusion into the WIPP but expressed concern about the availability of a rigorous method by which to determine the appropriate reduction due to PICs in the future likelihood of inadvertent intrusion. Some members of the Committee stated that, if credit were to be approved, the size of the credit should not reflect that PICs would be effective for more than a small fraction of the 10,000 year regulatory time frame.

Many public comments received on the proposed rule expressed skepticism about whether PICs would be effective for the entire 10,000 year regulatory time frame or for even a fraction thereof. Other comments stated the belief that civilizations living 1,000 to 10,000 years from now would, in fact, be capable of understanding the records and markers that were left behind at the WIPP. Still other comments asserted that, in allowing for the possibility of credit, the Agency had revised the intent of the

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSII 52

assurance requirements, one of which being the requirement for the implementation of PICs. Specifically, comments stated that the assurance requirements were not intended to be considered when determining compliance with the numerical containment requirements found at 40 CFR 191.13.

The provisions of the final rule entertaining possible credit for PICs are within EPA's authority. In adopting the assurance requirements in 40 CFR part 191, EPA expressly limited the credit for active institutional controls. EPA prohibited performance assessments from considering any contributions from active institutional controls for more than 100 years after disposal. See 40 CFR 191.14(a). EPA declined to similarly limit the effect of PICs in reducing the likelihood of human intrusion. 50 FR 38080. By contrast, EPA contemplated that PICs may discourage the likelihood of human intrusion for some period of time longer than active institutional controls. However, EPA indicated that it generally believed it was inappropriate to rely on PICs for extended periods of time. See 50 FR 38080. Based on the public comments and consistent with EPA's general view that it is inappropriate to rely on PICs for very long periods of time, EPA is constraining in the final rule the length of time that EPA could consider granting credit for PICs to several hundred years. EPA's decision about the actual efficacy of PICs proposed for the WIPP will be based on DOE's compliance application but may not exceed this limit.

Further, the degree to which PICs might reduce the future drilling rate can be reliably determined only through informed judgment. The Agency agrees with the NACEPT Committee that no rigorous and non-speculative method is available to determine the appropriate amount of credit for PICs. Thus, DOE's proposed reduction in the likelihood of human intrusion due to PICs would probably be conducted through an expert judgment process that considers the specific PICs to be implemented at the WIPP by DOE. The expert judgment performed specifically to determine the effect of PICs must satisfy the requirements of section 26 of today's action, on expert judgment. For example, this section requires that the range of professions represented on the expert panel must cover the complete spectrum of knowledge that will be necessary to address the question given to the experts. In the case of PICs, the Agency would expect that experts would be selected not only from professions such as archeology, but from professions which are concerned with the exploration and development of natural resources such as oil and natural gas.

Section 194.44 of the final rule implements the assurance requirement on engineered barriers. This section requires that DOE conduct a study of available options for engineered barriers at the WIPP and submit this study and evidence of its use with the compliance application. Consistent with the requirement, found at 40 CFR 191.13, that DOE analyze the performance of the complete disposal system, any engineered barriers that are ultimately implemented at the WIPP must be considered by the Department and, ultimately, EPA when evaluating compliance with both the containment requirements of 40 CFR 191.13 and the assurance requirement of 40 CFR 191.14(d).

Section 194.45 implements the assurance requirement that the disposal system be sited such that the benefits of the natural barriers of the disposal system compensate for the increased probability of disruptions of the disposal system resulting from exploration and development of nearby natural resources. This assurance requirement will be met if performance assessments comply with the numerical containment requirements of section 13 of 40 CFR part 191, provided that the potential effects of human intrusion at the WIPP will have been appropriately considered.

Section 194.46 implements the assurance requirement that the removal of waste remain possible for a reasonable period of time after disposal. The final rule has eliminated the requirement for the development of a plan for the removal of waste which had been contained in the proposed rule. In place of the requirement for a removal plan, EPA is including in the final rule a requirement that DOE perform an evaluation to demonstrate that the removal of waste will remain feasible for a reasonable period of time after disposal.

Sections 194.51 through 194.55 provide the criteria that must be met in order to demonstrate that the WIPP will comply with the ground-water requirements of subpart C of 40 CFR part 191 and the individual protection requirements of section 15 of 40 CFR part 191. Section 194.51 and 194.52 specify the assumptions that must be incorporated into compliance assessments in the analyses of annual committed effective dose equivalent received by individuals, used in determining compliance with the individual protection requirements. Compliance assessments should separately analyze the doses received by individuals from each pathway. Compliance assessments should assume that the protected individual resides at the single geographic point where the maximum dose would be received, calculated by the sum of all pathways.

Section 194.53 lists the assumptions that compliance assessments must include when analyzing the doses received through underground sources of drinking water (USDWs), used in determining compliance with subpart C of 40 CFR part 191. Doses can be received from any USDW outside of the controlled area, provided that a connective pathway could be expected to be established via ground-water travel between the disposal system and that USDW. The Agency expects that USDWs which lie closer to the disposal system will have a greater chance of being affected by releases of waste. The Agency therefore does not intend for DOE to expend resources analyzing doses received from USDWs located large distances from the disposal system. The calculations of doses received from USDWs should assume that drinking water is withdrawn directly from the contaminated USDW and consumed at a rate of two liters per day.

Section 194.54 defines the scope of compliance assessments. Compliance assessments should be conducted of the undisturbed performance of the disposal system, which, by the definition in section 12 of 40 CFR part 191, denotes that the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events. Section 194.55 requires that compliance assessments include calculations or "estimates" of three quantities: (1) The annual committed effective dose received from all pathways, an analysis which corresponds to the requirements of section 15 of 40 CFR part 191; (2) dose equivalents received from USDWs; and (3) concentrations of radionuclides present in USDWs, the latter two of which correspond to subpart C of 40 CFR part 191. To generate a "range" of estimates, compliance assessments must make repeated calculations, with each iteration employing a different set of randomly selected values for each uncertain parameter. Parameters of lesser sensitivity in compliance assessments may be held constant, provided that these values can be justified as being sufficiently conservative. The final rule requires that there be a 0.95 probability that the maximum estimate of each set so generated exceeds the 99th percentile of

Information Only

the population of estimates. The mean and the median of the population of each set of estimates must meet the requirements of section 15 and subpart C of 40 CFR part 191, as applicable, with at least a 95 percent level of statistical confidence.

Subpart D: Public Participation

Subpart D of today's action establishes procedures that EPA will use to involve the public in the decisions on certification and re-certification and requires EPA to publish notices of its actions in the Federal Register. Subpart D includes new provisions which require the Agency to involve the public in decisions to modify or revoke a certification. Section 194.65 requires that EPA publish a notice in the Federal Register announcing the Agency's proposed decision on the modification or revocation of the certification. The notice of proposed rulemaking must solicit comment on the proposed decision. Section 194.66 requires the Administrator to publish a notice of final rulemaking in the Federal Register, announcing whether the Agency has revoked, modified or taken no action to change the certification. Section 194.67 requires that EPA maintain a public docket with all information used in making the decisions on certification, re-certification, and modification and revocation of the certification.

Principal Changes in the Final Rule

In addition to the principal changes described below, today's action contains other minor modifications to the proposed rule. Further discussion of the rationale and information supporting significant changes found in today's action is contained in the Background Information Document and the Response to Comments, which may obtained as explained in the start of this notice.

Scope of Performance Assessments and Consideration of Drilling Events

In §§ 194.32 and 194.33 of the final rule, the Agency has provided further clarification on which activities fall within the scope of human intrusion. (Section 194.33 had been titled "Consideration of human initiated processes and events" in the proposed rule.) The final rule requires that the effects of deep drilling, shallow drilling and excavation mining must be included in performance assessments. In the proposed rule, the Agency had included excavation mining from consideration (60 FR 5774; January 30, 1995). The Agency received several public comments recommending that performance assessments should be required to include the effects of future mining during the regulatory time frame in order to account for the presence of potash in the vicinity of the repository. The Agency has re-evaluated the proposed exclusion of mining, in light of these public comments. The Agency believes that, while there is uncertainty surrounding the potential effects of mining, mining could nonetheless alter the hydrogeologic properties of certain formations that lie at shallower depths than the mined portion of the repository. Thus, the final rule requires performance assessments to consider the possible effects of excavation mining on the disposal system. As discussed previously, DOE may address this requirement by considering the changes that mining would induce in the hydraulic conductivity of the disposal system. Additionally, the requirements of the final rule specify the method for determining the size and shape, location and point in time at which mining occurs. The Agency specified these items to provide clarification on how mining should be considered and to avoid unbounded speculation that would result from the high uncertainty regarding whether, where and how mining would occur in the Land Withdrawal area. EPA's decision was based on a desire to include mining in performance assessment in a realistic fashion without recourse to such unconstrained speculation. To this end, the final rule has specified that mining will continue at the same rate as it has over the past 100 years, that the area to be mined is the area that contains mineral deposits of similar type and quality to those that are currently extracted in the Delaware Basin, and that only the major impacts on the disposal system of mining need be considered. EPA believes this is consistent with the future states assumptions of section 25 as they apply to the future activities of man.

The Agency has added definitions of deep drilling and shallow drilling in § 194.2. Both types of drilling shall include exploratory and developmental wells. The addition of these definitions was prompted by commenters who noted that the definitions of human intrusion and "human activity" that were in the proposed rule had caused confusion by distinguishing their meanings on the basis of the depth at which drilling occurs. In the final rule, the Agency has removed these definitions from the final rule and instead makes use of the defined terms, deep drilling and shallow drilling in order to provide greater clarity.

Commenters also requested that the final rule require analysis of disposal of brine that accumulates during the extraction of oil and of secondary recovery of oil performed using water-flood injection. The Agency considered this comment in the larger context of the nature of potential human intrusions during the next 10,000 years and what assumptions might hold true during that time. The Agency believes that no one resource will last for the entire 10,000 years and therefore has concluded that the techniques for extraction of any one resource—such as water-flood injection for oil recovery—are unlikely to be in use during much of the 10,000-year regulatory time frame. With respect to drilling rates, the Agency reasoned that while the resources drilled for today may not be the same as those drilled for in the future, the present rates at which these boreholes are drilled can nonetheless provide an estimate of the future rate at which boreholes will be drilled. The Agency does expect that drilling will never completely cease; while some resources may become depleted over time and, while the rate of extraction of those resources may decrease, the increased rate of drilling for newly discovered resources will compensate for this decline. In effect, when used for the purpose of determining the future drilling rate, today's drilling activities act as surrogates for the unknown resources that will be drilled for in the future. With respect to the consequence and releases due to future drilling, present-day drilling activities provide the only available basis for making assumptions in performance assessments. Future extraction of any resource will likely necessitate drilling a hole for its recovery. However, because there is doubt as to whether the resources associated with today's specialized extraction techniques and fluid injection will remain available for 10,000 years, the final rule does not require that performance assessments assume that such extraction activities will occur during the entire regulatory time frame, but does require that the effects of the drilling events themselves be analyzed. The techniques include, for example, water-flood injection for secondary recovery of oil, solution mining and the disposal by injection of brine accumulated during recovery of oil.

The Agency recognizes, however, that resource extraction and fluid injection activities which are currently performed in the Delaware Basin can alter the hydrogeologic properties of the initial state of the disposal system. The final

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NS11 54

rule requires that performance assessments and compliance assessments analyze the effects of all types of fluid-injection and all boreholes which can have an effect on the disposal system and which have been or will have been drilled prior to or soon after disposal. These boreholes shall be assumed to affect the properties of the disposal system for the entire 10,000-year regulatory time frame. Predictions about such future activities shall be strictly limited to the expected use of existing leases.

Today's final rule eliminates the proposed cap on the rate of deep drilling into the disposal system of 62.5 boreholes per square kilometer per 10,000 years as well as the proposed lower limit of 25 boreholes per square kilometer per 10,000 years. The Agency received numerous public comments objecting to the use of upper and lower limits on the rate of deep drilling. The Agency has concluded that the rate of drilling into the disposal system used in performance assessments covering the 10,000-year regulatory time frame should be derived solely from the historical record of drilling in the region surrounding the WIPP. In the proposed rule, the Agency had specified that the past 50 years of records on drilling shall be used to establish the rates for shallow drilling and deep drilling, the latter being subject to upper and lower caps. While developing the final rule, the Agency recognized that drilling activity has been at a maximum during the past 50 years, whereas during the past 100 years, a broader spectrum of high and low drilling rates can be found. In the long-term future, it can be expected that the drilling rate will consist of periods of high and low drilling activity, which makes the past 100 years a more appropriate period for calculating the drilling rate. In addition, more detailed examination of the available records in Texas and New Mexico since the time of the proposed rule has shown that accurate data on drilling activity dates back 100 years, rather than 50 years as was believed initially. The final rule therefore specifies that the rates of both shallow drilling and deep drilling are to be set based on data from the 100 year period ending at the time DOE prepares the compliance application.

Today's final rule includes a definition of the term "Delaware Basin," used in the regulation to be that area over which the past drilling rate is to be averaged in order to establish the rate of drilling used in performance assessments. In the proposed rule, the Agency had solicited comment on how to define the Delaware Basin. Many comments were received, with the bulk of the discussion focusing on whether the Capitan Reef should be included in the definition. In arriving at the definition in the final rule, the Agency considered the geologic and hydrogeologic characteristics of the formations which contain the WIPP versus those of the Capitan Reef. The Capitan Reef is more permeable to the flow of water and was formed from organic material which differs from the salt formations which immediately surround the WIPP. The Agency had stated its intention to define the Delaware Basin to be the largest contiguous area that has similar geologic properties. Because of the differences, noted above, between the Capitan Reef and the interior formations, the Agency has chosen to define the Delaware Basin to be those surface and subsurface formations which lie inside the innermost edge of the Capitan Reef. Where the Capitan Reef is absent to the south, the Delaware Basin includes those features which lie to the north of a straight line connecting the southeastern point of the Davis Mountains and the southwestern point of the Glass Mountains.

Waste Characterization

Numerous public comments were received on the proposed § 194.24, waste characterization. Commenters stated that this section required greater clarity in order to be implemented effectively at the WIPP. The final rule retains the use of "waste characteristics" to provide a description of the waste. The term, waste categories, has been eliminated in the final rule. The final rule uses the term, "waste components," to denote an amount of a type of waste—expressed as a volume, mass or weight (or curies, in the case of activity)—such as chelating agents and cellulosics. The waste categories in the proposed rule were to be established based on the assumption that wastes with similar waste characteristics would behave similarly in the disposal system. The Agency believes that using instead the term "waste components" provides a less abstract scheme for classifying waste which could be more easily implemented. In particular, the Agency believes that, for a given container of waste, DOE could more readily identify how much of each waste component is present rather than how much of each waste category is present. The final rule requires that these limits be established such that the results of performance assessments and compliance assessments will comply with the numerical requirements of 40 CFR Part 191 when the maximum or minimum values for each waste component are used, as appropriate.

To assist in establishing the waste characteristics and waste components and quantitative values of each, the final rule requires that compliance applications include an analysis to identify and assess the impact on long-term performance of those waste characteristics which influence the containment of waste in the disposal system. An analysis must also be conducted of waste components to determine which of these will influence the waste characteristics identified as having an influence on containment. This section of the final rule specifies those waste characteristics and waste components which, at a minimum, the respective analyses must investigate.

Peer Review

Section 194.26, peer review, has been narrowed in scope in the final rule. The Agency received many public comments stating that the requirements on peer review were stated too broadly such that an inordinate and unmanageable number of peer reviews would be required. Additionally, commenters noted that many of the activities that the proposed rule had required to be peer reviewed were subject to specific quality assurance requirements under § 194.22. Public comments noted that, in this instance, the proposed peer review requirements would be redundant with the quality assurance requirements. Such activities would include the computer codes and the data used to support all models—conceptual, mathematical and numerical—and computer codes.

The Agency consulted the WIPP Review Committee of NACEPT at the September, 1995 meeting and sought its advice on how to address peer review. The Committee suggested that peer review of quality assurance programs would be unnecessary, since, by requiring DOE to adhere to a program that meets the requirements of three sets of ASME's standards, today's action would already be sufficient to control the quality assurance process. The Agency agrees with both the Committee and with similar public comment and has eliminated the requirement for peer review of quality assurance programs and plans. The Committee also stated that peer review could be used both to insure that analyses use the correct model of repository behavior and to evaluate the subjective uncertainty in whether the appropriate conceptual model was selected. In the case of WIPP, unanimous agreement does not exist on the nature of the conceptual models of natural processes such as dissolution

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSII

which can have an effect on the disposal system. To subject these issues to wider scrutiny, the final rule specifies that peer review must be conducted of the conceptual models selected and developed by DOE.

Application of Release Limits

Section 194.31 of the final rule specifies that the release limits of Appendix A of 40 CFR part 191 shall be determined based on the total activity, in curies, of transuranic waste present at the time of disposal. Public comment was divided between those who recommended setting release limits at 100 years, as in the proposed rule, and those who recommended the time of disposal. The Agency solicited the views of the WIPP Review Committee of NACEPT on the subject of release limits in the meeting held in September, 1995. Some committee members noted that radionuclides such as plutonium 238 would quickly decay to less than half their original number in under 100 years and thus would not pose a threat for more than a small fraction of the 10,000-year regulatory time frame. Hence, some members of the committee recommended the option of setting the release limits at later times so that the release limits would be based on longer-lived radionuclides. Doing so would more accurately reflect the long-term hazards presented by the waste.

Some committee members also recommended that the Agency should base its decision on the original intent of the disposal regulations. The Agency believes that the disposal regulations were designed to avoid the undue influence of short-lived radionuclides on the size of the release limits. The disposal regulations accomplished this purpose in Appendix A by eliminating the contribution of radionuclides having half-lives of less than twenty years. The Agency has therefore chosen in the final rule to determine release limits based on the total activity, in curies, of transuranic waste present at the time of disposal.

Monitoring

The monitoring requirements have been modified to provide clearer direction for the development of a post-closure monitoring plan. Several commenters suggested that, by requiring that post-closure monitoring be conducted in a manner "compatible" with RCRA, DOE might be forced to implement two over-lapping monitoring programs in order to comply with both RCRA hazardous waste regulations and 40 CFR part 194. Other commenters noted that, in the event that RCRA monitoring at the WIPP were to be modified or eliminated, the requirement in 40 CFR Part 194 as proposed would be correspondingly reduced. To provide clearer direction on the performance of post-closure monitoring, the Agency has made two changes in the final rule. First, to eliminate potential overlap, the Agency is requiring that post-closure monitoring be required to be "complementary" with RCRA, so that information yielded by the one monitoring program would not be duplicated by the other. The Agency is requiring in the final rule that post-closure monitoring be conducted, to the extent practicable when considering technical feasibility and cost, of those parameters which are important to the containment of waste in the disposal system. Such parameters shall be identified in a required analysis that will assess which parameters are important to the containment of waste and which therefore should be included in post-closure (and pre-closure) monitoring.

Rulemaking Analyses

Executive Order 12866

Under Executive Order 12866, (58 FR 51,735 October 4, 1993), the Agency must determine whether the regulatory action is "significant" and therefore subject to OMB review and the requirements of the Executive Order. The Order defines "significant regulatory action" as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of Executive Order 12866, it has been determined that this rule is a "significant regulatory action" because it raises novel policy issues which arise from legal mandates. As such, this action was submitted to OMB for review. Changes made in response to OMB suggestions or recommendations will be documented in the public record.

Regulatory Flexibility Act

Pursuant to section 605(b) of the Regulatory Flexibility Act, 5 U.S.C. 605(b), the Administrator certifies that this rule will not have a significant economic impact on a substantial number of small entities. Today's final rule sets forth requirements which apply only to Federal agencies and the Administrator therefore certifies that no small entities will be affected.

Paperwork Reduction Act

The EPA has determined that this proposed rule contains no information collection requirements as defined by the Paperwork Reduction Act (44 U.S.C. 3501 *et seq*).

Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Pub. L. 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local and tribal governments and the private sector. Today's rule contains no Federal mandates (under the regulatory provisions of Title II of the UMRA) for State, local or tribal governments or the private sector. The rule implements requirements specifically set forth by the Congress in the Waste Isolation Pilot Plant Land Withdrawal Act (Pub. L. 102–579).

List of Subjects in 40 CFR Part 194

Administrative practice and procedure, Environmental protection, Incorporation by reference Nuclear materials, Radionuclides, Plutonium, Radiation protection, Uranium, Transuranics, Waste treatment and disposal.

Dated: February 1, 1996.

Carol M. Browner,

Administrator.

For the reasons set out in the preamble, 40 CFR part 194 is added as set forth below.

PART 194—CRITERIA FOR THE CERTIFICATION AND RE-CERTIFICATION OF THE WASTE ISOLATION PILOT PLANT'S COMPLIANCE WITH THE 40 CFR PART 191 DISPOSAL REGULATIONS

Subpart A—General Provisions

Sec.

194.1 Purpose, scope, and applicability.
194.2 Definitions.
194.3 Communications.
194.4 Conditions of compliance certification.
194.5 Publications incorporated by reference.

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSII 56

194.6 Alternative provisions.
194.7 Effective date.

Subpart B—Compliance Certification and Re-certification Applications

194.11 Completeness and accuracy of compliance applications.
194.12 Submission of compliance applications.
194.13 Submission of reference materials.
194.14 Content of compliance certification application.
194.15 Content of compliance re-certification application(s).

Subpart C—Compliance Certification and Re-certification General Requirements

General Requirements

194.21 Inspections.
194.22 Quality assurance.
194.23 Models and computer codes.
194.24 Waste characterization.
194.25 Future state assumptions.
194.26 Expert judgment.
194.27 Peer review.

Containment Requirements

194.31 Application of release limits.
194.32 Scope of performance assessments.
194.33 Consideration of drilling events in performance assessments.
194.34 Results of performance assessments.

Assurance Requirements

194.41 Active institutional controls.
194.42 Monitoring.
194.43 Passive institutional controls.
194.44 Engineered barriers.
194.45 Consideration of the presence of resources.
194.46 Removal of waste.

Individual and Ground-water Protection Requirements

194.51 Consideration of protected individual.
194.52 Consideration of exposure pathways.
194.53 Consideration of underground sources of drinking water.
194.54 Scope of compliance assessments.
194.55 Results of compliance assessments.

Subpart D—Public Participation

194.61 Advance notice of proposed rulemaking for certification.
194.62 Notice of proposed rulemaking for certification.
194.63 Final rule for certification.
194.64 Documentation of continued compliance.
194.65 Notice of proposed rulemaking for modification or revocation.
194.66 Final rule for modification or revocation.
194.67 Dockets.

Authority: The Waste Isolation Pilot Plant Land Withdrawal Act of 1992, Pub.L. 102–579, 106 Stat. 4777; Atomic Energy Act of 1954, as amended, 42 U.S.C. 2011–2296; Reorganization Plan No. 3 of 1970, 5 U.S.C. app.1; Nuclear Waste Policy Act of 1982, as amended, 42 U.S.C. 10101–10270.

Subpart A—General Provisions

§ 194.1 Purpose, scope and applicability.

This part specifies criteria for the certification or any re-certification, or subsequent actions relating to the terms or conditions of certification of the Department of Energy's Waste Isolation Pilot Plant's compliance with the disposal regulations found at part 191 of this chapter and pursuant to section 8(d)(1) and section 8(f), respectively, of the WIPP LWA. The compliance certification application submitted pursuant to section 8(d)(1) of the WIPP LWA and any compliance re-certification application submitted pursuant to section 8(f) of the WIPP LWA shall comply with the requirements of this part.

§ 194.2 Definitions.

Unless otherwise indicated in this part, all terms have the same meaning as in part 191 of this chapter.

Certification means any action taken by the Administrator pursuant to section 8(d)(1) of the WIPP LWA.

Compliance application(s) means the compliance certification application submitted to the Administrator pursuant to section 8(d)(1) of the WIPP LWA or any compliance re-certification applications submitted to the Administrator pursuant to section 8(f) of the WIPP LWA.

Compliance assessment(s) means the analysis conducted to determine compliance with § 191.15, and part 191, subpart C of this chapter.

Delaware Basin means those surface and subsurface features which lie inside the boundary formed to the north, east and west of the disposal system by the innermost edge of the Capitan Reef, and formed, to the south, by a straight line drawn from the southeastern point of the Davis Mountains to the most southwestern point of the Glass Mountains.

Deep drilling means those drilling events in the Delaware Basin that reach or exceed a depth of 2,150 feet below the surface relative to where such drilling occurred.

Department means the United States Department of Energy.

Disposal regulations means part 191, subparts B and C of this chapter.

Management systems review means the qualitative assessment of a data collection operation or organization(s) to establish whether the prevailing quality management structure, policies, practices, and procedures are adequate to ensure that the type and quality of data needed are obtained.

Modification means action(s) taken by the Administrator that alters the terms or conditions of certification pursuant to section 8(d)(1) of the WIPP LWA. Modification of any certification shall comply with this part and part 191 of this chapter.

Population of CCDFs means all possible complementary, cumulative distribution functions (CCDFs) that can be generated from all disposal system parameter values used in performance assessments.

Population of estimates means all possible estimates of radiation doses and radionuclide concentrations that can be generated from all disposal system parameter values used in compliance assessments.

Quality assurance means those planned and systematic actions necessary to provide adequate confidence that the disposal system will comply with the disposal regulations set forth in part 191 of this chapter. Quality assurance includes quality control, which comprises those actions related to the physical characteristics of a material, structure, component, or system that provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

Re-certification means any action taken by the Administrator pursuant to section 8(f) of the WIPP LWA.

Regulatory time frame means the time period beginning at disposal and ending 10,000 years after disposal.

Revocation means any action taken by the Administrator to terminate the certification pursuant to section 8(d)(1) of the WIPP LWA.

Secretary means the Secretary of Energy.

Shallow drilling means those drilling events in the Delaware Basin that do not reach a depth of 2,150 feet below the surface relative to where such drilling occurred.

Suspension means any action taken by the Administrator to withdraw, for a limited period of time, the certification pursuant to section 8(d)(1) of the WIPP LWA.

Waste means the radioactive waste, radioactive material and coincidental material subject to the requirements of part 191 of this chapter.

Waste characteristic means a property of the waste that has an impact on the containment of waste in the disposal system.

Waste component means an ingredient of the total inventory of the waste that influences a waste characteristic.

WIPP means the Waste Isolation Pilot Plant, as authorized pursuant to section 213 of the Department of Energy National Security and Military

Information Only

Applications of Nuclear Energy Authorization Act of 1980 (Pub.L. 96-164; 93 Stat. 1259, 1255).

WIPP LWA means the Waste Isolation Pilot Plant Land Withdrawal Act of 1992 (Pub.L. 102-579, 106 Stat. 4777).

§ 194.3 Communications.

(a) Compliance application(s) shall be:

(1) Addressed to the Administrator; and

(2) Signed by the Secretary.

(b) Communications and reports concerning the criteria in this part shall be:

(1) Addressed to the Administrator or the Administrator's authorized representative; and

(2) Signed by the Secretary or the Secretary's authorized representative.

§ 194.4 Conditions of compliance certification.

(a) Any certification of compliance issued pursuant to section 8(d)(1) of the WIPP LWA may include such conditions as the Administrator finds necessary to support such certification.

(b) Whether stated therein or not, the following conditions shall apply in any such certification:

(1) The certification shall be subject to modification, suspension or revocation by the Administrator. Any suspension of the certification shall be done at the discretion of the Administrator. Any modification or revocation of the certification shall be done by rule pursuant to 5 U.S.C. 553. If the Administrator revokes the certification, the Department shall retrieve, as soon as practicable and to the extent practicable, any waste emplaced in the disposal system.

(2) Any time after the Administrator issues a certification, the Administrator or the Administrator's authorized representative may submit a written request to the Department for information to enable the Administrator to determine whether the certification should be modified, suspended or revoked. Unless otherwise specified by the Administrator or the Administrator's authorized representative, the Department shall submit such information to the Administrator or the Administrator's authorized representative within 30 calendar days of receipt of the request.

(3) Any time after the Administrator issues a certification, the Department shall report any planned or unplanned changes in activities or conditions pertaining to the disposal system that differ significantly from the most recent compliance application.

(i) The Department shall inform the Administrator, in writing, prior to making such a planned change in activity or disposal system condition.

(ii) In the event of an unplanned change in activity or condition, the Department shall immediately cease emplacement of waste in the disposal system if the Department determines that one or more of the following conditions is true:

(A) The containment requirements established pursuant to § 191.13 of this chapter have been or are expected to be exceeded;

(B) Releases from already-emplaced waste lead to committed effective doses that are or are expected to be in excess of those established pursuant to § 191.15 of this chapter. For purposes of this paragraph (b)(3)(ii)(B), emissions from operations covered pursuant to part 191, subpart A of this chapter are not included; or

(C) Releases have caused or are expected to cause concentrations of radionuclides or estimated doses due to radionuclides in underground sources of drinking water in the accessible environment to exceed the limits established pursuant to part 191, subpart C of this chapter.

(iii) If the Department determines that a condition described in paragraph (b)(3)(ii) of this section has occurred or is expected to occur, the Department shall notify the Administrator, in writing, within 24 hours of the determination. Such notification shall, to the extent practicable, include the following information:

(A) Identification of the location and environmental media of the release or the expected release;

(B) Identification of the type and quantity of waste (in activity in curies of each radionuclide) released or expected to be released;

(C) Time and date of the release or the estimated time of the expected release;

(D) Assessment of the hazard posed by the release or the expected release; and

(E) Additional information requested by the Administrator or the Administrator's authorized representative.

(iv) The Department may resume emplacement of waste in the disposal system upon written notification that the suspension has been lifted by the Administrator.

(v) If the Department discovers a condition or activity that differs significantly from what is indicated in the most recent compliance application, but does not involve conditions or activities listed in paragraph (b)(3)(ii) of this section, then the difference shall be reported, in writing, to the Administrator within 10 calendar days of its discovery.

(vi) Following receipt of notification, the Administrator will notify the Secretary in writing whether any condition or activity reported pursuant to paragraph (b)(3) this section:

(A) Does not comply with the terms of the certification; and, if it does not comply,

(B) Whether the compliance certification must be modified, suspended or revoked. The Administrator or the Administrator's authorized representative may request additional information before determining whether modification, suspension or revocation of the compliance certification is required.

(4) Not later than six months after the Administrator issues a certification, and at least annually thereafter, the Department shall report to the Administrator, in writing, any changes in conditions or activities pertaining to the disposal system that were not required to be reported by paragraph (b)(3) of this section and that differ from information contained in the most recent compliance application.

§ 194.5 Publications incorporated by reference.

(a) The following publications are incorporated into this part by reference:

(1) U.S. Nuclear Regulatory Commission, NUREG-1297 "Peer Review for High-Level Nuclear Waste Repositories," published February 1988; incorporation by reference (IBR) approved for §§ 194.22, 194.23 and 194.27.

(2) American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA) Standard, NQA-1-1989 edition, "Quality Assurance Program Requirements for Nuclear Facilities;" IBR approved for § 194.22.

(3) ASME NQA-2a-1990 addenda, part 2.7, to ASME NQA-2-1989 edition "Quality Assurance Requirements for Nuclear Facility Applications;" IBR approved for § 194.22 and § 194.23.

(4) ASME NQA-3-1989 edition, "Quality Assurance Program Requirements for the Collection of Scientific and Technical Information for Site Characterization of High-Level Nuclear Waste Repositories" (excluding section 2.1 (b) and (c)); IBR approved for § 194.22.

(b) The publications listed in paragraph (a) of this section were approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies may be inspected or obtained from the Air Docket, Docket No. A-92-56, room M1500 (LE131),

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK:NS11 58

U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, or copies may be inspected at the Office of the Federal Register, 800 N. Capitol Street NW, 7th floor, Suite 700, Washington, DC, or copies may be obtained from the following addresses:

(1) For ASME standards, contact American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, phone 1-800-843-2763.

(2) For Nuclear Regulatory Commission documents, contact Division of Information Support Services, Distribution Service, U.S. Nuclear Regulatory Commission, Washington, DC 20555, or contact National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, phone 703-487-4650.

§ 194.6 Alternative provisions.

The Administrator may, by rule pursuant to 5 U.S.C. 553, substitute for any of the provisions of this part alternative provisions chosen after:

(a) The alternative provisions have been proposed for public comment in the Federal Register together with information describing how the alternative provisions comport with the disposal regulations, the reasons why the existing provisions of this part appear inappropriate, and the costs, risks and benefits of compliance in accordance with the alternative provisions;

(b) A public comment period of at least 120 days has been completed and public hearings have been held in New Mexico;

(c) The public comments received have been fully considered; and

(d) A notice of final rulemaking is published in the Federal Register.

§ 194.7 Effective date.

The criteria in this part shall be effective on April 9, 1996. The incorporation by reference of certain publications listed in the criteria is approved by the Director of the Federal Register as of April 9, 1996.

Subpart B—Compliance Certification and Re-certification Applications

§ 194.11 Completeness and accuracy of compliance applications.

Information provided to the Administrator in support of any compliance application shall be complete and accurate. The Administrator's evaluation for certification pursuant to section 8(d)(1)(B) of the WIPP LWA and evaluation for recertification pursuant to section 8(f)(2) of the WIPP LWA shall not begin until the Administrator has notified the Secretary, in writing, that a complete application in accordance with this part has been received.

§ 194.12 Submission of compliance applications.

Unless otherwise specified by the Administrator or the Administrator's authorized representative, 30 copies of any compliance application, any accompanying materials, and any amendments thereto shall be submitted in a printed form to the Administrator.

§ 194.13 Submission of reference materials.

Information may be included by reference into compliance application(s), provided that the references are clear and specific and that, unless otherwise specified by the Administrator or the Administrator's authorized representative, 10 copies of the referenced information are submitted to the Administrator. Referenced materials which are widely available in standard textbooks or reference books need not be submitted.

§ 194.14 Content of compliance certification application.

Any compliance application shall include:

(a) A current description of the natural and engineered features that may affect the performance of the disposal system. The description of the disposal system shall include, at a minimum, the following information:

(1) The location of the disposal system and the controlled area;

(2) A description of the geology, geophysics, hydrogeology, hydrology, and geochemistry of the disposal system and its vicinity and how these conditions are expected to change and interact over the regulatory time frame. Such description shall include, at a minimum:

(i) Existing fluids and fluid hydraulic potential, including brine pockets, in and near the disposal system; and

(ii) Existing higher permeability anhydrite interbeds located at or near the horizon of the waste.

(3) The presence and characteristics of potential pathways for transport of waste from the disposal system to the accessible environment including, but not limited to: Existing boreholes, solution features, breccia pipes, and other potentially permeable features, such as interbeds.

(4) The projected geophysical, hydrogeologic and geochemical conditions of the disposal system due to the presence of waste including, but not limited to, the effects of production of heat or gases from the waste.

(b) A description of the design of the disposal system including:

(1) Information on materials of construction including, but not limited to: Geologic media, structural materials, engineered barriers, general arrangement, and approximate dimensions; and

(2) Computer codes and standards that have been applied to the design and construction of the disposal system.

(c) Results of assessments conducted pursuant to this part.

(d) A description of input parameters associated with assessments conducted pursuant to this part and the basis for selecting those input parameters.

(e) Documentation of measures taken to meet the assurance requirements of this part.

(f) A description of waste acceptance criteria and actions taken to assure adherence to such criteria.

(g) A description of background radiation in air, soil and water in the vicinity of the disposal system and the procedures employed to determine such radiation.

(h) One or more topographic map(s) of the vicinity of the disposal system. The contour interval shall be sufficient to show clearly the pattern of surface water flow in the vicinity of the disposal system. The map(s) shall include standard map notations and symbols, and, in addition, shall show boundaries of the controlled area and the location of any active, inactive, and abandoned injection and withdrawal wells in the controlled area and in the vicinity of the disposal system.

(i) A description of past and current climatologic and meteorologic conditions in the vicinity of the disposal system and how these conditions are expected to change over the regulatory time frame.

(j) The information required elsewhere in this part or any additional information, analyses, tests, or records determined by the Administrator or the Administrator's authorized representative to be necessary for determining compliance with this part.

§ 194.15 Content of compliance re-certification application(s).

(a) In submitting documentation of continued compliance pursuant to section 8(f) of the WIPP LWA, the previous compliance application shall be updated to provide sufficient information for the Administrator to determine whether or not the WIPP continues to be in compliance with the disposal regulations. Updated documentation shall include:

(1) All additional geologic, geophysical, geochemical, hydrologic, and meteorologic information;

Information Only

(2) All additional monitoring data, analyses and results;

(3) All additional analyses and results of laboratory experiments conducted by the Department or its contractors as part of the WIPP program;

(4) An identification of any activities or assumptions that deviate from the most recent compliance application;

(5) A description of all waste emplaced in the disposal system since the most recent compliance certification or re-certification application. Such description shall consist of a description of the waste characteristics and waste components identified in §§ 194.24(b)(1) and 194.24(b)(2);

(6) Any significant information not previously included in a compliance certification or re-certification application related to whether the disposal system continues to be in compliance with the disposal regulations; and

(7) Any additional information requested by the Administrator or the Administrator's authorized representative.

(b) To the extent that information required for a re-certification of compliance remains valid and has been submitted in previous certification or re-certification application(s), such information need not be duplicated in subsequent applications; such information may be summarized and referenced.

Subpart C—Compliance Certification and Re-certification

General Requirements

§ 194.21 Inspections.

(a) The Administrator or the Administrator's authorized representative(s) shall, at any time:

(1) Be afforded unfettered and unannounced access to inspect any area of the WIPP, and any locations performing activities that provide information relevant to compliance application(s), to which the Department has rights of access. Such access shall be equivalent to access afforded Department employees upon presentation of credentials and other required documents.

(2) Be allowed to obtain samples, including split samples, and to monitor and measure aspects of the disposal system and the waste proposed for disposal in the disposal system.

(b) Records (including data and other information in any form) kept by the Department pertaining to the WIPP shall be made available to the Administrator or the Administrator's authorized representative upon request. If requested records are not immediately available, they shall be delivered within 30 calendar days of the request.

(c) The Department shall, upon request by the Administrator or the Administrator's authorized representative, provide permanent, private office space that is accessible to the disposal system. The office space shall be for the exclusive use of the Administrator or the Administrator's authorized representative(s).

(d) The Administrator or the Administrator's authorized representative(s) shall comply with applicable access control measures for security, radiological protection, and personal safety when conducting activities pursuant to this section.

§ 194.22 Quality assurance.

(a)(1) As soon as practicable after April 9, 1996, the Department shall adhere to a quality assurance program that implements the requirements of ASME NQA–1–1989 edition, ASME NQA–2a–1990 addenda, part 2.7, to ASME NQA–2–1989 edition, and ASME NQA–3–1989 edition (excluding Section 2.1 (b) and (c), and Section 17.1). (Incorporation by reference as specified in § 194.5.)

(2) Any compliance application shall include information which demonstrates that the quality assurance program required pursuant to paragraph (a)(1) of this section has been established and executed for:

(i) Waste characterization activities and assumptions;

(ii) Environmental monitoring, monitoring of the performance of the disposal system, and sampling and analysis activities;

(iii) Field measurements of geologic factors, ground water, meteorologic, and topographic characteristics;

(iv) Computations, computer codes, models and methods used to demonstrate compliance with the disposal regulations in accordance with the provisions of this part;

(v) Procedures for implementation of expert judgment elicitation used to support applications for certification or re-certification of compliance;

(vi) Design of the disposal system and actions taken to ensure compliance with design specifications;

(vii) The collection of data and information used to support compliance application(s); and

(viii) Other systems, structures, components, and activities important to the containment of waste in the disposal system.

(b) Any compliance application shall include information which demonstrates that data and information collected prior to the implementation of the quality assurance program required pursuant to paragraph (a)(1) of this section have been qualified in accordance with an alternate methodology, approved by the Administrator or the Administrator's authorized representative, that employs one or more of the following methods: Peer review, conducted in a manner that is compatible with NUREG–1297, "Peer Review for High-Level Nuclear Waste Repositories," published February 1988 (incorporation by reference as specified in § 194.5); corroborating data; confirmatory testing; or a quality assurance program that is equivalent in effect to ASME NQA–1–1989 edition, ASME NQA–2a–1990 addenda, part 2.7, to ASME NQA–2–1989 edition, and ASME NQA–3–1989 edition (excluding Section 2.1 (b) and (c) and Section 17.1). (Incorporation by reference as specified in § 194.5.)

(c) Any compliance application shall provide, to the extent practicable, information which describes how all data used to support the compliance application have been assessed for their quality characteristics, including:

(1) Data accuracy, i.e., the degree to which data agree with an accepted reference or true value;

(2) Data precision, i.e., a measure of the mutual agreement between comparable data gathered or developed under similar conditions expressed in terms of a standard deviation;

(3) Data representativeness, i.e., the degree to which data accurately and precisely represent a characteristic of a population, a parameter, variations at a sampling point, or environmental conditions;

(4) Data completeness, i.e., a measure of the amount of valid data obtained compared to the amount that was expected; and

(5) Data comparability, i.e., a measure of the confidence with which one data set can be compared to another.

(d) Any compliance application shall provide information which demonstrates how all data are qualified for use in the demonstration of compliance.

(e) The Administrator will verify appropriate execution of quality assurance programs through inspections, record reviews and record keeping requirements, which may include, but may not be limited to, surveillance, audits and management systems reviews.

§ 194.23 Models and computer codes.

(a) Any compliance application shall include:

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK: NSII 100

(1) A description of the conceptual models and scenario construction used to support any compliance application.

(2) A description of plausible, alternative conceptual model(s) seriously considered but not used to support such application, and an explanation of the reason(s) why such model(s) was not deemed to accurately portray performance of the disposal system.

(3) Documentation that:

(i) Conceptual models and scenarios reasonably represent possible future states of the disposal system;

(ii) Mathematical models incorporate equations and boundary conditions which reasonably represent the mathematical formulation of the conceptual models;

(iii) Numerical models provide numerical schemes which enable the mathematical models to obtain stable solutions;

(iv) Computer models accurately implement the numerical models; i.e., computer codes are free of coding errors and produce stable solutions;

(v) Conceptual models have undergone peer review according to § 194.27.

(b) Computer codes used to support any compliance application shall be documented in a manner that complies with the requirements of ASME NQA–2a–1990 addenda, part 2.7, to ASME NQA–2–1989 edition. (incorporation by reference as specified in § 194.5.)

(c) Documentation of all models and computer codes included as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but shall not be limited to:

(1) Descriptions of the theoretical backgrounds of each model and the method of analysis or assessment;

(2) General descriptions of the models; discussions of the limits of applicability of each model; detailed instructions for executing the computer codes, including hardware and software requirements, input and output formats with explanations of each input and output variable and parameter (e.g., parameter name and units); listings of input and output files from a sample computer run; and reports on code verification, benchmarking, validation, and quality assurance procedures;

(3) Detailed descriptions of the structure of computer codes and complete listings of the source codes;

(4) Detailed descriptions of data collection procedures, sources of data, data reduction and analysis, and code input parameter development;

(5) Any necessary licenses; and

(6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.

(d) The Administrator or the Administrator's authorized representative may verify the results of computer simulations used to support any compliance application by performing independent simulations. Data files, source codes, executable versions of computer software for each model, other material or information needed to permit the Administrator or the Administrator's authorized representative to perform independent simulations, and access to necessary hardware to perform such simulations, shall be provided within 30 calendar days of a request by the Administrator or the Administrator's authorized representative.

§ 194.24 Waste characterization.

(a) Any compliance application shall describe the chemical, radiological and physical composition of all existing waste proposed for disposal in the disposal system. To the extent practicable, any compliance application shall also describe the chemical, radiological and physical composition of to-be-generated waste proposed for disposal in the disposal system. These descriptions shall include a list of waste components and their approximate quantities in the waste. This list may be derived from process knowledge, current non-destructive examination/assay, or other information and methods.

(b) The Department shall submit in the compliance certification application the results of an analysis which substantiates:

(1) That all waste characteristics influencing containment of waste in the disposal system have been identified and assessed for their impact on disposal system performance. The characteristics to be analyzed shall include, but shall not be limited to: Solubility; formation of colloidal suspensions containing radionuclides; production of gas from the waste; shear strength; compactability; and other waste-related inputs into the computer models that are used in the performance assessment.

(2) That all waste components influencing the waste characteristics identified in paragraph (b)(1) of this section have been identified and assessed for their impact on disposal system performance. The components to be analyzed shall include, but shall not be limited to: metals; cellulosics; chelating agents; water and other liquids; and activity in curies of each isotope of the radionuclides present.

(3) Any decision to exclude consideration of any waste characteristic or waste component because such characteristic or component is not expected to significantly influence the containment of the waste in the disposal system.

(c) For each waste component identified and assessed pursuant to paragraph (b) of this section, the Department shall specify the limiting value (expressed as an upper or lower limit of mass, volume, curies, concentration, etc.), and the associated uncertainty (i.e., margin of error) for each limiting value, of the total inventory of such waste proposed for disposal in the disposal system. Any compliance application shall:

(1) Demonstrate that, for the total inventory of waste proposed for disposal in the disposal system, WIPP complies with the numeric requirements of § 194.34 and § 194.55 for the upper or lower limits (including the associated uncertainties), as appropriate, for each waste component identified in paragraph (b)(2) of this section, and for the plausible combinations of upper and lower limits of such waste components that would result in the greatest estimated release.

(2) Identify and describe the method(s) used to quantify the limits of waste components identified in paragraph (b)(2) of this section.

(3) Provide information which demonstrates that the use of process knowledge to quantify components in waste for disposal conforms with the quality assurance requirements found in § 194.22.

(4) Provide information which demonstrates that a system of controls has been and will continue to be implemented to confirm that the total amount of each waste component that will be emplaced in the disposal system will not exceed the upper limiting value or fall below the lower limiting value described in the introductory text of paragraph (c) of this section. The system of controls shall include, but shall not be limited to: Measurement; sampling; chain of custody records; record keeping systems; waste loading schemes used; and other documentation.

(5) Identify and describe such controls delineated in paragraph (c)(4) of this section and confirm that they are applied in accordance with the quality assurance requirements found in § 194.22.

(d) The Department shall include a waste loading scheme in any compliance application, or else performance assessments conducted

Information Only

pursuant to § 194.32 and compliance assessments conducted pursuant to § 194.54 shall assume random placement of waste in the disposal system.

(e) Waste may be emplaced in the disposal system only if the emplaced components of such waste will not cause:

(1) The total quantity of waste in the disposal system to exceed the upper limiting value, including the associated uncertainty, described in the introductory text to paragraph (c) of this section; or

(2) The total quantity of waste that will have been emplaced in the disposal system, prior to closure, to fall below the lower limiting value, including the associated uncertainty, described in the introductory text to paragraph (c) of this section.

(f) Waste emplacement shall conform to the assumed waste loading conditions, if any, used in performance assessments conducted pursuant to § 194.32 and compliance assessments conducted pursuant to § 194.54.

(g) The Department shall demonstrate in any compliance application that the total inventory of waste emplaced in the disposal system complies with the limitations on transuranic waste disposal described in the WIPP LWA.

(h) The Administrator will use inspections and records reviews, such as audits, to verify compliance with this section.

§ 194.25 Future state assumptions.

(a) Unless otherwise specified in this part or in the disposal regulations, performance assessments and compliance assessments conducted pursuant the provisions of this part to demonstrate compliance with § 191.13, § 191.15 and part 191, subpart C shall assume that characteristics of the future remain what they are at the time the compliance application is prepared, provided that such characteristics are not related to hydrogeologic, geologic or climatic conditions.

(b) In considering future states pursuant to this section, the Department shall document in any compliance application, to the extent practicable, effects of potential future hydrogeologic, geologic and climatic conditions on the disposal system over the regulatory time frame. Such documentation shall be part of the activities undertaken pursuant to § 194.14, Content of compliance certification application; § 194.32, Scope of performance assessments; and § 194.54, Scope of compliance assessments.

(1) In considering the effects of hydrogeologic conditions on the disposal system, the Department shall document in any compliance application, to the extent practicable, the effects of potential changes to hydrogeologic conditions.

(2) In considering the effects of geologic conditions on the disposal system, the Department shall document in any compliance application, to the extent practicable, the effects of potential changes to geologic conditions, including, but not limited to: Dissolution; near surface geomorphic features and processes; and related subsidence in the geologic units of the disposal system.

(3) In considering the effects of climatic conditions on the disposal system, the Department shall document in any compliance application, to the extent practicable, the effects of potential changes to future climate cycles of increased precipitation (as compared to present conditions).

§ 194.26 Expert judgment.

(a) Expert judgment, by an individual expert or panel of experts, may be used to support any compliance application, provided that expert judgment does not substitute for information that could reasonably be obtained through data collection or experimentation.

(b) Any compliance application shall:

(1) Identify any expert judgments used to support the application and shall identify experts (by name and employer) involved in any expert judgment elicitation processes used to support the application.

(2) Describe the process of eliciting expert judgment, and document the results of expert judgment elicitation processes and the reasoning behind those results. Documentation of interviews used to elicit judgments from experts, the questions or issues presented for elicitation of expert judgment, background information provided to experts, and deliberations and formal interactions among experts shall be provided. The opinions of all experts involved in each elicitation process shall be provided whether the opinions are used to support compliance applications or not.

(3) Provide documentation that the following restrictions and guidelines have been applied to any selection of individuals used to elicit expert judgments:

(i) Individuals who are members of the team of investigators requesting the judgment or the team of investigators who will use the judgment were not selected; and

(ii) Individuals who maintain, at any organizational level, a supervisory role or who are supervised by those who will utilize the judgment were not selected.

(4) Provide information which demonstrates that:

(i) The expertise of any individual involved in expert judgment elicitation comports with the level of knowledge required by the questions or issues presented to that individual; and

(ii) The expertise of any expert panel, as a whole, involved in expert judgment elicitation comports with the level and variety of knowledge required by the questions or issues presented to that panel.

(5) Explain the relationship among the information and issues presented to experts prior to the elicitation process, the elicited judgment of any expert panel or individual, and the purpose for which the expert judgment is being used in compliance applications(s).

(6) Provide documentation that the initial purpose for which expert judgment was intended, as presented to the expert panel, is consistent with the purpose for which this judgment was used in compliance application(s).

(7) Provide documentation that the following restrictions and guidelines have been applied in eliciting expert judgment:

(i) At least five individuals shall be used in any expert elicitation process, unless there is a lack or unavailability of experts and a documented rationale is provided that explains why fewer than five individuals were selected.

(ii) At least two-thirds of the experts involved in an elicitation shall consist of individuals who are not employed directly by the Department or by the Department's contractors, unless the Department can demonstrate and document that there is a lack or unavailability of qualified independent experts. If so demonstrated, at least one-third of the experts involved in an elicitation shall consist of individuals who are not employed directly by the Department or by the Department's contractors.

(c) The public shall be afforded a reasonable opportunity to present its scientific and technical views to expert panels as input to any expert elicitation process.

§ 194.27 Peer review.

(a) Any compliance application shall include documentation of peer review that has been conducted, in a manner required by this section, for:

(1) Conceptual models selected and developed by the Department;

(2) Waste characterization analyses as required in § 194.24(b); and

(3) Engineered barrier evaluation as required in § 194.44.

Information Only

(b) Peer review processes required in paragraph (a) of this section, and conducted subsequent to the promulgation of this part, shall be conducted in a manner that is compatible with NUREG–1297, "Peer Review for High-Level Nuclear Waste Repositories," published February 1988. (Incorporation by reference as specified in § 194.5.)

(c) Any compliance application shall:

(1) Include information that demonstrates that peer review processes required in paragraph (a) of this section, and conducted prior to the implementation of the promulgation of this part, were conducted in accordance with an alternate process substantially equivalent in effect to NUREG–1297 and approved by the Administrator or the Administrator's authorized representative; and

(2) Document any peer review processes conducted in addition to those required pursuant to paragraph (a) of this section. Such documentation shall include formal requests, from the Department to outside review groups or individuals, to review or comment on any information used to support compliance applications, and the responses from such groups or individuals.

Containment Requirements

§ 194.31 Application of release limits.

The release limits shall be calculated according to part 191, appendix A of this chapter, using the total activity, in curies, that will exist in the disposal system at the time of disposal.

§ 194.32 Scope of performance assessments.

(a) Performance assessments shall consider natural processes and events, mining, deep drilling, and shallow drilling that may affect the disposal system during the regulatory time frame.

(b) Assessments of mining effects may be limited to changes in the hydraulic conductivity of the hydrogeologic units of the disposal system from excavation mining for natural resources. Mining shall be assumed to occur with a one in 100 probability in each century of the regulatory time frame. Performance assessments shall assume that mineral deposits of those resources, similar in quality and type to those resources currently extracted from the Delaware Basin, will be completely removed from the controlled area during the century in which such mining is randomly calculated to occur. Complete removal of such mineral resources shall be assumed to occur only once during the regulatory time frame.

(c) Performance assessments shall include an analysis of the effects on the disposal system of any activities that occur in the vicinity of the disposal system prior to disposal and are expected to occur in the vicinity of the disposal system soon after disposal. Such activities shall include, but shall not be limited to, existing boreholes and the development of any existing leases that can be reasonably expected to be developed in the near future, including boreholes and leases that may be used for fluid injection activities.

(d) Performance assessments need not consider processes and events that have less than one chance in 10,000 of occurring over 10,000 years.

(e) Any compliance application(s) shall include information which:

(1) Identifies all potential processes, events or sequences and combinations of processes and events that may occur during the regulatory time frame and may affect the disposal system;

(2) Identifies the processes, events or sequences and combinations of processes and events included in performance assessments; and

(3) Documents why any processes, events or sequences and combinations of processes and events identified pursuant to paragraph (e)(1) of this section were not included in performance assessment results provided in any compliance application.

§ 194.33 Consideration of drilling events in performance assessments.

(a) Performance assessments shall examine deep drilling and shallow drilling that may potentially affect the disposal system during the regulatory time frame.

(b) The following assumptions and process shall be used in assessing the likelihood and consequences of drilling events, and the results of such process shall be documented in any compliance application:

(1) Inadvertent and intermittent intrusion by drilling for resources (other than those resources provided by the waste in the disposal system or engineered barriers designed to isolate such waste) is the most severe human intrusion scenario.

(2) In performance assessments, drilling events shall be assumed to occur in the Delaware Basin at random intervals in time and space during the regulatory time frame.

(3) The frequency of deep drilling shall be calculated in the following manner:

(i) Identify deep drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.

(ii) The total rate of deep drilling shall be the sum of the rates of deep drilling for each resource.

(4) The frequency of shallow drilling shall be calculated in the following manner:

(i) Identify shallow drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.

(ii) The total rate of shallow drilling shall be the sum of the rates of shallow drilling for each resource.

(iii) In considering the historical rate of all shallow drilling, the Department may, if justified, consider only the historical rate of shallow drilling for resources of similar type and quality to those in the controlled area.

(c) Performance assessments shall document that in analyzing the consequences of drilling events, the Department assumed that:

(1) Future drilling practices and technology will remain consistent with practices in the Delaware Basin at the time a compliance application is prepared. Such future drilling practices shall include, but shall not be limited to: The types and amounts of drilling fluids; borehole depths, diameters, and seals; and the fraction of such boreholes that are sealed by humans; and

(2) Natural processes will degrade or otherwise affect the capability of boreholes to transmit fluids over the regulatory time frame.

(d) With respect to future drilling events, performance assessments need not analyze the effects of techniques used for resource recovery subsequent to the drilling of the borehole.

§ 194.34 Results of performance assessments.

(a) The results of performance assessments shall be assembled into "complementary, cumulative distribution functions" (CCDFs) that represent the probability of exceeding various levels of cumulative release caused by all significant processes and events.

(b) Probability distributions for uncertain disposal system parameter values used in performance assessments shall be developed and documented in any compliance application.

(c) Computational techniques, which draw random samples from across the entire range of the probability distributions developed pursuant to paragraph (b) of this section, shall be used in generating CCDFs and shall be documented in any compliance application.

Information Only

(d) The number of CCDFs generated shall be large enough such that, at cumulative releases of 1 and 10, the maximum CCDF generated exceeds the 99th percentile of the population of CCDFs with at least a 0.95 probability. Values of cumulative release shall be calculated according to Note 6 of Table 1, Appendix A of Part 191 of this chapter.

(e) Any compliance application shall display the full range of CCDFs generated.

(f) Any compliance application shall provide information which demonstrates that there is at least a 95 percent level of statistical confidence that the mean of the population of CCDFs meets the containment requirements of § 191.13 of this chapter.

Assurance Requirements

§ 194.41 Active institutional controls.

(a) Any compliance application shall include detailed descriptions of proposed active institutional controls, the controls' location, and the period of time the controls are proposed to remain active. Assumptions pertaining to active institutional controls and their effectiveness in terms of preventing or reducing radionuclide releases shall be supported by such descriptions.

(b) Performance assessments shall not consider any contributions from active institutional controls for more than 100 years after disposal.

§ 194.42 Monitoring.

(a) The Department shall conduct an analysis of the effects of disposal system parameters on the containment of waste in the disposal system and shall include the results of such analysis in any compliance application. The results of the analysis shall be used in developing plans for pre-closure and post-closure monitoring required pursuant to paragraphs (c) and (d) of this section. The disposal system parameters analyzed shall include, at a minimum:

(1) Properties of backfilled material, including porosity, permeability, and degree of compaction and reconsolidation;

(2) Stresses and extent of deformation of the surrounding roof, walls, and floor of the waste disposal room;

(3) Initiation or displacement of major brittle deformation features in the roof or surrounding rock;

(4) Ground water flow and other effects of human intrusion in the vicinity of the disposal system;

(5) Brine quantity, flux, composition, and spatial distribution;

(6) Gas quantity and composition; and

(7) Temperature distribution.

(b) For all disposal system parameters analyzed pursuant to paragraph (a) of this section, any compliance application shall document and substantiate the decision not to monitor a particular disposal system parameter because that parameter is considered to be insignificant to the containment of waste in the disposal system or to the verification of predictions about the future performance of the disposal system.

(c) Pre-closure monitoring. To the extent practicable, pre-closure monitoring shall be conducted of significant disposal system parameter(s) as identified by the analysis conducted pursuant to paragraph (a) of this section. A disposal system parameter shall be considered significant if it affects the system's ability to contain waste or the ability to verify predictions about the future performance of the disposal system. Such monitoring shall begin as soon as practicable; however, in no case shall waste be emplaced in the disposal system prior to the implementation of pre-closure monitoring. Pre-closure monitoring shall end at the time at which the shafts of the disposal system are backfilled and sealed.

(d) Post-closure monitoring. The disposal system shall, to the extent practicable, be monitored as soon as practicable after the shafts of the disposal system are backfilled and sealed to detect substantial and detrimental deviations from expected performance and shall end when the Department can demonstrate to the satisfaction of the Administrator that there are no significant concerns to be addressed by further monitoring. Post-closure monitoring shall be complementary to monitoring required pursuant to applicable federal hazardous waste regulations at parts 264, 265, 268, and 270 of this chapter and shall be conducted with techniques that do not jeopardize the containment of waste in the disposal system.

(e) Any compliance application shall include detailed pre-closure and post-closure monitoring plans for monitoring the performance of the disposal system. At a minimum, such plans shall:

(1) Identify the parameters that will be monitored and how baseline values will be determined;

(2) Indicate how each parameter will be used to evaluate any deviations from the expected performance of the disposal system; and

(3) Discuss the length of time over which each parameter will be monitored to detect deviations from expected performance.

§ 194.43 Passive institutional controls.

(a) Any compliance application shall include detailed descriptions of the measures that will be employed to preserve knowledge about the location, design, and contents of the disposal system. Such measures shall include:

(1) Identification of the controlled area by markers that have been designed and will be fabricated and emplaced to be as permanent as practicable;

(2) Placement of records in the archives and land record systems of local, State, and Federal governments, and international archives, that would likely be consulted by individuals in search of unexploited resources. Such records shall identify:

(i) The location of the controlled area and the disposal system;

(ii) The design of the disposal system;

(iii) The nature and hazard of the waste;

(iv) Geologic, geochemical, hydrologic, and other site data pertinent to the containment of waste in the disposal system, or the location of such information; and

(v) The results of tests, experiments, and other analyses relating to backfill of excavated areas, shaft sealing, waste interaction with the disposal system, and other tests, experiments, or analyses pertinent to the containment of waste in the disposal system, or the location of such information.

(3) Other passive institutional controls practicable to indicate the dangers of the waste and its location.

(b) Any compliance application shall include the period of time passive institutional controls are expected to endure and be understood.

(c) The Administrator may allow the Department to assume passive institutional control credit, in the form of reduced likelihood of human intrusion, if the Department demonstrates in the compliance application that such credit is justified because the passive institutional controls are expected to endure and be understood by potential intruders for the time period approved by the Administrator. Such credit, or a smaller credit as determined by the Administrator, cannot be used for more than several hundred years and may decrease over time. In no case, however, shall passive institutional controls be assumed to eliminate the likelihood of human intrusion entirely.

§ 194.44 Engineered barriers.

(a) Disposal systems shall incorporate engineered barrier(s) designed to prevent or substantially delay the movement of water or radionuclides toward the accessible environment.

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK:NS11 64

(b) In selecting any engineered barrier(s) for the disposal system, the Department shall evaluate the benefit and detriment of engineered barrier alternatives, including but not limited to: Cementation, shredding, supercompaction, incineration, vitrification, improved waste canisters, grout and bentonite backfill, melting of metals, alternative configurations of waste placements in the disposal system, and alternative disposal system dimensions. The results of this evaluation shall be included in any compliance application and shall be used to justify the selection and rejection of each engineered barrier evaluated.

(c)(1) In conducting the evaluation of engineered barrier alternatives, the following shall be considered, to the extent practicable:

(i) The ability of the engineered barrier to prevent or substantially delay the movement of water or waste toward the accessible environment;

(ii) The impact on worker exposure to radiation both during and after incorporation of engineered barriers;

(iii) The increased ease or difficulty of removing the waste from the disposal system;

(iv) The increased or reduced risk of transporting the waste to the disposal system;

(v) The increased or reduced uncertainty in compliance assessment;

(vi) Public comments requesting specific engineered barriers;

(vii) The increased or reduced total system costs;

(viii) The impact, if any, on other waste disposal programs from the incorporation of engineered barriers (e.g., the extent to which the incorporation of engineered barriers affects the volume of waste);

(ix) The effects on mitigating the consequences of human intrusion.

(2) If, after consideration of one or more of the factors in paragraph (c)(1) of this section, the Department concludes that an engineered barrier considered within the scope of the evaluation should be rejected without evaluating the remaining factors in paragraph (c)(1) of this section, then any compliance application shall provide a justification for this rejection explaining why the evaluation of the remaining factors would not alter the conclusion.

(d) In considering the ability of engineered barriers to prevent or substantially delay the movement of water or radionuclides toward the accessible environment, the benefit and detriment of engineered barriers for existing waste already packaged, existing waste not yet packaged, existing waste in need of re-packaging, and to-be-generated waste shall be considered separately and described.

(e) The evaluation described in paragraphs (b), (c) and (d) of this section shall consider engineered barriers alone and in combination.

§ 194.45 Consideration of the presence of resources.

Any compliance application shall include information that demonstrates that the favorable characteristics of the disposal system compensate for the presence of resources in the vicinity of the disposal system and the likelihood of the disposal system being disturbed as a result of the presence of those resources. If performance assessments predict that the disposal system meets the containment requirements of § 191.13 of this chapter, then the Agency will assume that the requirements of this section and § 191.14(e) of this chapter have been fulfilled.

§ 194.46 Removal of waste.

Any compliance application shall include documentation which demonstrates that removal of waste from the disposal system is feasible for a reasonable period of time after disposal. Such documentation shall include an analysis of the technological feasibility of mining the sealed disposal system, given technology levels at the time a compliance application is prepared.

Individual and Ground-water Protection Requirements

§ 194.51 Consideration of protected individual.

Compliance assessments that analyze compliance with § 191.15 of this chapter shall assume that an individual resides at the single geographic point on the surface of the accessible environment where that individual would be expected to receive the highest dose from radionuclide releases from the disposal system.

§ 194.52 Consideration of exposure pathways.

In compliance assessments that analyze compliance with § 191.15 of this chapter, all potential exposure pathways from the disposal system to individuals shall be considered. Compliance assessments with part 191, subpart C and § 191.15 of this chapter shall assume that individuals consume 2 liters per day of drinking water from any underground source of drinking water in the accessible environment.

§ 194.53 Consideration of underground sources of drinking water.

In compliance assessments that analyze compliance with part 191, subpart C of this chapter, all underground sources of drinking water in the accessible environment that are expected to be affected by the disposal system over the regulatory time frame shall be considered. In determining whether underground sources of drinking water are expected to be affected by the disposal system, underground interconnections among bodies of surface water, ground water, and underground sources of drinking water shall be considered.

§ 194.54 Scope of compliance assessments.

(a) Any compliance application shall contain compliance assessments required pursuant to this part. Compliance assessments shall include information which:

(1) Identifies potential processes, events, or sequences of processes and events that may occur over the regulatory time frame;

(2) Identifies the processes, events, or sequences of processes and events included in compliance assessment results provided in any compliance application; and

(3) Documents why any processes, events, or sequences of processes and events identified pursuant to paragraph (a)(1) of this section were not included in compliance assessment results provided in any compliance application.

(b) Compliance assessments of undisturbed performance shall include the effects on the disposal system of:

(1) Existing boreholes in the vicinity of the disposal system, with attention to the pathways they provide for migration of radionuclides from the site; and

(2) Any activities that occur in the vicinity of the disposal system prior to or soon after disposal. Such activities shall include, but shall not be limited to: Existing boreholes and the development of any existing leases that can be reasonably expected to be developed in the near future, including boreholes and leases that may be used for fluid injection activities.

§ 194.55 Results of compliance assessments.

(a) Compliance assessments shall consider and document uncertainty in the performance of the disposal system.

(b) Probability distributions for uncertain disposal system parameter values used in compliance assessments shall be developed and documented in any compliance application.

Information Only

(c) Computational techniques which draw random samples from across the entire range of values of each probability distribution developed pursuant to paragraph (b) of this section shall be used to generate a range of:

(1) Estimated committed effective doses received from all pathways pursuant to § 194.51 and § 194.52;

(2) Estimated radionuclide concentrations in USDWs pursuant to § 194.53; and

(3) Estimated dose equivalent received from USDWs pursuant to § 194.52 and § 194.53.

(d) The number of estimates generated pursuant to paragraph (c) of this section shall be large enough such that the maximum estimates of doses and concentrations generated exceed the 99th percentile of the population of estimates with at least a 0.95 probability.

(e) Any compliance application shall display:

(1) The full range of estimated radiation doses; and

(2) The full range of estimated radionuclide concentrations.

(f) Any compliance application shall document that there is at least a 95 percent level of statistical confidence that the mean and the median of the range of estimated radiation doses and the range of estimated radionuclide concentrations meet the requirements of § 191.15 and part 191, subpart C of this chapter, respectively.

Subpart D—Public Participation

§ 194.61 Advance notice of proposed rulemaking for certification.

(a) Upon receipt of a compliance application submitted pursuant to section 8(d)(1) of the WIPP LWA and § 194.11, the Agency will publish in the Federal Register an Advance Notice of Proposed Rulemaking announcing that a compliance application has been received, soliciting comment on such application, and announcing the Agency's intent to conduct a rulemaking to certify whether the WIPP facility will comply with the disposal regulations.

(b) A copy of the compliance application will be made available for inspection in Agency dockets established pursuant to § 194.67.

(c) The notice will provide a public comment period of 120 days.

(d) A public hearing concerning the notice will be held if a written request is received by the Administrator or the Administrator's authorized representative within 30 calendar days of the date of publication pursuant to paragraph (a) of this section.

(e) Any comments received on the notice will be made available for inspection in the dockets established pursuant to § 194.67.

(f) Any comments received on the notice will be provided to the Department and the Department may submit to the Agency written responses to the comments.

§ 194.62 Notice of proposed rulemaking for certification.

(a) The Administrator will publish a Notice of Proposed Rulemaking in the Federal Register announcing the Administrator's proposed decision, pursuant to section 8(d)(1) of the WIPP LWA, whether to issue a certification that the WIPP facility will comply with the disposal regulations and soliciting comment on the proposal.

(b) The notice will provide a public comment period of at least 120 days.

(c) The notice will announce public hearings in New Mexico.

(d) Any comments received on the notice will be made available for inspection in the dockets established pursuant to § 194.67.

§ 194.63 Final rule for certification.

(a) The Administrator will publish a Final Rule in the Federal Register announcing the Administrator's decision, pursuant to section 8(d)(1) of the WIPP LWA, whether to issue a certification that the WIPP facility will comply with the disposal regulations.

(b) A document summarizing significant comments and issues arising from comments received on the Notice of Proposed Rulemaking, as well as the Administrator's response to such significant comments and issues, will be prepared and will be made available for inspection in the dockets established pursuant to § 194.67.

§ 194.64 Documentation of continued compliance.

(a) Upon receipt of documentation of continued compliance with the disposal regulations pursuant to section 8(f) of the WIPP LWA and § 194.11, the Administrator will publish a notice in the Federal Register announcing that such documentation has been received, soliciting comment on such documentation, and announcing the Administrator's intent to determine whether or not the WIPP facility continues to be in compliance with the disposal regulations.

(b) Copies of documentation of continued compliance received by the Administrator will be made available for inspection in the dockets established pursuant to § 194.67.

(c) The notice will provide a public comment period of at least 30 days after publication pursuant to paragraph (a) of this section.

(d) Any comments received on such notice will be made available for public inspection in the dockets established pursuant to § 194.67.

(e) Upon completion of review of the documentation of continued compliance with the disposal regulations, the Administrator will publish a notice in the Federal Register announcing the Administrator's decision whether or not to re-certify the WIPP facility.

§ 194.65 Notice of proposed rulemaking for modification or revocation.

(a) If the Administrator determines that any changes in activities or conditions pertaining to the disposal system depart significantly from the most recent compliance application, the Agency will publish a Notice of Proposed Rulemaking in the Federal Register announcing the Administrator's proposed decision on modification or revocation, and soliciting comment on the proposal.

(b) Any comments received on the notice will be made available for inspection in the dockets established pursuant to § 194.67.

§ 194.66 Final rule for modification or revocation.

(a) The Administrator will publish a Final Rule in the Federal Register announcing the Administrator's decision on modification or revocation.

(b) A document summarizing significant comments and issues arising from comments received on the Notice of Proposed Rulemaking as well as the Administrator's response to such significant comments and issues will be prepared and will be made available for inspection in the dockets established pursuant to § 194.67.

§ 194.67 Dockets.

The Agency will establish and maintain dockets in the State of New Mexico and Washington, DC. The dockets will consist of all relevant, significant information received from outside parties and all significant information considered by the Administrator in certifying whether the WIPP facility will comply with the disposal regulations, in certifying whether or not the WIPP facility continues to be in compliance with the disposal regulations, and in determining whether compliance certification should be modified, suspended or revoked.

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SWCF-A 1.2.07.3: PA: QA: TSK: NS11 66

Appendix NS11.2

Reproduced from WID memo:
Future Mining Events in the Performance Assessment

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Westinghouse
Electric Corporation

Government and Environmental
Services Company

WS:96:03105
DA:96:11017

Waste Isolation Division

Box 2078
Carlsbad New Mexico 88221

April 3, 1996

Mr. Mel Marietta, Manager
WIPP Project Compliance Department
Sandia National Laboratories
115 N. Main Street
Carlsbad, NM 88220

Subject: FUTURE MINING EVENTS IN THE PERFORMANCE ASSESSMENT

Dear Mr. Marietta:

Per our discussion, this submittal updates our earlier package provided to you on February 29, 1996 (DA:96:11004, attached). The revised information includes changes made to incorporate comments received from Mr. Kurt Larson of your staff.

The map in Figure 5 of the attachment has been revised with additional information by including areas where potash has already been mined and areas currently considered barren of potash by the Bureau of Land Management.

Our earlier recommendation to use Figure 8 to incorporate the effects of mining in WIPP Performance Assessment remains the same.

Should you have any further questions, please contact me at (505) 234-8380, or Mr. R. F. Kehrman at (505) 234-8690.

Sincerely,

B. A. Howard, Manager
Long-Term Regulatory Compliance

hmp

Attachments

cc: without map

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Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSII 68

EXTENT OF MINING POSITION PAPER
Revision 1

1.0 INTRODUCTION

In 40 CFR Part 194, the Environmental Protection Agency's recently published standard for the certification of WIPP's compliance to 40 CFR Part 191, they (the EPA) have specified that the DOE must consider the impact of mining in the analysis of the long-term performance of the disposal system. The specific requirement being imposed by the EPA is stated in 40 CFR Part 194[1], section 32(a), (b), and (c) as follows:

> (a) *Performance assessments shall consider natural processes and events, mining, deep drilling, and shallow drilling that may affect the disposal system during the regulatory time frame.*
>
> (b) *Assessments of mining effects may be limited to changes in the hydraulic conductivity of the hydrogeologic units of the disposal system from excavation mining for natural resources. Mining shall be assumed to occur with a one in 100 probability in each century of the regulatory time frame. Performance assessments shall assume that mineral deposits of those resources, similar in quality and type to those resources currently extracted from the Delaware Basin, will be completely removed from the controlled area during the century in which such mining is randomly calculated to occur. Complete removal of such mineral resources shall be assumed to occur only once during the regulatory time frame.*
>
> (c) *Performance assessments shall include an analysis of the effects on the disposal system of any activities that occur in the vicinity of the disposal system prior to disposal and are expected to occur in the vicinity of the disposal system soon after disposal. Such activities shall include, but shall not be limited to, existing boreholes and the development of any existing leases that can be reasonably expected to be developed in the near future, including boreholes and leases that may be used for fluid injection activities.*

The phrase *"Performance assessments shall assume that mineral deposits of those resources, similar in quality and type to those resources currently extracted from the Delaware Basin, will be completely removed from the controlled area"* in section (b) and the phrase " *any activities that occur in the vicinity of the disposal system prior to disposal and are expected to occur in the vicinity of the disposal system soon after disposal"* in section (c) require a definition of an area within the controlled area (b) and outside the controlled area (c) for the purposes of analysis. Defining the requisite areas to satisfy these requirements is the subject of this paper.

The EPA provides extensive discussion of how the impacts of mining are to be considered in the supplemental information provided with the new standard. However, the EPA only gives limited guidance on how to determine the extent of mining that must be considered. This is an important factor, because the extent of mining determines whether or not the effect of subsidence will directly affect the performance of the disposal system. In the Supplemental Information provided with the rule, the EPA states: *"Some natural resources in the vicinity of the WIPP can be extracted by mining. These natural resources lie within the geologic formations found at shallower depths than the tunnels and shafts of the repository and do not lie vertically above the repository. Were mining of these resources to occur, this could alter the hydrologic properties of overlying formations ..."* Following this statement, the Agency proceeds to provide a methodology to bound such considerations based on their analysis of the effects of subsidence. Subsequently, the EPA states that *"The final rule specifies those assumptions and methods that shall be used in performance assessments to account for the effects of mining."* As a basis for the assumptions that are specified in the rule, the EPA points out their intent that *"the historical record of the*

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[1]U. S. Environmental Protection Agency, 1996, "Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's compliance With the 40 CFR Part 191 Disposal Regulations; Final Rule", *Federal Register*, Vol. 61, No. 28, pp 5224, February 9, 1996.

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSII 69

past 100 years' mining activity in the Delaware Basin provides a reasonable basis for predicting the nature of future mining activity." The EPA applied the historical record in two ways. First, it used the record to determine a frequency for mining as specified in the rule, and second, it used the record to address the physical characteristics of the mining activity. Only this second aspect is of concern in this paper.

With regard to the physical characteristics of the mining activity, the agency imposes assumptions and limitations that assure consistency with the future states requirements elsewhere in 40 CFR Part 194. Specifically, in the supplemental information, the agency states that *"the size and shape of the mine"* should conform with *"existing mineral deposits that are similar in type and quality to those extracted in the Delaware Basin."* The EPA provides the following rationale for this requirement: *"The Agency basis for this requirement was their consideration of the physical nature of mining activities that are currently underway in the Delaware Basin. First, the Agency assumed that the size and shape of a mine will be dictated by the size and shape of the mineral deposits that are to be extracted with no two mines being alike. The mineral deposits that will be mined in the future may consist of minerals of current economic interest, or of materials not useful or valuable in present-day terms. Without knowledge of what these future resources might be, any attempt to predict the size and shape of the associated mineral deposits would be speculative, as would any attempt to determine the size and shape of the mines used to extract them. The Agency further recognized that individual mines are of highly irregular shape and there is every reason to believe that deposits of minerals that are mined in the future will also vary in size and be highly irregular in shape. The Agency believes that no logical mathematical scheme exists that could be used to predict the potentially wide variety of sizes and highly irregular shapes. In light of the speculativeness and mathematical difficulty, the Agency has chosen to use existing mineral deposits as "stand-ins" to be used to determine the size and shape of the unknown mineral deposits that might be mined in the future. Thus, the final rule requires performance assessments to assume that all the presently known mineral resources lying within the controlled area will be extracted at the single point in time determined by the method in the final rule, discussed above."* In other words, because implementing this requirement can lead to a great deal of speculation which the EPA seeks to prevent, the DOE should use the existing minerals as the basis for demonstrating compliance with this requirement. The only minerals of interest are the potash minerals that occur in the McNutt Potash Member of the Salado.

The discussion in the Supplemental Information clearly equates "presently known mineral resources lying within the controlled area" to "existing mineral deposits lying within the controlled area that are of similar quality and typw to those minerals currently extracted" (see the last two paragraphs on 61 FR 5229). The entire controlled area is overlain by potash mineralization. Both the thickness and purity vary spatially. The EPA recognized that the current practice within the potash mining area is to recover those resources that can be extracted economically. The challenge for the DOE is to assign a boundary to the extent of mining that is consistent with the certification criterion, thus accomplishing the EPA's goals.

In order to assign a suitable boundary, the DOE can turn to further text in the supplemental information. In the section titled "Changes to the proposed rule," EPA clarifies that they intend for the DOE to use current practices as the standard for this analysis. Specifically, the EPA states: *"Additionally, the requirements of the final rule specify the method for determining the size and shape, location and point in time at which mining occurs. The Agency specified these items to provide clarification on how mining should be considered and to avoid unbounded speculation that would result from the high uncertainty regarding whether, where and how mining would occur in the Land Withdrawal area. EPA's decision was based on a desire to include mining in performance assessment in a realistic fashion without recourse to such unconstrained speculation. To this end, the final rule has specified that mining will continue at the same rate as it has over the past 100 years, that the area to be mined is the area that contains mineral deposits of similar type and quality to those that are currently extracted in the Delaware Basin, and that only the major impacts on the disposal system of mining need be considered. EPA believes this is consistent with the future states assumptions of section 25 as they apply to the future*

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK: NS11 70

activities of man."

This clarification certainly indicates that the EPA did not intend that "all" potash be considered. Instead, only those considered to be resources consistent with current usage of the term. Applying the EPA's guidance raises the question "whose estimate of resources should be used?" As stated above, the EPA's intent of their requirement is to use current conditions to provide estimates for future conditions. The current knowledge regarding resources consists of two parts: 1) the overall resource and 2) that portion that is economically developable today. The first part is reflected in maps and analyses published by several agencies such as the Bureau of Land Management (BLM), the U.S. Bureau of Mines (USBM), the U.S. Geological Survey (USGS), and the New Mexico Bureau of Mines and Mineral Resources (NMBMMR). Determining the second part is somewhat more difficult to determine since it changes periodically as the economics of potash changes. Mining companies file mine development maps and plans with regulatory agencies as a means of indicating their plans for development of potash. These maps and plans are proprietary and are not available to the public. As a substitute for actual mining plans, the current lease map can be used as an indication of what the potash industry as a whole considers to be ore that can be extracted. Identifying leased areas outside the controlled area is relatively straightforward. However, since there are no leases within the WIPP site boundary, it is necessary to look at both the published analyses and estimates, the potash development history and the areas that were considered at one time to be viable potash properties because they were previously leased for production.

2.0 BACKGROUND

The development of potash in southeastern New Mexico dates back to 1926, with the first commercial shipment occurring in 1931. At one time, eleven different companies were exploring for potash in the region. A large portion of the potash minerals lie within properties owned by the Federal Government and administered by the BLM. The BLM administers these resources under the federal Mineral and Leasing Act of 1920 and the Federal Land Policy and Management Act. Management policy is codified as 43 CFR Part 3000. Part of the BLM's responsibility is resolving disputes between the oil and gas industry and the potash industry over priority use of leases. These disputes develop because, according to Olsen, 1993[2], "... exploiting petroleum and potash at the same location would create unacceptable safety risks for underground mining and would create petroleum production difficulties." Conflicts began before 1939 when the first federal order designating the potash area banned oil and gas leasing. Much of the conflict was resolved in 1987 when the oil and gas and potash industries signed the "Statement of Agreement between the Potash and Oil and Gas Industries on concurrent Operations in the Potash Area". The state of New Mexico incorporated the principles of the agreement into their order R-111-P. The BLM has proposed rule changes to incorporate R-111-P into the federal system, however, the change is still pending. Typically, the BLM resolves any resource development issues in favor of potash.

One key to understanding the BLM's decision process is the concept of the Potash Enclave. The enclave is an area within the boundaries established by the Secretary of Interior Order which defines the area available for potash leasing. To qualify for enclave status, lands must contain ore that meets minimal leasing criterion based on boreholes that are up to 1.5 miles apart. (The 1993 enclave map[3] will be superimposed on the lease map in Figure 1 when the digitization of the enclave map is completed.) The long-standing policy of the BLM (since 1975) is to deny requests to drill oil and gas wells from surface locations within the enclave. However, the current policy uses the concept of drilling islands within the enclave for oil and gas resources that may not be available from outside the enclave. Drilling islands are

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[2]Olsen, James A., 1993, "Federal Management of the Potash Area in Southeastern New Mexico", in *Carlsbad Region, New Mexico and West Texas*, by D. W. Love et al., New Mexico Geological Society 44th Annual Field Conference, October 6-9, 1993.

[3]U. S. Bureau of Land Management, 1993, "Preliminary Map Showing Distributions of Potash Resources, Carlsbad Mining District, Eddy & Lea Counties, New Mexico", U.S. Bureau of Land Management, Roswell, NM.

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSH 71

permitted within the enclave when certain conditions are met as defined in the BLM's regulations[4]. Currently, the BLM enforces either a 0.25 mile barrier for oil wells and a 0.5 mile barrier for gas wells in the vicinity of existing operating mines or a barrier that is equal to 110 percent of the depth to the mine.

The BLM maintains estimates of potash resources and reserves based on information provided by the U.S. Geological Survey, the DOE, and operating companies. The operating company data are generally held by the BLM as proprietary and are not available to the public. In addition, operators are required to file mine development plans with the BLM. These, too, are proprietary and are not available for inspection.

Estimates of the active life of mining in the area have been prepared at various times. The most recent are shown below and were collected by the EPA for the Background Information Document supporting the 40 CFR Part 194 Final Rulemaking[5]. The EPA's information reflects mining both within the Delaware Basin and outside the Delaware Basin. In the following table, the resources of Eddy Potash and Horizon Potash lie outside the Delaware Basin; those of New Mexico Potash, IMC, and Mississippi Chemical lie both outside and within the Delaware Basin; and those of Western-Ag lie within the Delaware Basin.

Active Potash Mines in New Mexico Showing Estimated Capacity, Average Ore Grade, and Mine Life at the Average 1992 Price of $81.14/st product

Operator	County	Product Capacity (st/yr[1])	Ore Grade (% K_2O)	Mine Life (yrs)
Eddy Potash Inc.[2]	Eddy	550,000	18	4
Horizon Potash Co.	Eddy	450,000	12	6
IMC Fertilizer, Inc.	Eddy	1,000,000[3]	11[3]	33
Mississippi Chemical	Eddy	300,000	15	125
New Mexico Potash[2]	Eddy	450,000	14	25
Western Ag-Minerals[4]	Eddy	400,000	8[5]	30

Data from J.P. Searls, U.S. Bureau of Mines, oral communication, 1993.
[1] May not be operating at full capacity.
[2] Owned by Trans-Resource, Inc.
[3] Muriate, langbeinite, and sulfate combined.
[4] Owned by Rayrock Resources of Canada.
[5] Langbeinite only.

Certain public information is available and has been consulted for this paper. This includes property title abstracts for the sections of land within the controlled area (which is the area inside the WIPP site boundary), BLM lease maps, BLM reserve maps, and a mineral evaluation report prepared by the NMBMMR at the request of the DOE. In addition, a map of current oil well drilling within the enclave was used.

2.1 Background on leased areas outside the WIPP controlled area

The current lease holdings within the potash area[6] are shown in Figure 1. Typically, potash leases are obtained as the result of exploration and as the reward for discovery. While numerous interest have historically owned potash leases in the area, these have been consolidated through acquisition into the

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[4]U.S. Department of Interior Secretarial Order dated October 28, 1986 designating the Oil-Potash Area, 51 FR 39425.

[5]U.S. Environmental Protection Agency, 1996, Background Information Document, 40 CFR Part 194, Chapter 9, Table 9-2.

[6]U. S. Bureau of Land Management, 1995, "Preliminary Lease Map of the Carlsbad Mining District, Eddy and Lea Counties, New Mexico".

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NS11 72

eight holding companies shown in Figure 1. Five of these companies are currently mining in the area. One of the holding companies is an oil company.

Under current federal regulations, all mine operators are required to file a life of mine reserves (LMR) document with the BLM. This document, which is held as proprietary by the BLM, defines the proposed extent of mining that a company plans. The LMR is used by the BLM in resolving leasing conflicts between oil and gas interests and potash interests. Figure 2 illustrates the distribution of oil and gas wells within the Delaware Basin in the vicinity of the WIPP[7]. For the most part, the wells within the potash area are in locations determined to be barren by the Bureau of Land Management and, consequently, not likely to conflict with potash development.

Another area of interest is the leased area directly north of the WIPP site. This area is shown as being leased to both a potash company and an oil company. Priority for use of this area is currently under litigation. It is likely that as long as the oil interest holds the lease, no mining will occur.

2.2 Background on potash within the WIPP controlled area

There are no active potash leases within the controlled area. A historical leasing chronology of this area is provided in Table 1. Those leases in Sections 15, 17, and 18 were allowed to expire by their holders. The others (Sections 16, 22, 27, 32, and 34) were acquired by the DOE in 1988 and in 1990. Based on information recorded in title abstracts, prospecting occurred on all sections within the controlled area as evidenced by the information in Table 1.

In 1995, the DOE requested that the NMBMMR[8] re-evaluate the natural resource information available for the controlled area and the area within one mile of the controlled area. This report focused on oil and gas and potash resources and used existing data to update resource estimates used in the 1980 WIPP Environmental Impact Statement. Figures 3 and 4 are the potash reserve estimates for this area. The heavy line marks the ore grade-thickness product that is considered to be economic by local potash companies. The dashed line depicts the ore grade-thickness product that is generally considered by the BLM to be lease grade and thereby qualify a property for inclusion in the potash enclave. These are referred to as "Lease Grade Reserves" and are defined in the 1986 Secretarial Order as criterion for inclusion in the enclave. The following table summarizes these values based on the NMBMMR assessment.

Reserve Type	Langbeinite (Figure 3)		Sylvite (Figure 4)	
BLM Lease Grade	16 contour	4% K_2O at 4'	40 contour	10% K_2O at 4'
Economic-mining	37.5 contour		55 contour	

The assumptions that were used in the NMBMMR assessment are valid for today's potash economy and the projections made in that report. One assumption is that the potash within the immediate vicinity of the controlled area could (and would) be mined by extending existing facilities. If, sometime in the future, after the cessation of active controls, the ore within the controlled area were mined, such an activity would require a new infrastructure which would drastically alter the economics of mining.

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[7]Westinghouse Electric Corporation, 1996, Preliminary Map of Oil Wells in the Delaware Basin, Based on Data Collected by Petroleum Information Service Through June, 1995", Westinghouse Electric Corporation, Carlsbad, NM.

[8]NMBMMR, 1995, "Economic Mineral Resources at the Waste Isolation Pilot Plant (WIPP) Site", New Mexico bureau of Mines and Mineral Resources, Socorro, NM, March 31, 1995.

Information Only

SWCF-A 1.2.07.3:PA:QA:TSK:NS11 73

3.0 DISCUSSION

Based on the information in the standard and the supplemental information, and on discussions with the EPA regarding their intent for the analysis of mining, the following criteria can be established for describing the anticipated areal extent for mining.

Criterion 1: **Quantifiable evidence of resources upon which to base future estimates:** The standard requires the resources currently being extracted from the Delaware basin be "stand-ins" for characterizing future resources that may be subject to mining.

Criterion 2: **Quantifiable experience in extraction:** The standard assumes that mining in the future will be the same as it is today.

Criterion 3: **Quantifiable limit on quality:** EPA only requires consideration of resources that are of similar quality to those being mined today. "Quality" in this context refers to ore of sufficient grade and thickness to make mining economical.

In addition, several assumptions and givens are needed to formulate an extent of future mining.

Assumption 1: Mining within the controlled area is independent (from a feasibility viewpoint) of mining outside the controlled area. It is likely that all economically extractable potash outside the controlled area will be removed by the end of the active control period. This situation is assumed not to affect the chance of mining within the controlled area.[9]

Assumption 2: Mining inside the controlled area will not occur within the first 100 years after decommissioning. Since this is the active control period, mining will be deterred.

Assumption 3: Mining technology will be the same. This means that methods used today will be used in the future and those methods that are not economic today will be avoided in the future.

Assumption 4: Only those potash zones being mined today will be mined in the future. Currently uneconomical zones will not be mined; however, all currently economic potash will be extracted from the ore zones being mined today.

Assumption 5: The economics of mining today and not the presence of minerals will dictate the extent of mining. Specifically, the current economic extraction contour will be used as the indicator of the extent of future mining.

Assumption 6: The presence of the two hydrocarbon holes within the controlled area will have no impact on the future development of mineral resources. Without this simplifying assumption significant portions of the minable reserves would be thrown out.[10]

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[9]This assumption is conservative since, in reality, based on the NMBMMR report, the construction of a mine and mill results in a net financial loss from mining within the WIPP and the one mile area around the WIPP. The case of constructing a mine and mill for mining the reserves within the controlled area alone was not run by the NMBMMR, however, the reduction on minable resources associated with the smaller area would only exacerbate the loss.

[10]In reality, the presence of these bore holes and the assumptions with regard to future drilling have the potential to significantly reduce the extent of mining in the future if one assumes that requirements for buffer areas between drilling and mining are imposed in the future as they are today.

Information Only

SWCF-A 1.2.07.3: PA:QA:TSK: NSII 79

Assumption 7: The term "quality" in Section 194.32(b) is interpreted to refer to the economics of mining. That is, the phrase "resources of similar quality" means "resources of similar grade and thickness". Specifically, this is the 37.5 grade-thickness contour for langbeinite and the 55 grade-thickness contour for sylvite.

Assumption 8: Beginning in 1993, there are no more that 50 years of minable potash reserves in the Delaware Basin portion of the Potash Area. Even though one company reports up to 125 years of active mining, most of that company's reserves are north of the Delaware Basin.

Finally, data sources need to be summarized since they form the basis for determining what areas meet the criteria. Three primary sources of potash data exist. These are the NMBMMR study, the BLM map, and the leasing histories.

- The **NMBMMR report** provides a snapshot (as of 1995) of those resources that are economic to recover under the assumptions made in the assessment.
- The **BLM map** shows the extent of resources that are of lease quality and that have been offered for development.
- The **leasing history** shows those areas that have been traditionally considered worth retaining by companies for future development in the area[11].

In addition, a fourth source of data that is important is the hydrocarbon drilling record associated with the area outside the controlled area. Since buffer zones are required between drilled areas and present or future mined areas as discussed above, this factor will be used to reduce the amount of leased area outside the controlled area that may be mined in the foreseeable future.

4.0 RECOMMENDATIONS

The recommended extent of mining for the **area outside the controlled area** is depicted in Figure 5. This area represents the currently leased area less areas that are precluded from mining by the presence of existing hydrocarbon holes. Hydrocarbon hole barriers are set at either 0.25 miles for shallow oil, 0.5 mile for holes deeper than 5000 feet, or 110 percent of the depth to the mine. The use of leases is justified since the actual grade-thickness information is not available (since it is proprietary information) and the BLM lease grade map bounds the economic mining areas. In addition, areas that are known to be barren of resource grade potash and are not leased as shown in Figure 1 have been excluded. (Note, once the BLM map is digitized, mined out areas can also be excluded as well as leased areas that are barren.) No effort was made to distinguish between the various ore zones on this map. An average mine height of 6 feet should be used.

Three possible interpretations for the extent of mining **inside the controlled area** are shown in Figures 6, 7, and 8. These have been compiled from the three sources mentioned above. Figure 6 shows the most conservative interpretation based on the BLM lease map. This map, however, includes a significant volume of potash that is not minable under today's economic conditions. Figure 7 shows areas that have been previously leased for potash mining. Note that Section 32 has been deleted since it is shown to be essentially barren of lease grade potash on the BLM lease grade map in Figure 6. This area is most consistent with the approach used to identify the extent of mining outside the controlled area. However,

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[11]Leasing history is particularly important within the controlled area since there are no current leases to indicate what a mining company would consider for mining or what may be included in a life of mine plan. Such leases did exist recently. However, as indicated in Table 1, the DOE purchased these leases as part of the process of preserving the controlled area.

Information Only

SWCF-A 1.2.07.3: PA: QA: TSK: NSH 75

the lease approach was used outside the controlled area due to the lack of sufficient data to draw a more precise boundary. Figure 8 depicts a more precise area based on the most current interpretation of what are economically viable potash leases. Figure 8 is the recommended area for use in the analysis[12]. Because of the detail available in the background information, the area has been divided into sections that may be mined for langbeinite, sections that may be mined for sylvite, and sections may be mined for both. The parameters for mining should be as depicted in the following table, based on information in the NMBMMR report.

	Mining Method	Mine layout	Mine height	Extraction Ratio
Langbeinite (4th ore zone)	Conventional	Room and pillar	4 to 8 feet	60 percent
Sylvite (10th ore zone)	Continuous	Long panel	4 to 5 feet	80 percent

The area in Figure 8 is based on the "55" and "37.5" contours in the NMBMMR report.

[12]The contours in the NMBMMR report are the result of a specific contouring program used by the investigator. Other interpretations are possible using different packages or by contouring without the use of software. This paper simply accepts the work done by the NMBMMR as a valid representation of the data. Other equally valid representations may exist and may be of interest in the evaluation of the impacts of mining.

SWCF-A 1.2.07.3: PA: QA: TSL: NSH 76

Information Only

TABLE 1: HISTORY OF POTASH PROSPECTING AND LEASING ON THE WIPP SITE
TOWNSHIP 22 SOUTH RANGE 31 EAST

SECTION	SERIAL NO.	DATE OF ACTION	STATUS
15: All	LC047600(Pot. Per.)	5/26/33	Canceled 9/30/36
All	LC065503(Pot. Per.)	3/7/50	Canceled 5/29/54
All	NM011422(Pot. Per.)	1/27/54	Canceled 6/30/54
All	NM011812(Pot. Per.)	11/21/57	Expired 11/21/59
All	NM075014(Pot. Per.)	5/3/60	Lease issued 7/1/64
16: All	M-14957-1(Pot. Les.)	2/4/67	DOE Acquired Lease 3/4/88
17: All	LC065504(Pot. Per.)	1/16/50	Canceled 5/29/52
All	NM011813(Pot. Per.)	4/7/58	Expired 4/7/60
All	NM094314(Pot. Per.)	8/1/60	Lease Issued 7/31/64, Lease Relinquished 12/22/72
18: All	LC065506(Pot. Per.)	12/14/54	Expired 12/14/56
Lots 1,2,3,4 E½W½, E½	NM057290(Pot. Per.)	10/28/59	Lease Issued 1/1/64, Lease Relinquished 12/22/72
19: All	NM08285(Pot. Per.)	9/18/56	Lease Expired 9/18/60
Lots 1,2,3,4 W½E½, E½W¼, SE¼SE¼	NM02535(Pot. Per.)	6/1/67	Lease Terminated 8/31/68
20: All	NM08285(Pot. Per.)	9/18/56	Lease Expired 9/18/60
All	NM0384583(Pot. Per.)	12/1/63	Lease Expired 1/9/68
21: All	NM08285(Pot. Per.)	9/18/56	Lease Expired 9/18/60
All	NM384583(Pot. Per.)	12/1/63	Lease Expired 1/9/68
22: SW¼SE¼, NW¼SE½	LC045236 (Pot. Per.)	5/23/32	Canceled 6/2/36
NW¼SE¼	NM08285(Pot. Per.)	9/18/56	Lease Expired 9/18/60
All	NM0384584(Pot. Per.)	9/1/63	Leased 11/1/67, Lease Acquired by DOE

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SWCF-A 1.2.07.3: PA.QA.TSK.NS11 TT

TABLE 1: HISTORY OF POTASH PROSPECTING AND LEASING ON THE WIPP SITE
TOWNSHIP 22 SOUTH RANGE 31 EAST (Continued)

SECTION	SERIAL NO.	DATE OF ACTION	STATUS
27: NW¼	LC047927(Pot. Per.)	5/14/48	Canceled 6/13/51
NW¼	NM0214(Pot. Per.)	10/27/55	Expired 10/27/57
NW¼	NM08285(Pot. Per.)	9/18/56	Expired 9/18/60
NE¼	NM038266(Pot. Per.)	7/29/59	Expired 7/29/61
27: SW¼,SE¼	NM0221(Pot. Per.)	4/23/56	Expired 4/23/58
SW¼,SE¼	NM045331(Pot. Per.)	7/29/59	Expired 7/29/61
All	NM0384584(Pot. Per.)	9/1/63	Leased 11/1/67, Lease Acquired by DOE
28: All	NM0384583(Pot. Per.)	12/1/63	Lease Expired 1/9/68
29: All	NM0384583(Pot. Per.)	12/1/63	Expired 11/30/67
30: Lots 1,2,3,4 E½W½, SE¼	NM038136(Pot. Per.)	7/29/59	Lease Expired 9/13/61
Lots 1,2,3,4 NE¼, E½W½, W½SE¼	NM0359163(Pot. Per.)	6/1/63	Expired 5/31/67
Lots 1,2,3,4 NE¼, E½W½, W½SE¼	NM 2535(Pot. Per.)	6/1/67	Lease Terminated 8/31/68
31: All	LC045662(Pot. Per.)	10/11/32	Canceled 6/2/36
All	LC066113(Pot. Per.)	1/5/55	Expired 1/5/57
Lots 1,2,3,4 E½W½, E½ (All)	NM038136(Pot. Per.)	7/29/59	Expired 9/13/61
32: All	M-14957(Pot. Les)	2/4/67	Lease Acquired by DOE 3/4/88

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TABLE 1: HISTORY OF POTASH PROSPECTING AND LEASING ON THE WIPP SITE
TOWNSHIP 22 SOUTH RANGE 31 EAST (Continued)

SECTION	SERIAL NO.	DATE OF ACTION	STATUS
33: All	LC045661(Pot. Per.)	10/21/32	Canceled 3/23/37
All	NM0359161(Pot. Per.)	6/1/63	Expired 5/31/67
All	NM02534(Pot. Per.)	9/1/67	Terminated 8/31/68
All	NM10409(Pot. Per.)	2/1/70	Expired 1/31/72
34: NE¼, NW¼, NE¼SW½	LC047602(Pot. Per.)	5/26/33	Canceled 9/30/36
NW¼,SW¼	NM0384584(Pot. Per.)	9/1/63	Leased 11/1/67, Lease Acquired by DOE

Pot. Per. = Permit for potash exploration

Pot. Les. = Potash lease

Reference: Abstract No. 29990 and 29989

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SWCF-A 1.2.07.3:PA.QA:TSL:NSII 79

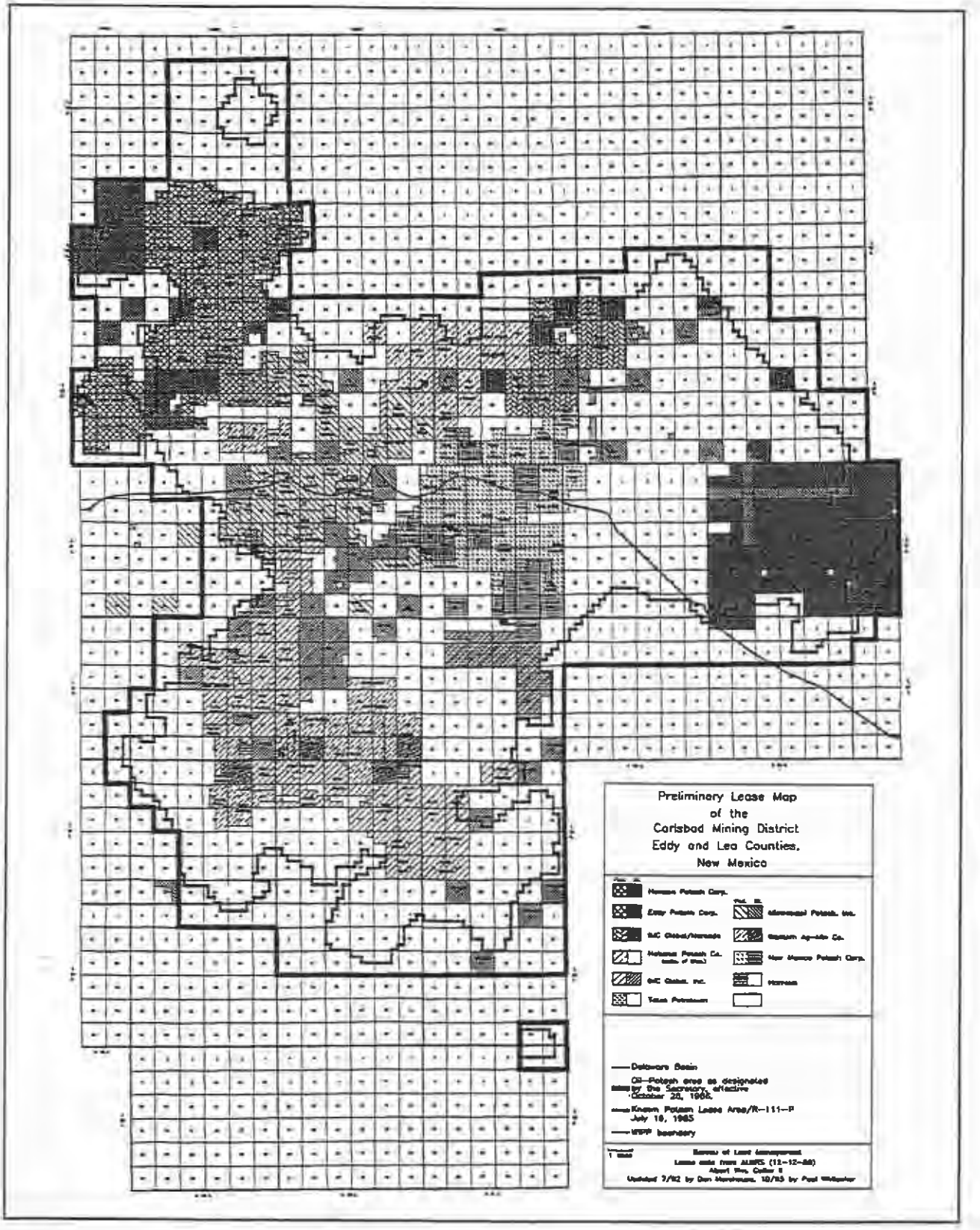

Figure 1
1995 Potash Lease Map

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BKPPS

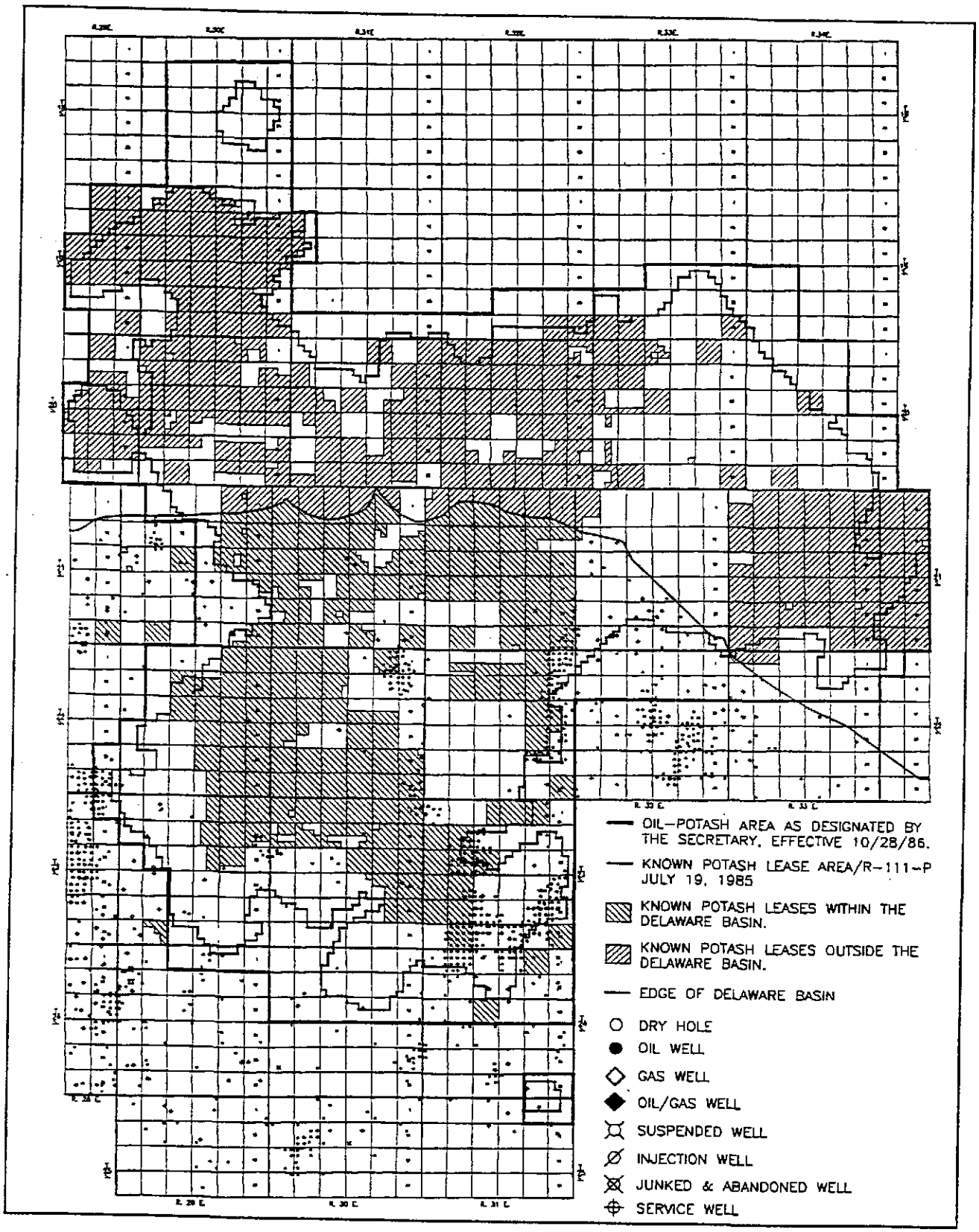

Figure 2

Oil and Gas Wells Within the Carlsbad Potash Enclave

Information Only

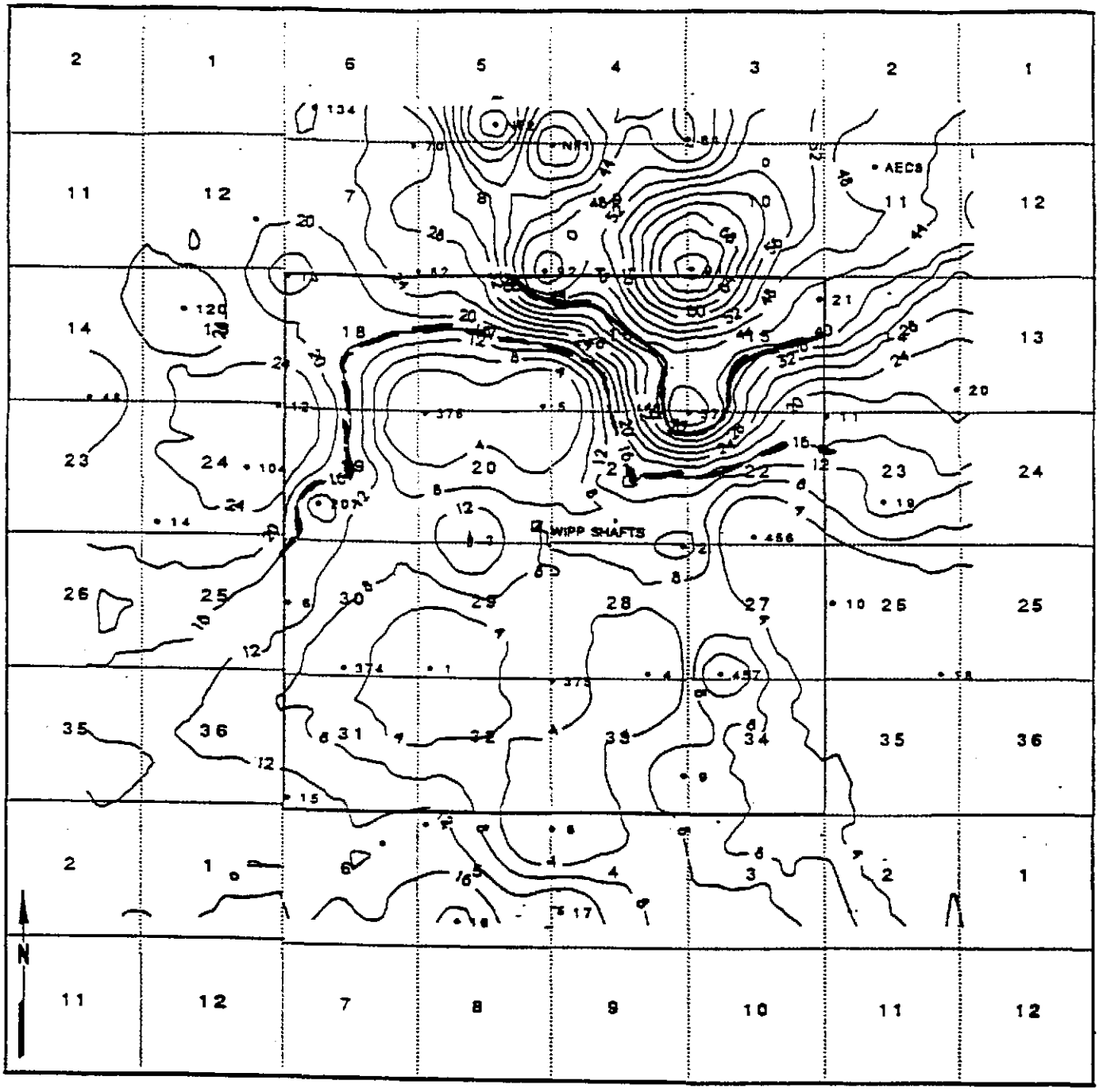

Figure 3
Langbeinite Reserves Based on NMBMMR.

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BKPP7

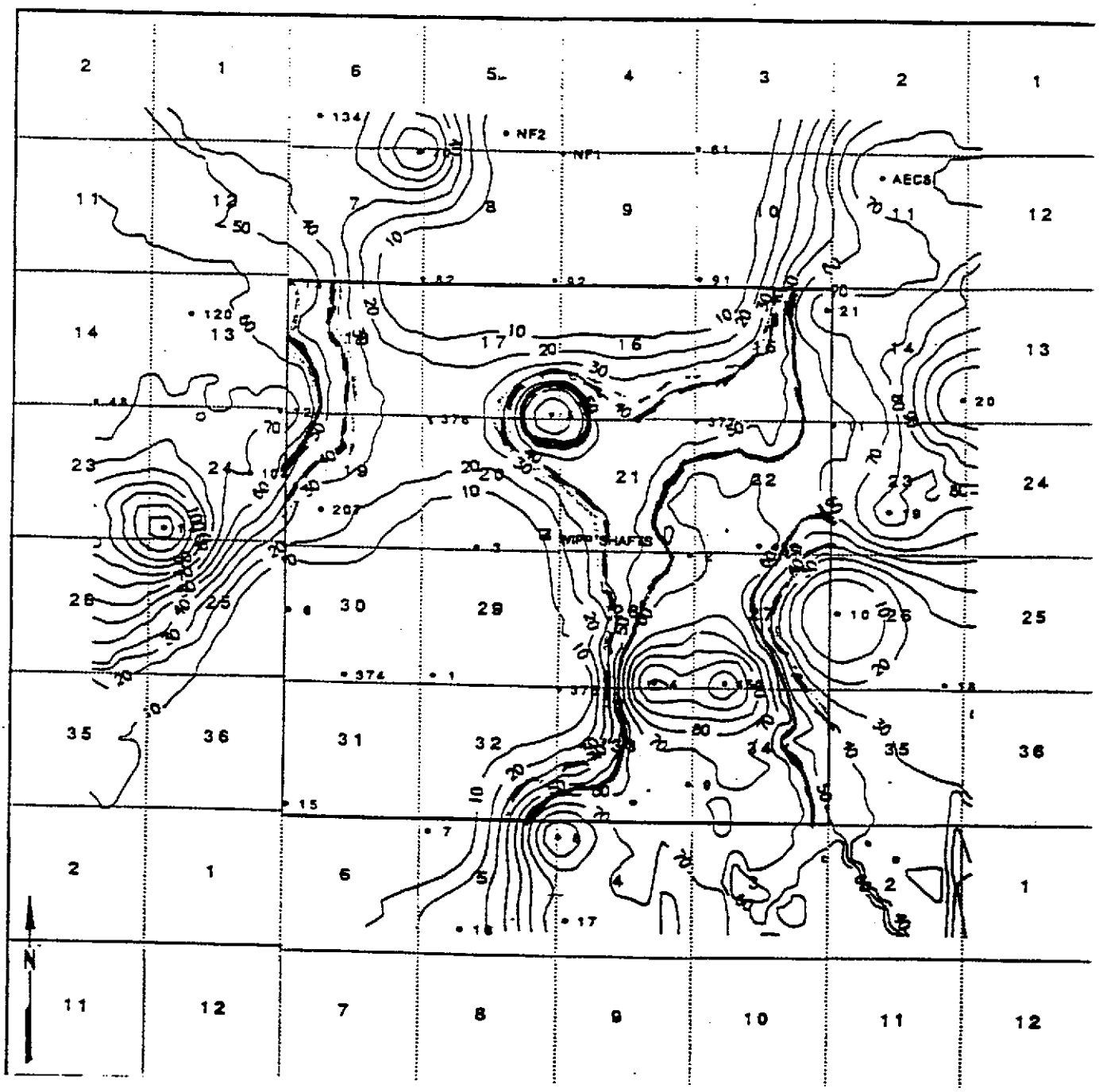

Figure 4
Sylvite Reserves Based on NMBMMR.

Information Only

SWCF-A 1.2.07.3:PA QA: TSK: NSI 15

BKPP8

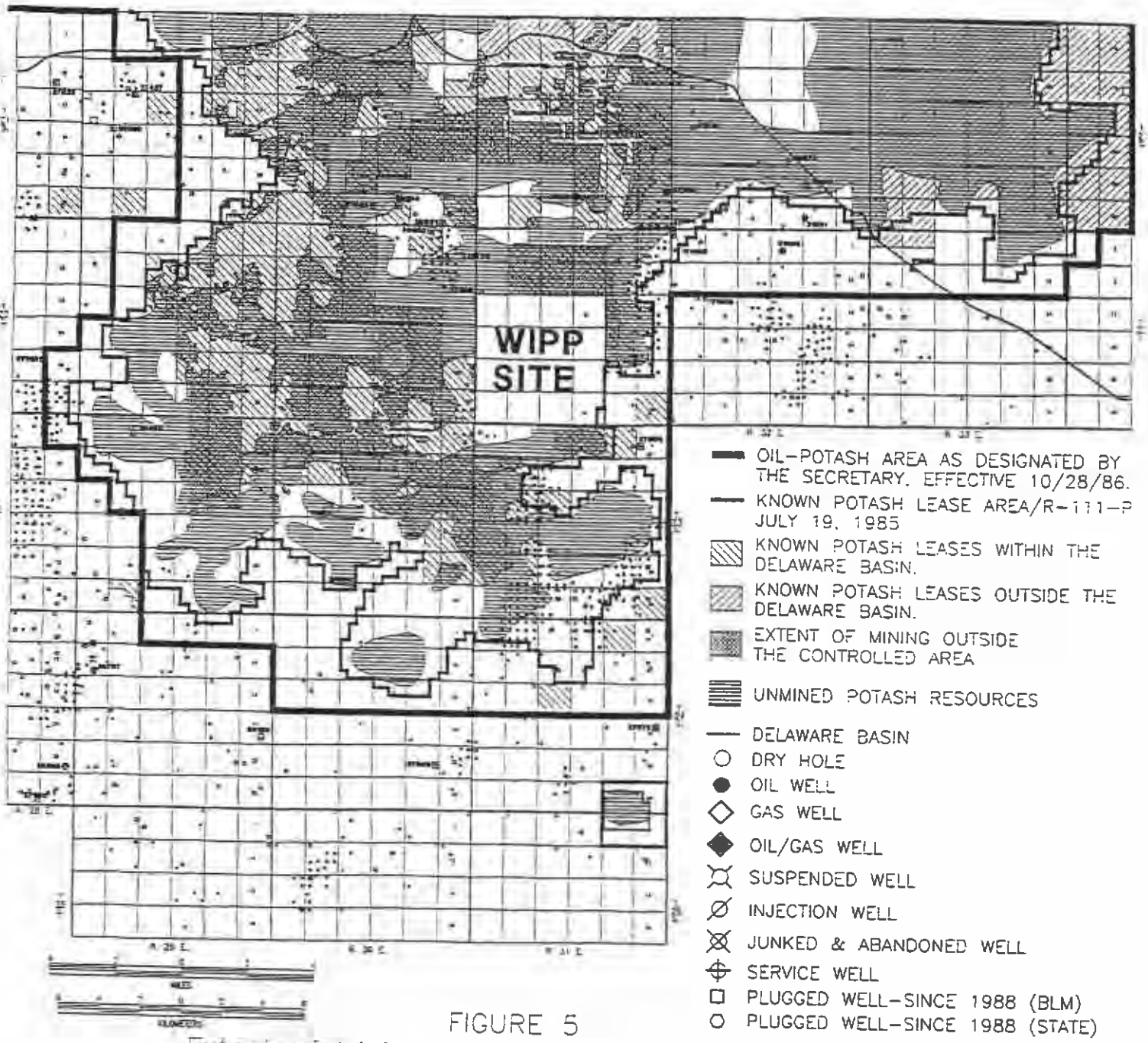

FIGURE 5
Extent of Mining Outside the Controlled Area

BKPP1

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Information Only

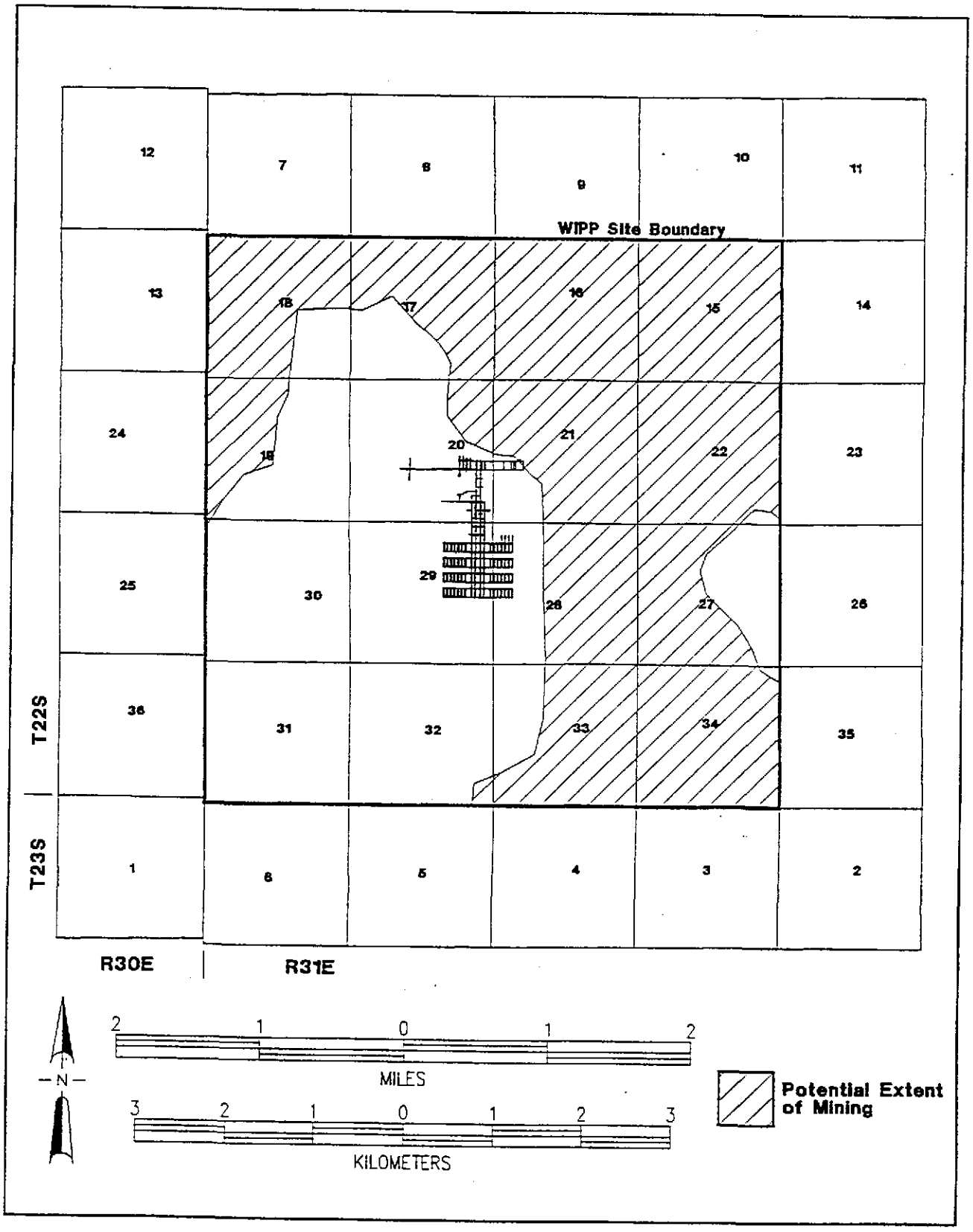

Figure 6
Potential Extent of Mining Based on Lease Grade Ore (1993 BLM Lease Map)

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BKPP2

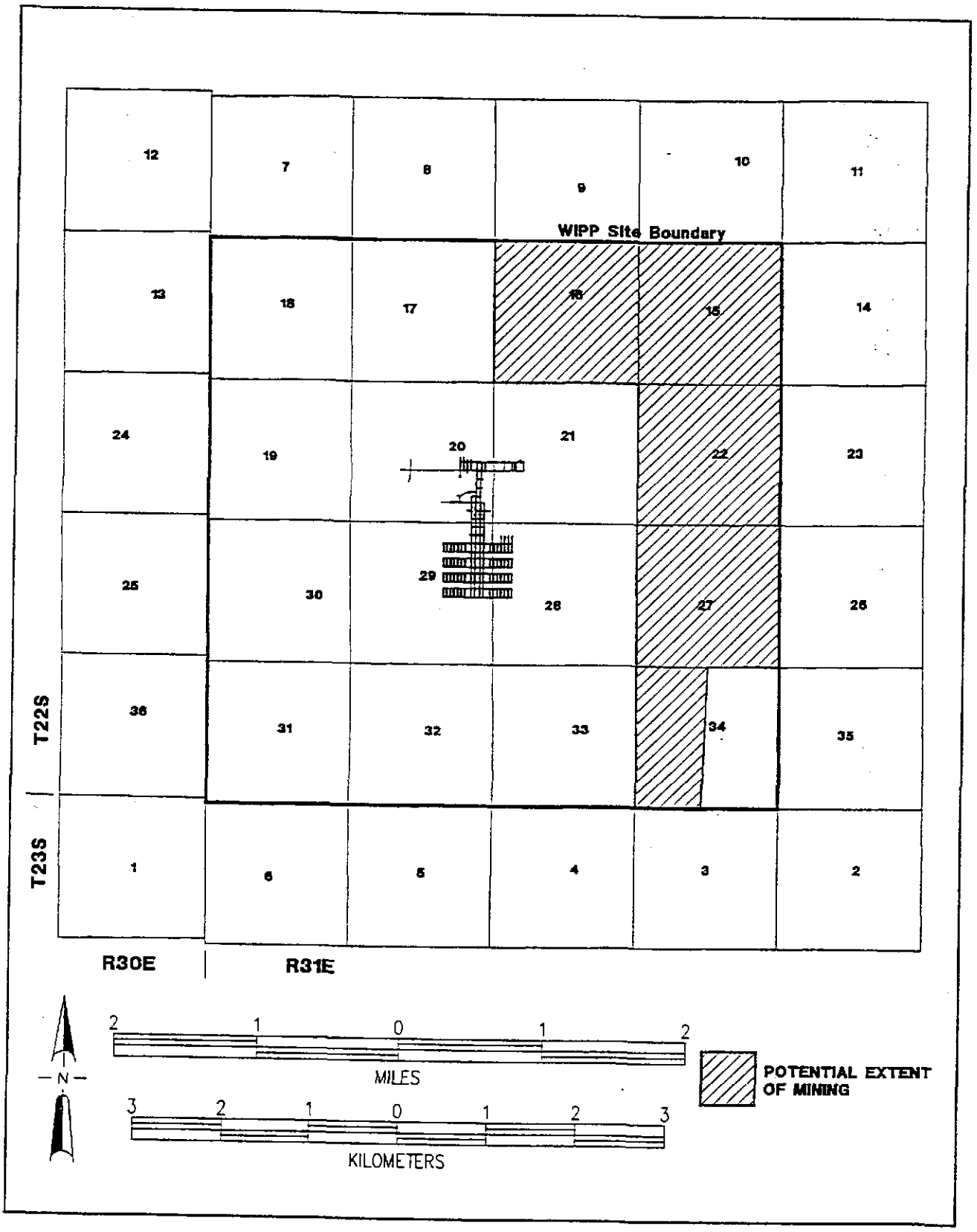

Figure 7
Potential Extent of Mining Based on Historically Leased Areas
Within the LWA Containing Economic Ore Grade

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BKPP3

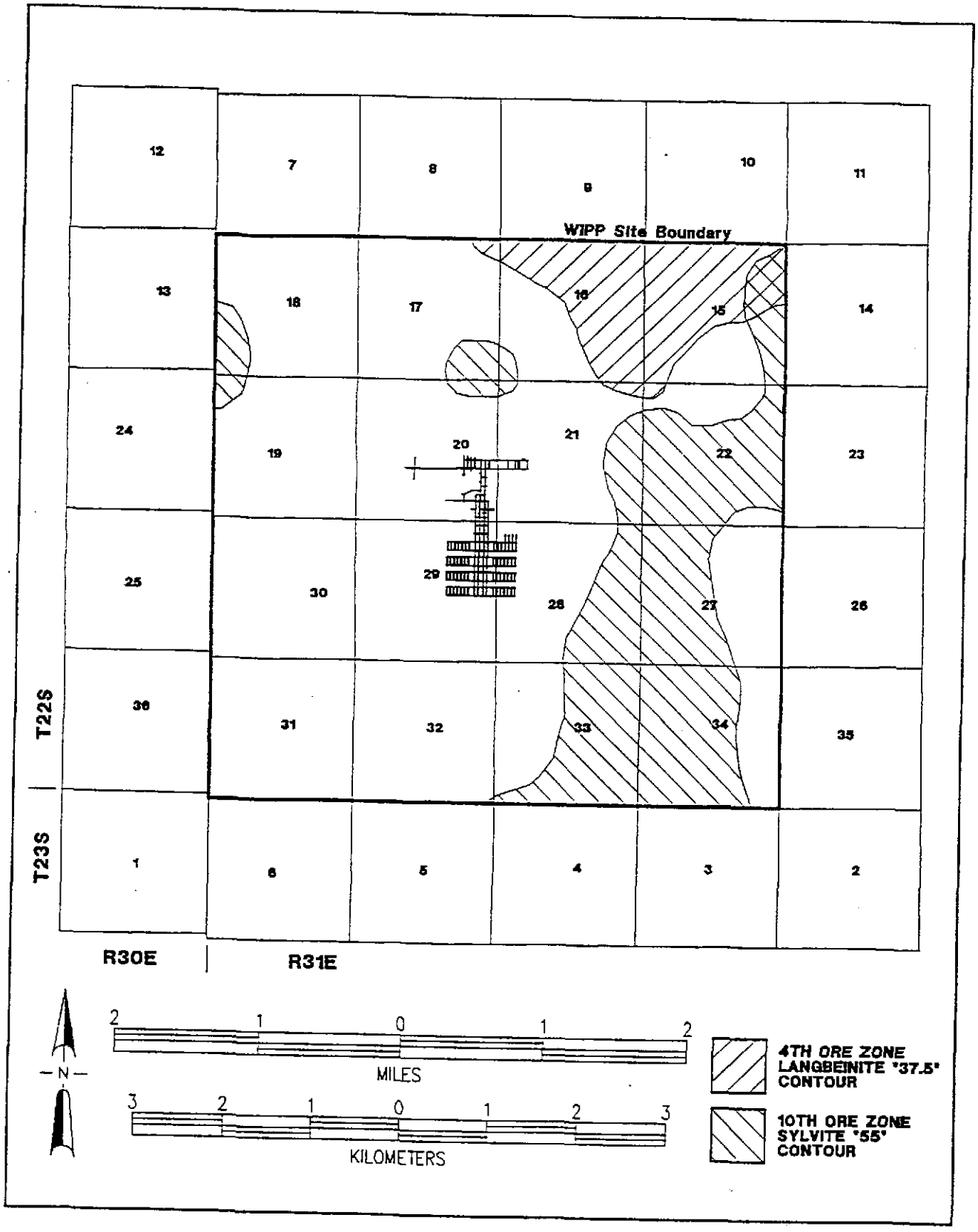

Figure 8
Extent of Mining of Economic Grade Ore Based on NMBMMR Report

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BKPP4

Appendix NS11.3 Particle Tracking Study

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).

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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 1. Exit boundaries are also specified. The exit boundaries used represent the southern, eastern, and western LWB. 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. In addition, 1300 individual particles were tracked for the no-mining case.

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. Table APNS11.1 contains the summary population statistics. Tables APNS11.2, APNS11.3, and APNS11.4 summarize all of the travel times and the associated statistics for the individual cases.

Table APNS11.1 Summary Statistics for the Three Flow Cases, each based on a population of 1300 travel times

Case	Mean Travel Time (years)	Standard Deviation (years)	Coefficient of Variation
no-mining	12,577	41,854	3.33
partial-mining	26,911	50,085	1.86
full-mining	70,565	111,090	4.17

The travel time results are summarized graphically in Figures 2 through 4 corresponding to the three subseries. In those scatterplot figures, travel times are plotted along the y axis and rankings along the x axis. 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.

As can be seen, both mining subseries show a total range of travel times covering at least two orders of magnitude. Spreads of travel times for individual configurations can range from relatively narrow (<1 order of magnitude) to relatively large (1 order of magnitude <= spread <=2 orders of magnitude). Generally the full mining subseries has a greater range of travel times for any configuration that the other subseries. The no-mining series has the narrowest range of travel times. Examination of the travel path figures shows a correspondingly greater range in flow directions for the full mining case than for the partial mining case.

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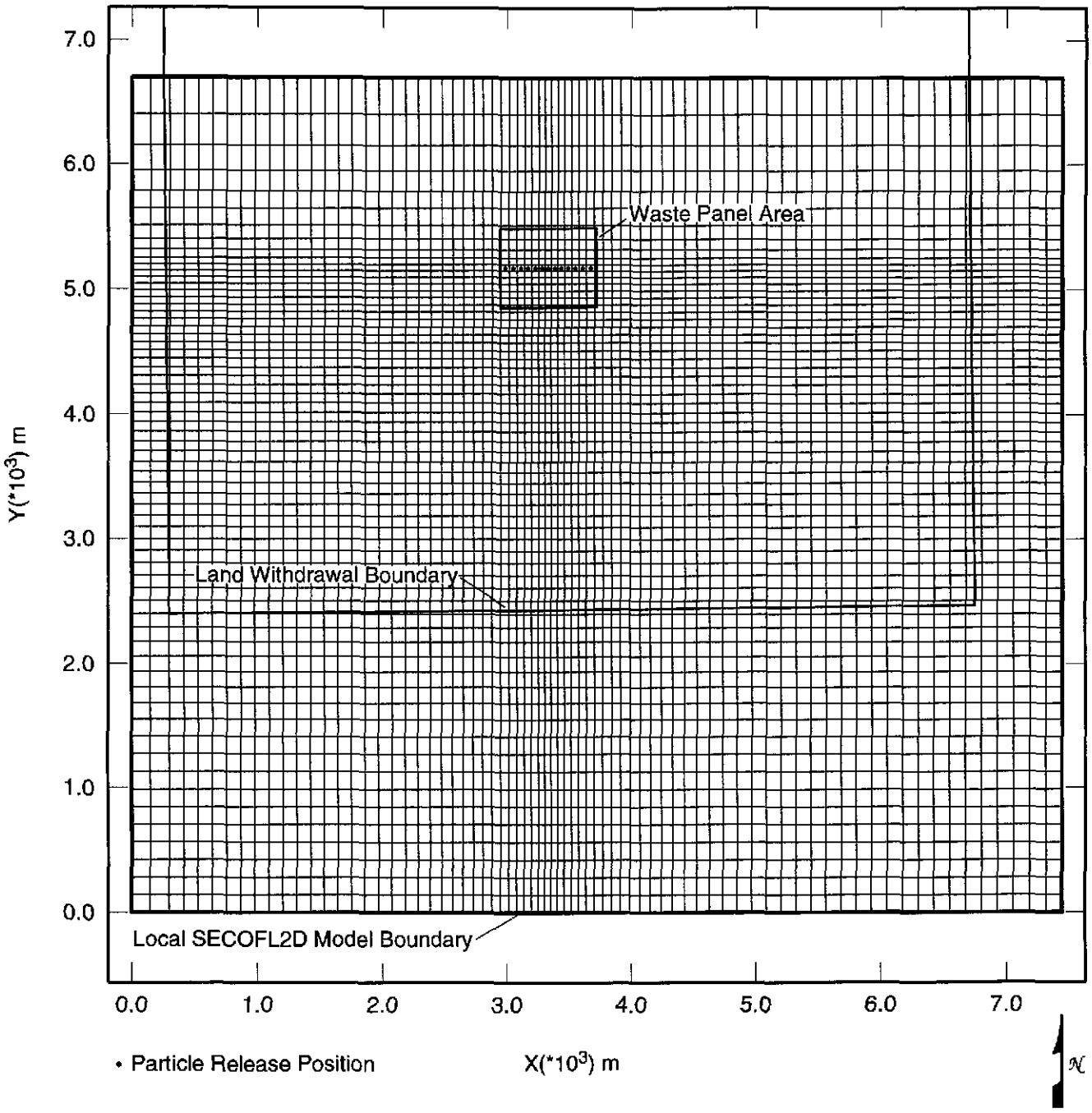

Figure 1. Particle Tracking Configuration

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Figure 2. Scatter Plot of Travel Times for No-Mining Case, Replicate 1
100 SecoFl2D steady state runs, 13 particle tracks per run

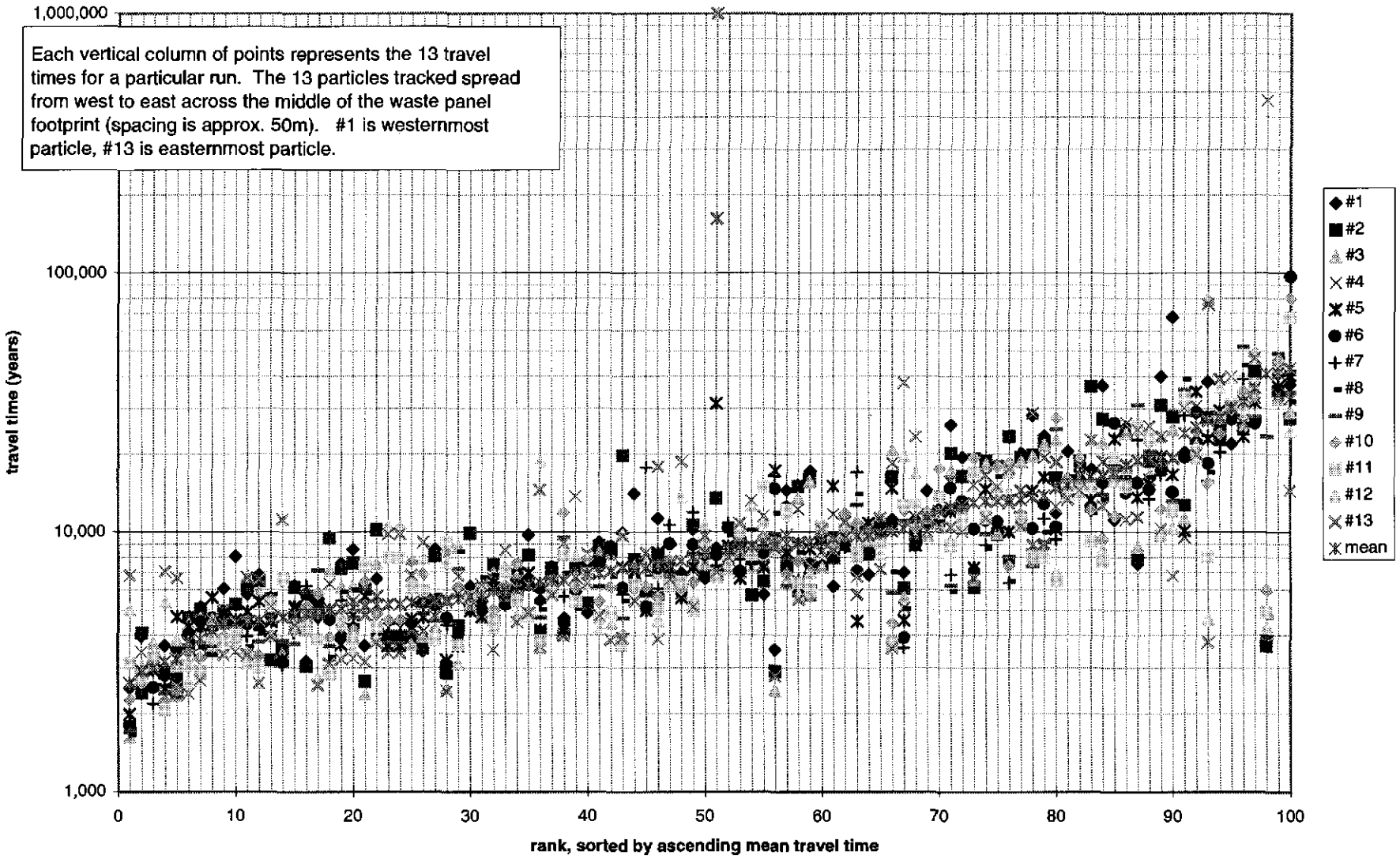

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Figure 3. Scatter Plot of Travel Times for Partial Mining Case, Replicate 1
100 SecoFl2D steady state runs, 13 particle tracks per run

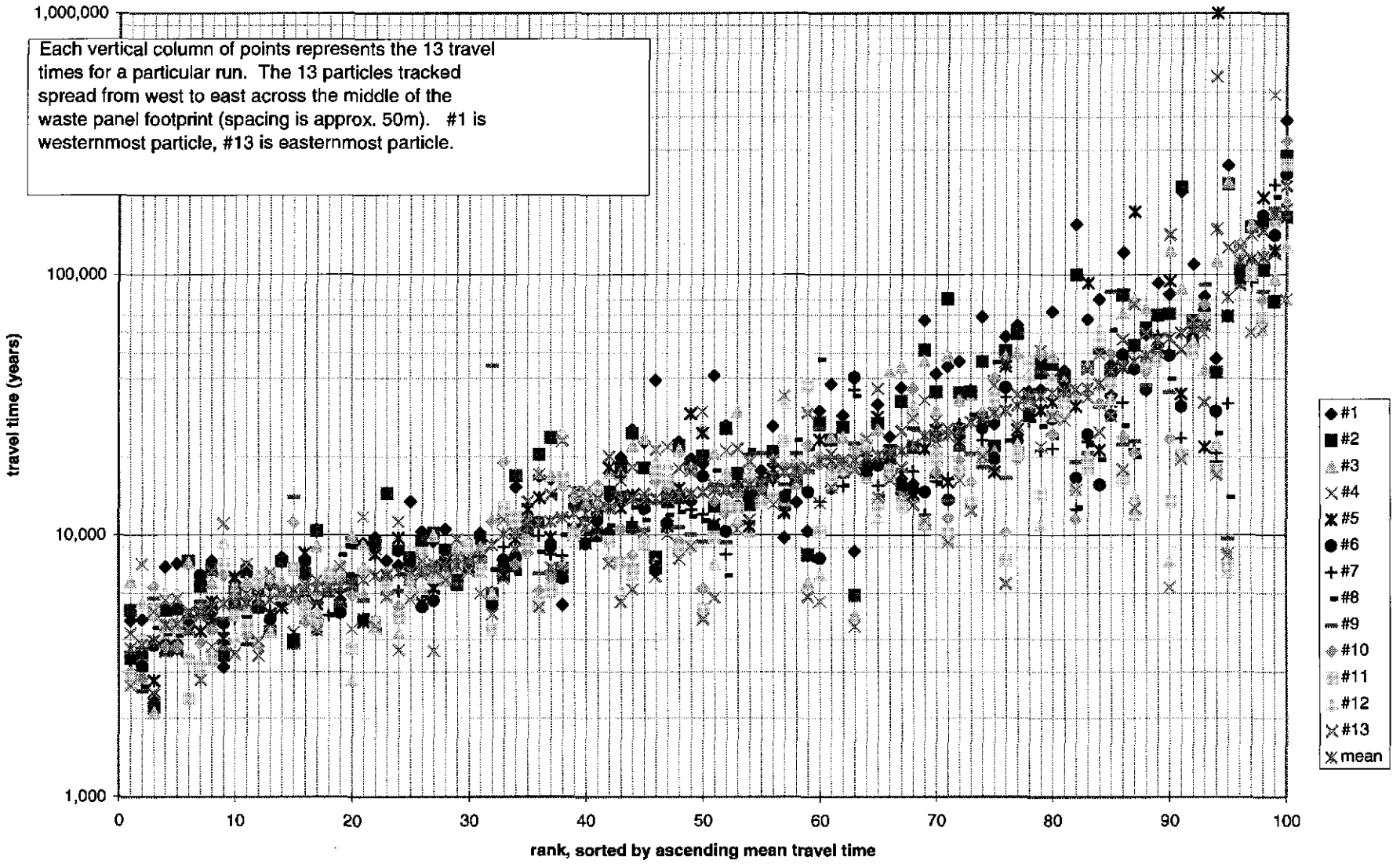

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Figure 4. Scatter Plot of Travel Times for Full Mining Case, Replicate 1
100 SecoFl2D steady state runs, 13 particle tracks per run

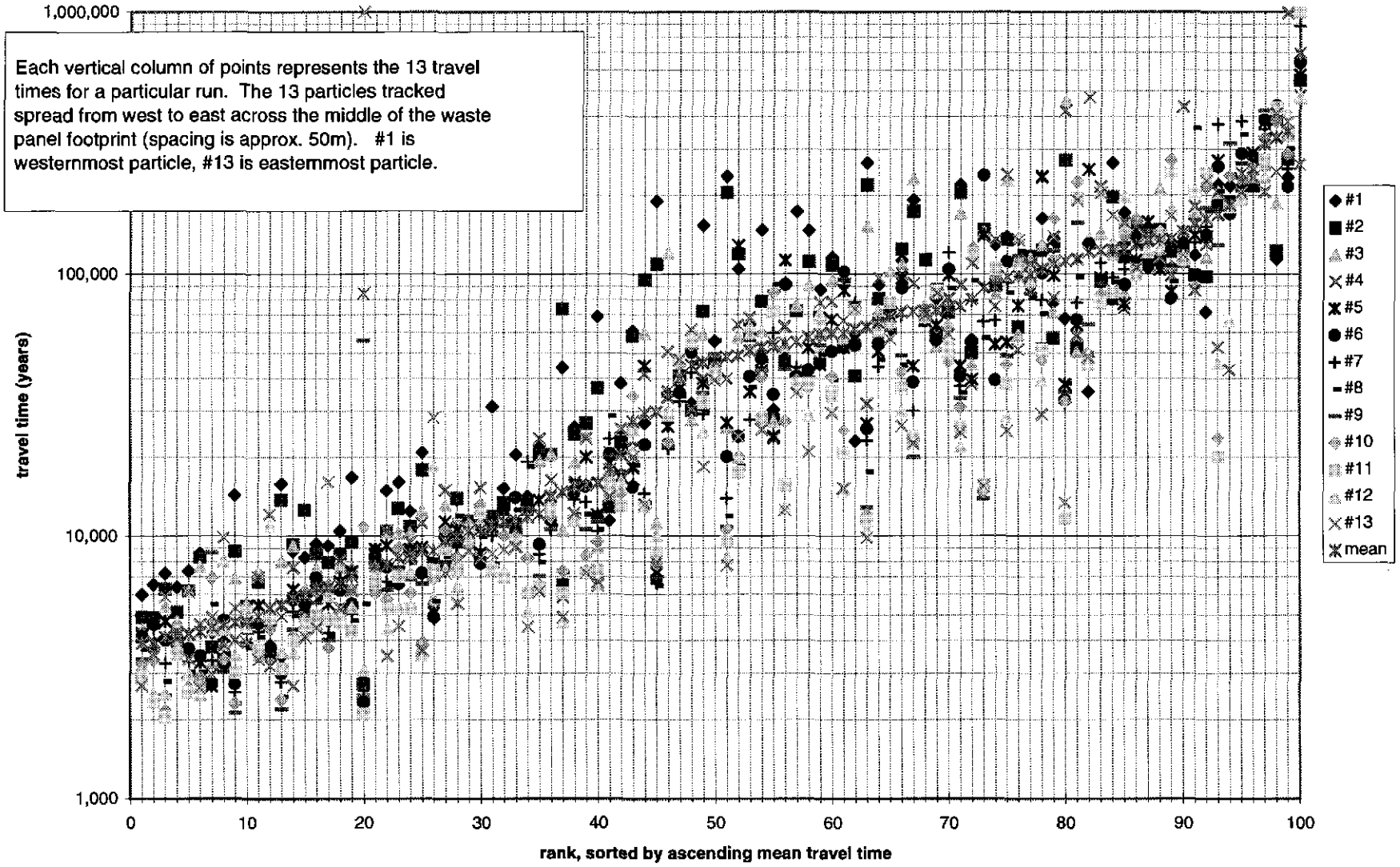

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Figure 5 shows the total distributions of travel times for the three cases. Some trends are immediately apparent. First, there appears to be a lower limit to the travel time ranges, of about 2,000 years. This limit seems to hold for all cases. Possibly this time reflects a minimum length of Culebra, unaffected in all cases by mining, through which the particles must first pass before they reach zones of higher conductivity, given the current range of trajectories.

The second trend is an apparent trimodality of the results. This is believed to be a result of three distinct preferential flow domains, that persist through a majority of the K realizations. The apparent mode, associated with the travel times in the 25,000 year range, is possibly associated with flow paths that lie slightly west of the original 'high T' zone. They go in the same general direction of that zone but lie in a lower-K region to the west. They are prevented from an even more westerly path by an extremely low K band that lies in that direction. The 200,000 year travel time grouping is probably associated with particles that actually penetrate through that low-K zone and exit via the western LWB. The 5,500 year travel time grouping is likely associated with particles that approach or reach the high-T zone. Their paths are likely similar to the 20,000 year group, except slightly to the east.

To confirm this, one would have to examine the bulk of the 3,900 particle track plots. Therefore, these conjectures should not be relied upon as a definitive interpretation at this time.

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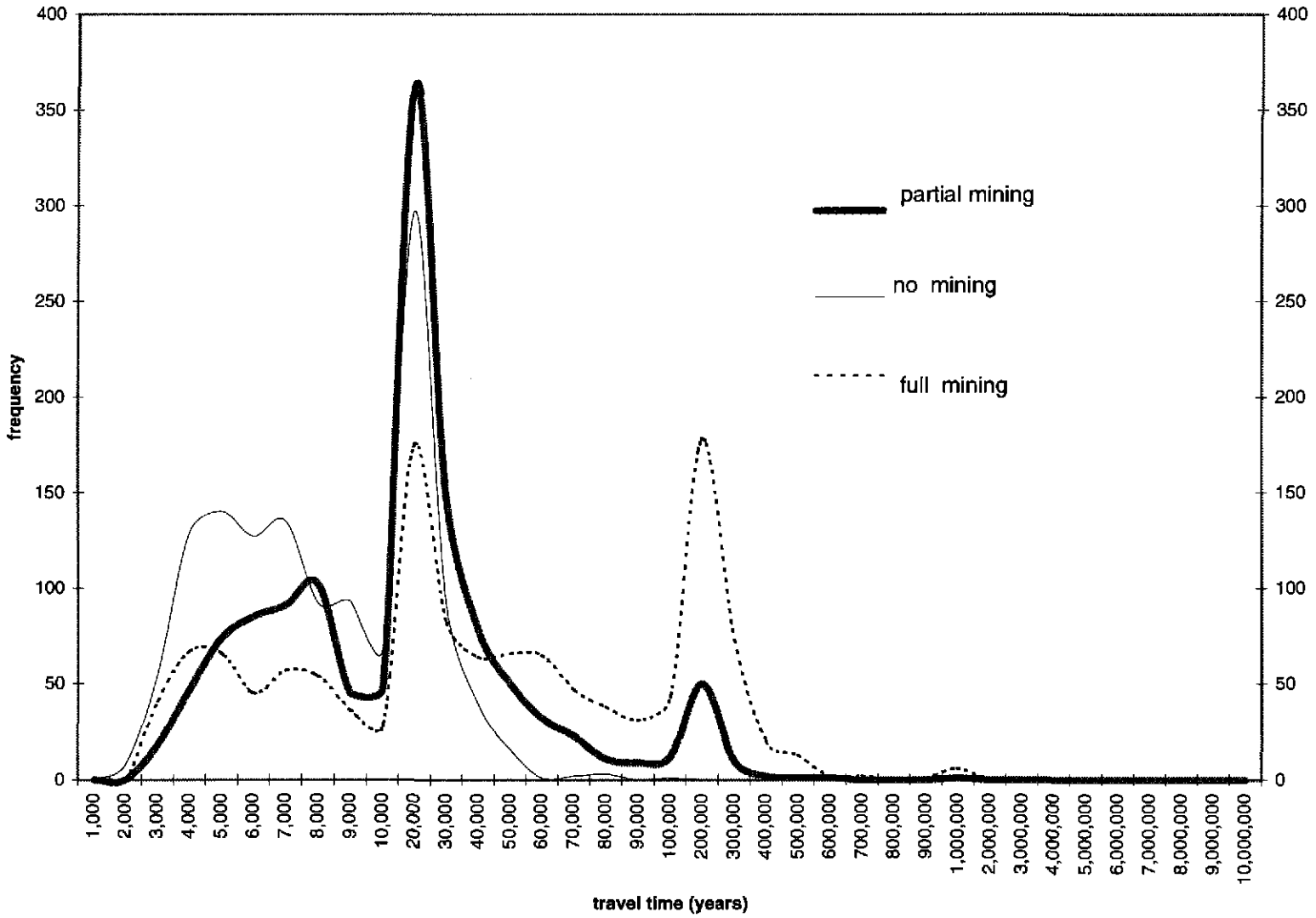
Figure 5. Frequency of Travel Times, 3 Cases, 1300 sampled vectors each



Information Only

mgw, rlb, 10-13-96				Travel Times (years) of 13 Particles from a Constant Line of Release Points													No Mining Effects		
				line is E-W, penetrating midpoint of waste panel area.													file is Microsoft Excel		
spring/96				release points are equally spaced along this line.						constant porosity = 0.16							Wallace PC		
grasp-	rep #1			exit boundary is the LWB.						data sorted by mean travel time						C:\data\paramete\minp_fac\virtimes\virgin4.xls				
t-field	cca	new							PARTICLE NUMBER										
index	run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
40	30	1	2507	1778	1626	1974	1990	1787	1692	1660	1733	2256	3131	5007	6781	2609	1560	2.43E+06
80	86	2	3961	4088	2681	2456	2396	2380	2459	2751	2849	2624	2728	3042	3454	2913	574	3.30E+05
16	59	3	3007	3162	3708	2937	2922	2513	2180	2909	3128	3112	3264	3083	2988	2993	361	1.30E+05
17	55	4	3644	2861	2507	2329	2484	2798	2735	2554	2415	2215	2069	5355	7035	3154	1445	2.09E+06
44	12	5	2839	2630	2351	2538	4722	3549	2795	2437	2320	2449	3029	3834	6654	3242	1241	1.54E+06
25	49	6	4658	4690	4405	4310	4310	3993	3676	3803	3581	3422	3048	2627	2389	3762	740	5.47E+05
9	31	7	5133	5038	4658	3612	4341	4500	4151	3612	3327	3264	2909	2827	2684	3851	841	7.07E+05
67	43	8	4215	3486	3644	3898	5577	4658	4215	3644	3644	3834	3898	4595	4595	4146	587	3.45E+05
3	89	9	6052	4943	4626	4975	4848	4626	4468	4310	4278	3929	3803	3612	3359	4449	704	4.95E+05
31	66	10	8049	5260	3929	4024	4595	4468	4278	4119	4088	4151	4056	3708	3454	4475	1159	1.34E+06
38	24	11	5767	6116	6750	6654	4912	4405	3961	3612	3486	3422	3327	3099	3359	4528	1354	1.83E+06
58	56	12	6813	6464	5831	6559	5387	4341	4183	4056	3771	3327	2985	2621	2614	4535	1517	2.30E+06
71	5	13	3961	3200	3993	3961	4500	4753	4722	4373	5767	5419	5292	5165	5165	4636	729	5.31E+05
19	63	14	3612	3612	3391	3169	3232	3143	3064	3166	3803	6433	6686	6559	11123	4692	2389	5.71E+06
91	78	15	6211	6116	4722	5070	5165	4722	4088	5229	3708	4151	4405	4436	4373	4800	748	5.60E+05
45	57	16	3169	3036	4183	4753	5640	5736	6211	5767	5894	5165	4373	4405	4753	4853	1012	1.02E+06
96	45	17	4690	4912	5229	4975	5260	5387	5577	5260	7130	5799	3834	2732	2570	4873	1230	1.51E+06
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62	4	32	7257	7510	6940	6623	6401	6084	6401	6813	5862	5007	4531	4310	3517	5943	1234	1.52E+06
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14	13	37	6813	6464	6623	6908	7257	7288	7066	6369	6052	5894	5926	5894	5704	6481	556	3.09E+05
49	16	38	4658	4024	4024	3993	4183	4500	5640	6908	9506	11851	8176	8176	9031	6513	2613	6.83E+06
23	20	39	5355	7510	6084	5736	5609	5450	5324	5070	7098	6116	5387	8080	13721	6657	2318	5.37E+06
4	79	40	4880	5324	7827	8239	7288	7066	7478	6845	6971	7890	6908	6338	6338	6876	972	9.45E+05
90	98	41	9126	8809	8334	7859	7669	7573	7447	7732	6179	5387	4658	4246	4753	6906	1661	2.76E+06
35	19	42	8809	8587	8239	8397	8619	8778	8271	6781	6084	6116	4912	4436	3834	7066	1808	3.27E+06
33	33	43	9918	19742	9823	9665	7288	6084	5767	5450	4658	3993	3676	3771	3898	7210	4433	1.97E+07

Information Only

mgw, rlb, 10-13-96				Travel Times (years) of 13 Particles from a Constant Line of Release Points												No Mining Effects			
				line is E-W, penetrating midpoint of waste panel area.												file is Microsoft Excel			
spring/96				release points are equally spaced along this line.						constant porosity = 0.16						Wallace PC			
grasp	rep #1			exit boundary is the LWB.						data sorted by mean travel time						C:\data\paramete\minp_fac\virtimes\virgin4.xls			
t-field	*cca*	*new*						PARTICLE NUMBER											
index	run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var	
57	32	44	14070	7827	7383	6845	6908	6876	7035	6528	6274	6052	6243	6496	5419	7227	2144	4.60E+06	
6	7	45	7827	5926	5355	5133	4975	5133	17714	6876	6211	6147	7257	7700	8302	7274	3330	1.11E+07	
89	99	46	11249	8176	6971	17904	8334	7257	6052	5545	5799	5577	5102	4563	3866	7415	3694	1.36E+07	
12	84	47	6243	6750	6559	6750	7225	8999	10647	8999	7922	7795	6274	6147	6559	7452	1370	1.88E+06	
72	76	48	6940	6464	6179	5831	5577	5862	6243	6369	6147	5989	6433	13721	18696	7727	3914	1.53E+07	
26	14	49	10235	10647	7352	7162	7320	8904	11915	10647	8239	6401	5324	4975	5133	8020	2307	5.32E+06	
43	91	50	6623	6813	7510	8556	8619	8176	7985	7985	8080	8524	9031	10679	9633	8324	1084	1.17E+06	
34	65	51	8651	13499	1000000	1000000	31308	8144	7415	7193	6591	6654	6654	6845	7003	162304	7682	1.38E+11	
98	73	52	8366	7573	7193	8112	8809	10330	10806	9728	8873	8112	8049	7605	7985	8580	1098	1.21E+06	
52	83	53	8239	9063	8334	6971	6623	7035	7859	9221	9316	9665	10140	10172	10806	8726	1339	1.79E+06	
84	21	54	8334	5704	7257	8714	8271	7795	7510	8080	10140	8746	8144	12644	13246	8814	2090	4.37E+06	
41	10	55	5736	6464	7510	7447	7288	8271	8841	8778	8714	9570	14925	10932	11503	8921	2427	5.89E+06	
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8	41	61	6179	7985	9190	11725	15052	9380	9285	9221	9253	9190	9158	8904	8461	9460	2062	4.25E+06	
78	75	62	9031	8968	9633	9190	8999	8936	8714	8556	9348	11788	10204	9665	10964	9538	940	8.83E+05	
10	47	63	10235	10299	10109	5736	4531	7035	17017	14038	12707	10806	8334	8080	6718	9665	3492	1.22E+07	
54	6	64	6845	8239	9285	10235	10806	10235	10109	10489	10362	9665	9475	9918	10267	9687	1076	1.16E+06	
15	29	65	10330	10679	11503	11249	10362	10013	10172	10489	9728	9316	9031	8207	7193	9867	1195	1.43E+06	
51	70	66	11154	16351	20629	18411	14735	10742	10235	7003	5831	4436	3771	3644	3549	10038	5962	3.55E+07	
53	40	67	6971	6084	5609	5102	4563	3898	3581	5070	10996	12073	12644	19615	37709	10301	9449	8.93E+07	
2	2	68	11123	9950	9411	9063	8873	8841	8873	9094	9506	10362	12675	16890	23386	11388	4246	1.80E+07	
27	35	69	14418	10806	9633	10045	11566	11756	11059	11091	12010	11946	11471	11313	11154	11405	1138	1.29E+06	
95	17	70	12232	11091	10837	11313	11820	11408	11059	11091	11946	17460	13658	11883	10394	12015	1825	3.33E+06	
85	85	71	25921	20217	17207	15749	12041	14767	6845	5926	6243	9094	8873	8904	10457	12480	6013	3.62E+07	
94	92	72	19425	16414	12580	10330	11534	13119	12834	12644	12548	12105	11123	10647	10013	12717	2590	6.71E+06	
92	23	73	7162	6147	6559	6591	7288	10267	16319	19963	19773	19330	16890	17428	15147	12990	5690	3.24E+07	
20	54	74	18474	18686	18284	16605	14640	11091	8936	8651	9855	11281	11566	11281	11344	13146	3737	1.40E+07	
100	90	75	10261	9841	9885	10596	10590	10939	13435	16429	18659	17849	14366	13558	14939	13181	3110	9.67E+06	
99	8	76	23196	23449	18759	12897	10013	7700	6369	6496	8017	7383	17017	14228	17555	13314	6212	3.86E+07	
61	61	77	20122	19425	18696	14481	11186	11154	11154	11313	11820	11725	11059	10552	10552	13326	3617	1.31E+07	
37	97	78	28139	19837	19615	28614	14418	10299	8587	7890	7383	7732	8080	8176	8936	13670	7831	6.13E+07	
22	22	79	23481	22403	21706	19361	16256	12834	11249	9982	9158	8683	7985	7985	8999	13853	5969	3.56E+07	
29	26	80	11851	16161	22625	18633	10235	10425	9348	14798	24970	27474	6496	6971	12517	14808	6805	4.63E+07	
18	60	81	20471	15210	16288	14608	14418	13879	14291	16383	13404	15971	14957	13911	13372	15166	1888	3.56E+06	
60	62	82	18538	18759	19647	18094	16573	15907	15464	15274	15400	15337	14355	14038	14513	16300	1855	3.44E+06	
56	74	83	17460	36441	22594	15305	13277	12485	12041	11820	12105	12168	9190	14957	22625	16344	7283	5.30E+07	
42	44	84	36758	27315	22182	18696	16478	15495	14101	13372	13911	9411	7605	8556	12612	16653	8139	6.63E+07	
11	64	85	11154	18886	18664	18442	22910	26301	18284	11503	11661	11503	19393	15844	16541	17007	4672	2.18E+07	
70	52	86	25459	24019	24012	26349	17119	14201	14710	15785	15965	14645	15039	17657	11156	18163	4995	2.50E+07	

Information Only

mgw, rlb, 10-13-96				Travel Times (years) of 13 Particles from a Constant Line of Release Points												No Mining Effects			
				line is E-W, penetrating midpoint of waste panel area.												file is Microsoft Excel			
spring/96				release points are equally spaced along this line.						constant porosity = 0.16						Wallace PC			
grasp-	rep #1			exit boundary is the LWB.						data sorted by mean travel time						C:\data\paramete\minp_fac\virtimes\virgin4.xls			
t-field	cca	new						PARTICLE NUMBER											
index	run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var	
36	1	87	7542	8049	8746	11408	13626	15464	22689	25129	30959	24748	25541	26333	24939	18859	8237	6.78E+07	
1	36	88	22689	18854	16763	15971	15337	14577	13436	16351	20471	22308	22910	24558	25667	19222	4102	1.68E+07	
73	88	89	39927	30959	23544	23417	19615	17397	16668	18601	17809	12168	9697	9792	10299	19222	8776	7.70E+07	
79	18	90	67496	27981	24875	19266	16668	14260	14006	13246	13151	12517	12137	10362	6781	19442	15540	2.41E+08	
47	72	91	20312	12739	11313	9538	10109	19456	28202	38976	35491	33589	32956	30737	30135	24120	10619	1.13E+08	
74	51	92	22435	21675	21770	30642	34857	28963	28773	28868	28393	24527	20629	19330	19995	25450	4894	2.39E+07	
55	81	93	38026	27695	79220	75735	22910	18379	23576	17080	15654	15464	8049	4626	3771	26937	24301	5.91E+08	
88	27	94	24970	22784	28614	38976	29407	26206	20375	25889	24178	23988	27664	36124	28107	27483	5151	2.65E+07	
50	25	95	21896	27917	30357	29692	28519	27188	27790	28773	29185	29723	31276	39293	39927	30118	4777	2.28E+07	
83	48	96	25794	25002	25350	33272	23354	27505	38976	44046	51968	34857	30167	28139	26301	31903	8561	7.33E+07	
24	96	97	38343	41828	49750	32956	31688	26269	26808	26745	27822	33272	37392	46581	46898	35873	8307	6.90E+07	
97	95	98	3834	3803	3739	3708	3644	3612	3708	4722	23449	5926	4912	4278	462646	40922	126826	1.61E+10	
77	71	99	40878	35174	32639	33906	36441	41195	43096	47215	48800	46265	43413	43413	43096	41195	5181	2.68E+07	
13	94	100	37075	27474	29026	32639	40244	96649	40561	32005	34540	79537	67179	24463	14450	42757	23700	5.62E+08	
													summary mean, std. dev.:			12577	3964.428		
													coefficient of variation				0.315212		
													mean of total population				12577		
													std. dev. of tot. pop.				41854.35		
													skewness of tot. pop.				21.23466		
													coeff. of variation of tot. pop.				3.32784		

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mgw, rlb, 10-15-96			Travel Times (years) of 13 Particles from a Constant Line of Release Points.											Partial Mining Case				
			line is E-W, penetrating midpoint of waste panel area.					constant porosity = 0.16						file is Microsoft Excel				
			release points are equally spaced along this line.											Wallace PC				
grasp/inv	rep 1		exit boundary is the LWB.				data sorted by mean travel time					C:\data\parame\minp_fac\pmtimes\.parmin3.xls						
original	original	new						PARTICLE NUMBER										
T-field #	cca run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
31	66	1	4722	5165	6654	4215	3422	3422	3232	3017	2966	2988	2855	2681	2659	3692	1187	1.41E+06
40	30	2	4753	3549	2808	3166	3929	3150	2836	2630	2545	2861	3961	5514	7732	3803	1471	2.16E+06
30	42	3	2389	2199	2101	2478	2773	3771	3866	4436	5736	6338	5229	4975	5102	3953	1462	2.14E+06
64	100	4	7575	5167	4043	3596	3708	3778	3805	4195	3510	3740	4460	6018	5647	4557	1217	1.48E+06
48	34	5	7795	5229	4056	3612	3676	3771	3803	4151	3581	3739	4436	5989	5736	4583	1267	1.61E+06
87	37	6	7827	7985	7859	5102	4658	4500	4468	4531	4215	3391	2361	3391	4373	4974	1805	3.26E+06
9	31	7	6528	6401	5482	4912	4278	7003	6876	6559	5577	3866	3140	3020	2795	5111	1547	2.39E+06
38	24	8	7985	7415	6591	7257	5577	5102	4785	4626	4595	4341	3486	3327	3739	5294	1556	2.42E+06
32	58	9	3131	3486	3834	3803	4024	4595	4215	3866	4785	7003	7764	9411	11059	5460	2529	6.39E+06
62	4	10	5862	6052	6274	6750	6908	5450	4753	4943	5957	5767	4943	4056	3517	5480	1002	1.00E+06
19	63	11	7542	7257	6654	5989	5482	4975	4373	4088	3834	4119	4531	5229	7732	5523	1385	1.92E+06
86	3	12	6401	5292	3771	3454	5767	6464	6147	5894	6211	6433	6654	7066	3929	5653	1188	1.41E+06
71	5	13	6433	4278	4278	4563	5007	4753	5133	4943	6338	6718	7162	7035	7193	5679	1145	1.31E+06
21	39	14	8207	7954	6654	5450	5260	5545	5450	5514	5894	5799	5862	6052	5926	6121	940	8.83E+05
45	57	15	5894	3866	4088	4246	3961	3961	4088	5640	13974	11218	7383	5767	5704	6138	3109	9.67E+06
44	12	16	8049	7098	6147	5767	8556	7890	5831	4975	4658	4658	5165	5545	6464	6216	1316	1.73E+06
63	28	17	10489	10394	9094	6718	5450	4341	4341	4722	5482	5989	4531	5102	4310	6228	2280	5.20E+06
16	59	18	6401	6116	6433	6750	6654	6433	4943	4943	5862	6591	7066	6591	6369	6243	645	4.17E+05
91	78	19	5419	5197	5387	5894	5894	5038	6116	8397	5419	6686	7352	7732	7573	6316	1114	1.24E+06
17	55	20	9538	9348	9823	6781	6433	6813	6686	6401	6179	5862	3708	2789	4373	6518	2145	4.60E+06
43	91	21	9316	7288	5989	4785	4658	4722	4785	4975	5640	7415	7288	9158	11756	6752	2229	4.97E+06
28	80	22	9792	9506	9094	8873	8461	9285	9506	4373	4246	4468	4658	4405	4500	7013	2499	6.25E+06
46	11	23	7985	14481	7225	6623	6306	6116	6116	6084	6021	6433	6496	5989	5799	7052	2309	5.33E+06
7	93	24	7669	8904	9728	11281	9760	8714	6116	7098	6147	5324	4848	4215	3644	7188	2379	5.66E+06
67	43	25	13467	8207	6845	6559	7795	7542	6654	6243	6528	6591	5957	6369	5704	7266	1995	3.98E+06
89	99	26	10299	9506	7890	7098	5514	5324	6052	5894	7035	7352	8556	6243	7954	7286	1530	2.34E+06
96	45	27	9475	10204	7764	7764	6274	5609	6116	7795	7478	7542	6908	9982	3612	7425	1825	3.33E+06
3	89	28	10520	8809	7859	8017	7795	7510	7003	6781	6750	6876	6908	6750	6750	7564	1098	1.21E+06
4	79	29	7035	6496	8746	9633	7922	7288	7573	6623	6528	8176	7795	7510	8207	7656	913	8.33E+05
69	67	30	7859	7573	7890	7795	7637	7542	7573	7320	7859	9316	9094	8746	7288	7961	661	4.36E+05
35	19	31	10172	9728	8999	8239	7795	8112	7922	7985	8144	8587	7732	7225	5989	8202	1056	1.11E+06
97	95	32	6021	5926	5989	6021	5736	5419	5387	7383	44680	11281	4373	5957	5000	9167	10801	1.17E+08
49	16	33	7669	7130	7066	6845	7035	8017	8999	12200	11408	19076	12739	11566	11439	10091	3501	1.23E+07
6	7	34	15274	16890	10489	8841	9633	8144	7447	7130	7352	7732	11851	11471	10109	10182	3062	9.38E+06
12	84	35	9158	10711	12168	13436	12580	10932	11281	9950	9190	8556	9348	9665	11344	10640	1490	2.22E+06
33	33	36	16826	20375	17302	17080	13911	11186	9950	8651	7130	6147	5514	5292	5324	11130	5376	2.89E+07
81	38	37	16383	23671	16890	14291	9792	8968	8461	14228	7193	6845	6211	6084	7510	11271	5382	2.90E+07
11	64	38	5419	7447	7827	7383	6940	6813	8334	10013	11851	15274	16731	24653	23037	11671	6366	4.05E+07
72	76	39	10616	10425	10299	9982	10520	12865	14133	15084	13879	13721	10140	10679	14798	12088	1996	3.98E+06
52	83	40	12960	13309	13119	10711	9316	9253	9697	10140	11534	14038	14672	14545	14735	12156	2125	4.52E+06
41	10	41	12041	10013	11218	10235	10742	11725	12232	12580	13214	15527	14577	13277	13879	12405	1666	2.78E+06
68	50	42	14006	14672	17397	20027	18189	10172	9411	10901	12992	12612	9475	8302	7795	12765	3934	1.55E+07
26	14	43	19837	18189	17143	16224	12707	13816	16858	19140	14545	10520	7859	6147	5545	13733	4874	2.38E+07

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Table APNS11.3

original	original	new						PARTICLE NUMBER											
T-field #	cca run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
39	87	44	25414	24622	22055	18189	14228	10647	11218	12770	10394	8397	7383	7098	6211	13740	6719	4.51E+07
57	32	45	22657	18157	23513	14418	13024	12612	13689	11439	10457	9665	9158	10013	10299	13777	4797	2.30E+07
23	20	46	39293	8271	7827	6940	7478	7320	7573	7859	13341	16066	17460	19203	21263	13838	9232	8.52E+07
5	68	47	14640	13467	11439	10077	10806	11059	11281	11915	14165	15115	16351	18696	21738	13904	3438	1.18E+07
82	46	48	22784	22055	21199	18031	15147	14133	13309	12327	10742	9475	8714	8904	8112	14226	5274	2.78E+07
58	56	49	19615	18601	18031	17555	29216	13594	12517	11820	10077	8873	9031	9094	9063	14391	6007	3.61E+07
51	70	50	18728	20154	25604	29755	24590	16795	12041	11376	9443	6211	5197	4912	4785	14584	8640	7.46E+07
59	77	51	40878	12897	20502	15527	10996	10774	13119	17682	15591	13499	9855	7764	5767	14988	8737	7.63E+07
53	40	52	26333	25699	17175	14735	12992	10299	8461	7003	9411	12105	12992	16795	21104	15008	6223	3.87E+07
76	9	53	15464	17238	29660	21485	14608	12897	12802	12802	13151	14323	12739	11376	10489	15310	5145	2.65E+07
93	82	54	15781	13087	10394	11439	10806	14165	13055	21136	20375	18506	16383	19013	19140	15637	3752	1.41E+07
78	75	55	17650	15907	15274	15622	14767	14862	16256	17460	20566	15020	13309	13499	14481	15744	1940	3.76E+06
15	29	56	26111	20914	19425	19330	17809	16541	16098	13911	13499	13753	14006	14070	13151	16817	3825	1.46E+07
84	21	57	9760	13119	13626	12295	12137	14006	14228	14735	15654	18379	22974	32005	34223	17472	7663	5.87E+07
54	6	58	13372	16098	15686	16193	18316	17872	19235	23132	20566	18728	18347	17809	17397	17904	2401	5.76E+06
8	41	59	10362	8429	6591	5831	8366	14608	22087	21485	17619	22182	37075	30896	29375	18070	10159	1.03E+08
10	47	60	30009	27093	20407	13277	23196	8144	13467	47215	25572	18633	10299	7035	5577	19225	11638	1.35E+08
18	60	61	38026	23227	23798	20471	17587	15147	15084	15400	16478	17587	16763	15876	15274	19286	6365	4.05E+07
14	13	62	28773	25953	23829	18728	17524	17397	15464	15559	17112	17492	18062	18442	18284	19432	4097	1.68E+07
75	15	63	8683	5894	4943	4468	19013	40244	36124	34223	22467	21263	19298	18189	17904	19439	11832	1.40E+08
100	90	64	19171	17840	16668	17682	17872	17650	20217	21516	22942	21675	22277	22277	23449	20095	2377	5.65E+06
70	52	65	31688	26871	25382	36441	28361	18474	15527	14196	13594	13594	12897	11693	13943	20205	8400	7.06E+07
27	35	66	23798	21041	42145	20217	19742	19552	19773	17524	17587	17999	17302	16636	16288	20739	6755	4.56E+07
94	92	67	36758	32639	44363	25065	17175	15654	15020	14545	14450	13848	12802	13372	18157	21065	10385	1.08E+08
36	1	68	15686	21738	14070	13055	14355	14862	17587	25477	25636	36441	29090	31435	28044	22113	7753	6.01E+07
37	97	69	66545	51335	46581	32956	21389	14608	12010	10932	10647	10869	11123	11123	11376	23961	19146	3.67E+08
1	36	70	41511	35491	29977	27347	25255	23893	16098	15781	16795	17397	19361	21516	22815	24095	7862	6.18E+07
66	53	71	44363	80488	48800	25541	15971	13626	16446	13753	13531	11598	10109	9665	9380	24098	21277	4.53E+08
98	73	72	46265	35174	32956	23766	22815	25636	26618	23798	21263	19393	17555	17777	16256	25329	8455	7.15E+07
90	98	73	35491	35174	34540	34857	35491	35491	36124	28931	20502	15971	13214	13911	12422	27086	10109	1.02E+08
95	17	74	68763	46265	29818	27474	27283	25636	23069	20375	18252	19552	20661	20344	19963	28266	14230	2.02E+08
92	23	75	26523	21960	20882	18347	17460	19647	27283	45948	40244	39927	33906	30737	37392	29251	9524	9.07E+07
73	88	76	57672	51018	48166	45948	44363	36758	33906	23006	16605	10267	7985	8176	6528	30031	18683	3.49E+08
2	2	77	63693	59257	50067	34540	25350	22974	21104	21389	20059	19456	20502	22277	26364	31310	15784	2.49E+08
74	51	78	35491	32956	32005	33589	34857	28456	27347	27569	30199	40244	45948	40878	33272	34062	5542	3.07E+07
29	26	79	36124	42145	52285	51018	30167	46265	21104	26174	42145	49117	14481	10964	21801	34138	14267	2.04E+08
88	27	80	71932	45314	48483	39927	32322	27917	21485	23766	24241	24273	28678	39927	28614	35145	14078	1.98E+08
61	61	81	42779	40878	38976	37392	37075	36124	35174	34540	34857	34540	32322	29565	27727	35535	4169	1.74E+07
99	8	82	155589	100134	34857	31181	31308	16605	12612	12802	19140	11503	14925	15210	14988	36219	42938	1.84E+09
56	74	83	67179	44363	44997	43413	92846	24305	22815	22213	20692	19678	18094	20185	33906	36514	22328	4.99E+08
65	69	84	80171	52285	37392	24907	21199	15591	15559	19520	31149	32005	55454	61158	49433	38140	20079	4.03E+08
83	48	85	44997	41828	38976	36124	32639	28741	34857	61158	86192	49750	38343	33272	28773	42742	15823	2.50E+08
42	44	86	121365	83657	70981	56405	44046	49117	32322	26364	22340	23798	16921	16288	17904	44731	31578	9.97E+08
20	54	87	53236	53553	79854	76685	173968	43413	21389	19995	22942	20724	11978	14070	12739	46503	45011	2.03E+09
24	96	88	58940	62426	73833	47215	45631	36124	35808	36124	37709	42462	45314	51652	59574	48678	11962	1.43E+08
80	86	89	92846	69714	53236	48800	50067	52602	58623	53870	50701	47215	46898	48800	50067	55649	12705	1.61E+08
55	81	90	83973	70664	123584	142280	94431	48800	50701	39927	35491	23417	13499	7922	6306	57000	43666	1.91E+09
79	18	91	207874	216113	87776	51335	34857	31118	23544	20502	20882	19900	20439	21199	19583	59625	70285	4.94E+09

Information Only

Table APNS11.3

original	original	new						PARTICLE NUMBER											
T-field #	oca run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var	
50	25	92	109324	66545	62109	60207	60524	55771	57672	65594	53236	51335	50067	55454	66545	62645	15075	2.27E+08	
47	72	93	82389	66862	43096	32322	21770	72566	61158	91579	91262	77002	68129	62109	59257	63808	21149	4.47E+08	
34	65	94	47532	42145	112810	570386	1000000	29755	20597	24590	19013	17840	17904	22530	17048	149396	296601	8.80E+10	
85	85	95	261744	221817	225619	127069	69080	69080	32005	14038	9728	8556	7700	7225	8461	81702	95351	9.09E+09	
77	71	96	127069	109007	95064	91262	96649	100451	104254	110275	128971	129921	115662	129604	127386	112736	14569	2.12E+08	
60	62	97	154955	152103	155589	141963	114394	109007	94114	94431	101085	103620	104888	99184	59890	114248	28793	8.29E+08	
25	49	98	160025	104571	121048	147033	196783	167313	154321	107106	85875	79854	67813	60841	61475	116466	45012	2.03E+09	
22	22	99	78903	78586	96332	120098	123584	141329	220549	198051	179038	165729	159708	160975	487997	170068	105000	1.10E+10	
13	94	100	389763	284559	190445	178087	166046	241463	270933	160975	166362	323218	263011	128654	80171	218745	85793	7.36E+09	
													summary mean, std. dev.:			26911.3	3693.27		
														coefficient of variation			0.13724		
														mean of total population			26911		
														std. dev. of tot. pop.			50085.6		
														skewness of tot. pop.			8.8429		
														coeff. of variation of tot. pop.			1.86113		

101

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mgw, rlb, 10-15-96			Travel Times (years) of 13 Particles from a Constant Line of Release Points.											Full Mining Case				
			line is E-W, penetrating midpoint of waste panel area.					constant porosity = 0.16						file is Microsoft Excel				
			release points are equally spaced along this line.											Wallace PC				
grasp./inv	rep 1		exit boundary is the LWB.				data sorted by mean travel time			C:\data\parame\minp_fac\fmtimes\.fulmin3.xls								
original	original	new						PARTICLE NUMBER										
T-field #	cca run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var
69	67	1	5989	4912	4405	4278	4183	4119	3961	3708	3391	3264	2979	2868	2690	3903	913	8.33E+05
17	55	2	6528	4880	3898	3486	3898	4595	4436	4024	3739	3359	2332	2516	3549	3942	1065	1.13E+06
19	63	3	7193	6274	5387	4753	4722	3993	3264	2789	2469	2161	2041	2516	5862	4109	1719	2.96E+06
49	16	4	6369	5133	4722	4278	3961	3676	3612	3708	3929	3549	3549	3803	4024	4178	810	6.57E+05
38	24	5	7352	6179	6147	6116	4215	3708	3327	3042	2858	2665	2548	2963	3391	4193	1652	2.73E+06
31	66	6	8587	8302	7637	4595	3296	3486	3327	3029	2928	2890	2646	2488	2636	4296	2282	5.21E+06
30	42	7	4278	3771	3296	2969	2681	2713	3359	5514	8651	6908	4373	4785	4912	4478	1744	3.04E+06
32	58	8	3200	3391	3866	3834	4151	4753	4246	3549	3039	3391	4405	8017	9855	4592	2025	4.10E+06
64	100	9	14350	8730	6880	4000	3016	2720	2540	2300	2120	2301	3007	3510	5298	4675	3522	1.24E+07
16	59	10	5482	5387	5514	5038	4690	4690	3929	3771	4310	4785	5197	4531	3929	4712	602	3.62E+05
3	89	11	6654	6718	7288	6971	5450	4626	4310	4119	3803	3676	3676	3549	3391	4941	1472	2.17E+06
8	41	12	3834	3612	3517	3200	3581	4848	4785	4658	4626	4405	4880	10964	12105	5309	2832	8.02E+06
48	34	13	15844	13721	7985	4943	3327	2985	2779	2449	2199	2389	3121	3612	5482	5449	4459	1.99E+07
96	45	14	8746	9253	9158	7573	6243	5704	5165	4975	4405	4151	3961	3581	2687	5815	2217	4.91E+06
46	11	15	8271	12580	6274	5862	5704	5482	5229	5133	5038	4848	4595	4341	4119	5960	2250	5.06E+06
35	19	16	9316	8587	7478	6528	6179	6908	6021	5767	5577	6147	4975	4595	4468	6350	1445	2.09E+06
87	37	17	9190	7922	6591	5957	5514	4753	4278	4151	4024	3739	4817	5926	16066	6379	3320	1.10E+07
78	75	18	10425	8556	7605	8080	6686	6211	6876	5419	5165	4912	4658	4880	5324	6523	1744	3.04E+06
63	28	19	16731	9506	7573	7193	7320	5514	5070	4753	5355	6211	4341	5355	6211	7010	3242	1.05E+07
97	95	20	2811	2728	2551	2380	2285	2329	2583	5514	55771	10837	2101	3090	1000000	84229	275543	7.59E+10
14	13	21	8873	7922	7985	8112	8904	8302	8366	7415	6338	6052	6623	7288	7669	7681	909	8.26E+05
15	29	22	14893	10425	10330	10457	9190	7605	6686	6464	6243	5736	5260	4405	3486	7783	3148	9.91E+06
76	9	23	16034	12739	10267	8271	6813	6559	6686	6845	7573	9031	7003	5292	4531	8280	3154	9.95E+06
72	76	24	12422	10869	10235	9475	8873	8778	8461	7890	6845	6052	5292	7225	8207	8509	1964	3.86E+06
33	33	25	20851	17872	12453	11186	9031	7193	6940	7066	6559	3898	3517	3549	3644	8751	5528	3.06E+07
84	21	26	7162	7827	5767	5229	5102	4912	4848	5672	6845	6845	7415	18347	28424	8800	6865	4.71E+07
4	79	27	7415	7669	13087	14988	11344	9950	10489	8366	7795	10520	8904	7478	7225	9633	2413	5.82E+06
7	93	28	13784	13974	11725	10806	10520	9538	9094	11946	9697	8271	7447	6464	5545	9909	2593	6.72E+06
71	5	29	11313	9728	10045	10394	10932	10520	10774	10204	11851	11091	10425	9665	8778	10440	797	6.35E+05
86	3	30	10774	11725	8080	15305	8619	7859	8904	9950	10837	13182	12263	11344	8239	10545	2238	5.01E+06
11	64	31	31149	11915	10964	10616	10901	11123	10045	7859	7605	7383	7447	7764	8556	11025	6268	3.93E+07
40	30	32	15210	13467	12770	13214	13277	12580	12073	11313	10901	10013	7003	7257	8873	11381	2490	6.20E+06
9	31	33	20439	11059	10045	9760	9443	14006	14006	12580	10394	9950	9633	9411	9094	11525	3168	1.00E+07
12	84	34	14133	13467	12834	12897	12612	13277	19203	18411	12770	8239	6116	5165	4500	11817	4611	2.13E+07
58	56	35	22055	20502	19330	23481	13689	9253	8524	7954	7035	6528	6369	6274	6147	12088	6776	4.59E+07
52	83	36	20280	20439	20439	16351	12865	11471	10679	10964	10616	11756	12675	12739	14070	14257	3817	1.46E+07
89	99	37	43970	73634	10471	5850	6374	6450	6824	7274	7340	7330	6065	4710	4913	14708	20533	4.22E+08
21	39	38	25953	24368	19140	16066	15654	14545	13753	12041	11725	11439	11471	11756	12200	15393	4909	2.41E+07
51	70	39	27030	26935	24083	23576	19995	15432	13499	12073	10584	8429	7225	7383	7225	15651	7720	5.96E+07
45	57	40	68763	36758	9031	6496	12041	11756	10425	10616	11344	9538	7352	6528	6654	15946	17708	3.14E+08
54	6	41	11408	12897	14545	20787	19013	20566	23513	28773	20344	17175	15654	14703	14101	17960	4839	2.34E+07
26	14	42	38343	22784	16795	16446	16858	21199	24685	21896	17619	14481	12992	16224	25636	20458	6661	4.44E+07
68	50	43	60524	58306	27505	18633	18221	15369	15717	18728	22435	34223	25350	21326	20027	27413	15101	2.28E+08

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Table APNS11.4

original	original	new						PARTICLE NUMBER											
T-field #	cca run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var	
6	7	44	26998	95064	59257	41511	44680	22277	14545	13436	13024	12834	12897	13246	13246	29463	24920	6.21E+08	
5	68	45	189812	109641	11218	8271	7225	6876	6591	6464	6971	7795	8651	10013	7954	29806	55698	3.10E+09	
60	62	46	34857	28456	29914	33906	26269	22467	21611	21738	22055	22720	28931	120415	50701	35695	26692	7.12E+08	
62	4	47	40878	40878	39293	37075	36758	35174	32639	34223	41828	44997	47215	40244	47215	39878	4693	2.20E+07	
44	12	48	32005	30167	27822	30516	44997	50067	42145	45948	52285	53553	57989	55454	61158	44931	11524	1.33E+08	
79	18	49	153370	72249	58940	39927	38343	31498	29185	30294	35174	33589	32322	24939	18379	46016	35219	1.24E+09	
57	32	50	55454	46581	48166	45631	43413	47532	55771	55771	49433	44363	41511	39927	39293	47142	5730	3.28E+07	
70	52	51	236393	204705	26016	39927	27030	20027	13911	11915	10806	10552	9601	8302	7732	48224	77320	5.98E+09	
41	10	52	104571	119464	57355	64010	128654	23956	19615	18474	18126	20027	17587	19868	23988	48900	42199	1.78E+09	
53	40	53	64010	57039	59257	51652	35491	40561	27790	37075	53236	51968	51968	63376	68129	50889	12280	1.51E+08	
98	73	54	147350	78586	60524	42145	42779	47215	50067	46581	42779	40244	27600	29438	25446	52366	31807	1.01E+09	
92	23	55	30262	27759	27315	23576	23988	34540	59574	90945	85558	84924	71615	72249	55137	52880	26054	6.79E+08	
23	20	56	47532	46265	53236	63059	112810	90945	92212	91579	43413	27315	15622	12897	12548	54572	33641	1.13E+09	
18	60	57	173334	72249	75735	42779	39610	40561	44046	40878	38343	39293	38026	36441	35174	55113	37853	1.43E+09	
74	51	58	146716	111542	90628	57355	52285	42779	40561	39927	39927	36758	38343	28868	20914	57431	36608	1.34E+09	
22	22	59	87142	68129	52602	46265	45314	45631	46898	49433	53553	57989	62742	70664	77953	58794	13607	1.85E+08	
20	54	60	115978	108690	95064	78586	67179	50701	40561	39610	36758	40561	35808	34223	29533	59481	30418	9.25E+08	
81	38	61	52285	52919	57039	66545	86825	102036	90311	94431	95381	25255	20787	14925	15242	59537	32636	1.07E+09	
28	80	62	23069	40878	53870	57989	56405	53553	78270	73516	73199	73199	73199	73199	73833	61860	16293	2.65E+08	
90	98	63	265546	218648	152737	32005	26871	25604	23164	17619	12897	12073	11471	10520	9855	63001	88484	7.83E+09	
85	85	64	91262	80805	72566	60207	50701	54504	44363	47215	66545	64961	60841	61475	96649	65546	16089	2.59E+08	
82	46	65	71615	76368	102353	69080	68446	65277	61792	59890	61475	64644	77953	65911	56722	69348	11680	1.36E+08	
25	49	66	112810	124851	109641	100134	96649	88410	69397	44997	49117	42462	36758	30040	26396	71666	35068	1.23E+09	
95	17	67	191713	173968	231006	92212	44680	38659	30135	23164	20059	23037	23925	23386	22657	72200	75620	5.72E+09	
80	86	68	67813	113760	76051	69080	66545	66228	67179	70031	68763	67813	68446	69080	69714	72346	12680	1.61E+08	
67	43	69	80488	58623	52919	59890	63693	55771	55454	85875	90945	87142	85875	84924	84924	72809	14907	2.22E+08	
66	53	70	70031	71615	64644	80805	99184	103937	121048	88410	50067	46265	49750	56088	58940	73906	23425	5.49E+08	
94	92	71	218965	204705	171116	91262	44680	40561	37392	35174	33589	31023	25953	21896	24843	75474	72770	5.30E+09	
39	87	72	56088	50067	45314	38026	39610	54820	79220	94431	115978	125485	119147	115345	110275	80293	34117	1.16E+09	
91	78	73	143864	147666	145448	139111	141646	237661	65911	57039	13911	14735	15654	15781	15495	88763	74090	5.49E+09	
47	72	74	129604	90311	83657	75101	53870	39293	66545	87776	94747	97599	104888	108056	135308	89750	27298	7.45E+08	
75	15	75	138794	135625	227837	239562	54820	111542	92846	85241	48800	45314	38343	28519	25160	97877	71358	5.09E+09	
10	47	76	60841	63059	58623	51652	75735	101402	135942	122633	117563	110908	104254	139428	134991	98233	32309	1.04E+09	
50	25	77	116929	117246	115028	107106	102036	90311	83657	81438	84290	90945	102669	93480	110275	99647	13078	1.71E+08	
37	97	78	163511	123900	130238	232907	236076	100768	79854	70664	53870	46898	51335	39610	29058	104515	69939	4.89E+09	
2	2	79	77953	57039	71615	81438	98867	135308	122316	128654	123584	163511	112493	112810	139111	109592	30676	9.41E+08	
59	77	80	67813	272201	459477	418283	38026	32956	32322	38343	35491	32639	11756	11915	13467	112668	160099	2.56E+10	
43	91	81	52919	52285	50384	58306	64010	66862	77953	97282	156856	224669	195199	195199	191079	114077	67206	4.52E+09	
27	35	82	35491	45948	135942	472153	250336	130555	127703	126435	64327	49750	45314	48483	48166	121585	121774	1.48E+10	
55	81	83	92846	94114	143230	215479	96649	93163	110591	92846	92212	83973	77636	204705	203438	123145	50849	2.59E+09	
42	44	84	265863	196783	119781	87142	80171	79854	96966	93163	83340	121365	85241	131506	167947	123779	55902	3.12E+09	
77	71	85	171116	116612	84290	73833	77002	90945	104254	116612	130872	139111	150518	197734	157173	123852	38329	1.47E+09	
29	26	86	136259	146716	162243	151469	112810	109958	109641	127386	156539	161609	103620	99184	105838	129482	23922	5.72E+08	
100	90	87	105204	109324	121999	144498	158440	145448	141963	139111	146399	135942	133724	121682	136259	133846	15341	2.35E+08	
93	82	88	145765	147666	210409	107423	103937	112810	111542	144181	147666	145448	140378	125168	115662	135235	28260	7.99E+08	
73	88	89	131506	121999	108056	98550	85875	80488	81122	93797	108056	271884	242731	177453	166679	136015	61970	3.84E+09	
34	65	90	132139	121999	148934	434127	132139	127386	116929	109324	107106	109958	114077	117246	118197	145351	87535	7.66E+09	
99	8	91	118197	99184	91579	86508	140378	98867	131822	361244	162877	164778	205973	174601	181256	155174	72716	5.29E+09	

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Table APNS11.4

original	original	new					PARTICLE NUMBER												
T-field #	cca run #	rank	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	mean	std dev	var	
36	1	92	71615	98233	116295	130238	139111	141012	152103	173968	179038	215162	242097	232274	226253	162877	54105	2.93E+09	
56	74	93	218648	182840	206606	206289	271250	256674	373919	207557	129287	23608	19837	45631	52602	168827	108326	1.17E+10	
1	36	94	217063	188861	180622	179038	183791	169848	188227	239562	315613	236076	180622	66228	43096	183742	69658	4.85E+09	
24	96	95	203754	208191	230056	225619	208824	288045	383426	342231	265229	200902	193297	198367	205656	242584	60626	3.68E+09	
61	61	96	220232	216747	234809	241780	289946	282024	276320	270933	261110	252871	248435	241146	233224	251506	23286	5.42E+08	
83	48	97	269032	265546	261110	320050	380257	386595	358075	339063	421452	332725	272201	235126	205973	311323	65113	4.24E+09	
65	69	98	114077	122633	186009	245266	389763	437296	399270	392932	377088	383426	430958	427789	408776	331945	119848	1.44E+10	
88	27	99	233858	274736	339063	991837	222450	215162	252237	300720	286460	286777	345400	411945	380257	349300	202169	4.09E+10	
13	94	100	662281	548204	468984	478490	573554	636931	880929	1000000	1000000	1000000	1000000	475321	262060	691289	255096	6.51E+10	
													summary mean, std. dev.:			70565.4	5991.48		
													coefficient of variation				0.08491		
													mean of total population				70565		
													std. dev. of tot. pop.				111090		
													skewness of tot. pop.				4.17188		
													coeff. of variation of tot. pop.				1.57428		

h01

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