DESCRIPTION AND RATIONALE FOR ENHANCEMENT TO THE BASELINE ESF CONFIGURATION

CALC. # B00000000-01717-0200-00089 REV 01

DECEMBER 1, 1993

CRWMS/M&O

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Revision No.	Description of Revision
0	INITIAL RELEASE
1	INCORPORATION OF COMMENTS RESULTING FROM
	LEVEL 3 CCR REVIEW (SEE MEMO LVSB.PWM.12/93-105
	FOR INFORMATION ON REVISION 1). CHANGES APPEAR ON
	PAGES 4, 6, 12, 16, 24, 25, 5, 7.

1. PURPOSE

The purpose of this Design Analysis is to describe an adjustment to the Baseline Exploratory Studies Facility (ESF)/Conceptual Repository configuration, to discuss the rationale for the change, and to address technical and programmatic issues arising from the change. When the design analysis has been technically reviewed, it will form the basis for a proposed change in the ESF Technical Baseline to be submitted to the Yucca Mountain Site Characterization Project (YMP) Change Control Board (CCB).

This document consists of: a main body containing descriptions of the current baseline configuration, the adjustments to that configuration, and the rationale for these changes; Appendix 1, containing discussions on several issues and considerations, both technical and programmatic, that must be addressed when making changes of this type; and Appendix 2, containing additional figures showing the potential repository emplacement areas imposed on the structure maps used to develop the configuration.

2. QUALITY ASSURANCE

The configuration of the ESF is considered to be Quality Affecting.

3. METHOD

Engineering calculations and graphic methods were utilized in the development of this analysis.

4. CODES AND STANDARDS

4.1 CODE OF FEDERAL REGULATIONS (CFR):

10 CFR 60	Disposal of High-Level Radioactive Waste in Geologic Repositories, January 1, 1993
10 CFR 960	General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, January 1, 1993
29 CFR 1910	Occupational Safety and Health Standards, July 1, 1992
29 CFR 1926	Safety and Health Regulations for Construction, July 1, 1992
30 CFR	Chapter I, Subchapters D, E, and N, Mine Safety and Health Administration, July 1, 1992

40 CFR 191 Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, July 1, 1992

4.2 CALIFORNIA ADMINISTRATIVE CODE (CAC):

Title 8, Division 1; Chapter 4; Subchapter 20 - California Tunneling Orders, October 9, 1992

4.3 STATE OF NEVADA:

Nevada Revised Statutes, Title 46, Mines and Minerals - Chapter 512, State of Nevada Health and Safety Standards for Open Pit and Underground Metal and Nonmetal Mines and Sand, Gravel, and Crushed Stone Operations, July 1, 1985

Nevada Revised Statutes Title 53, Labor and Industrial Relations - Chapter 618, Occupational Safety and Health, 1989

In addition to these requirements, the design and operation of the ESF is subject to an extensive list of guidelines including: DOE Orders, State Statutes, and Standards of various industrial and professional societies such as the American Society for Testings and Materials (ASTM) and the American Society of Civil Engineers (ASCE). A complete listing of these orders, statutes and standards is given in Appendix E of the Exploratory Studies Facility Design Requirements (YMP/CM-0019).

5. DESIGN INPUTS

Design inputs to the analysis include the ESF Technical Baseline, the ESF Design Requirements, and output from the Interactive Graphics Information System (IGIS) geologic model operated by Sandia National Laboratories (SNL). Both the IGIS model and the bulk of the geologic data are unqualified. Overall, confidence in the current geologic model is not high. This is primarily due to a lack of data on the west side of the Ghost Dance fault. FY 1994 drilling activity should help to solidify the model and increase confidence. The information used is the best available and its use is consistent with the program's past design efforts. SNL uses a controlled process to maintain traceability of data used in the IGIS Model. The first data set came from a 1984 Sandia report (Reference 9.12), and changes subsequent to that have been tracked by SNL (Reference 9.13).

6. DESIGN CRITERIA

Section 3 of the ESF Design Requirements Document (YMP/CM-0019) contains the criteria governing design and operation of the ESF.

7. ASSUMPTIONS

The current version, Rev. 2 of the ESF Technical Baseline, contains drawings showing the slope of the North Topopah Spring Level (TSL) Ramp to be 9.52% and the Main TSL Drift slope to be 5.92%. Volumes 1 and 3 of the Title I Design Summary Report (Reference 9.1) were used to form the ESF Technical Baseline Document (Reference 9.3). A revision to the Title I Design was developed prior to its incorporation into the ESF Technical Baseline, but the revision was not made part of the Title I Package before the ESF Technical Baseline was formed. The revision incorporated a change in the TSL "entry point" elevation which in turn changed the slope of the north ramp to 6.9% and the main TSL drift slope to 4.7%. The entry point is the place where the curve of the north ramp ends and the TSL main drift begins. The elevation change was prompted by a re-evaluation of existing drill core which resulted in the raising of the Topopah Spring Welded (TSw1-TSw2) contact elevation by some 140 feet. This is discussed further in Section 10.1.3.3.

The failure to incorporate the revision is an oversight which must be corrected via Change Request in the near future. The revised drawing package will be inserted into the ESF Technical Baseline by the Change Request. Therefore, when reference is made in this Design Analysis to the ESF Technical Baseline, it is assumed that the revised drawings are in the Baseline.

The terms "repository" and "potential repository" are synonymous in this document. Where the term "repository" is used, it is assumed that "potential" is inferred.

8. COMPUTER PROGRAMS

The IGIS model operated by SNL was utilized to prepare the following structure maps:

- Surface Contours
- TSw1 - TSw2 Contact
- TSw2 - TSw3 Contact
- Top of Water Table

These maps were used manually to develop the ESF/Conceptual Repository configuration.

See Section 5. Design Inputs for more information on the IGIS model and data base.

9. REFERENCES

9.1 YMP/92-40 "Title I Design Summary Report for the Exploratory Studies Facility"

9.2 SAND91-0025 "Exploratory Studies Facility Alternatives Study (ESFAS)"

9.3 YMP/CM-0016 "ESF Technical Baseline"

9.4 SAND84-1351 "Two Stage Repository Development at Yucca Mountain: An Engineering Feasibility Study"

9.5 "Sixth Report to the U.S. Congress and the U.S. Secretary of Energy," Nuclear Waste Technical Review Board (NWTRB), December 1992

9.6 YMP/91-28 "Documentation of the Evaluation of Findings of the ESFAS Used to Develop a Reference Design Concept"

9.7 YMP/CM-0019 "Exploratory Studies Facility Design Requirements"

9.8 "Underground Locomotive Haulage," Health and Safety Executive Library and Information Services, Broad Lane, Sheffield, S3 7HQ, England, 1991

9.9 SAND84-2641 "Site Characterization Plan Conceptual Design Report," September 1987.

9.10 RSN Calculation ST-MN-208, Rev. 0, 1/31/92~~4~~ "Determination of Potential Repository Boundary Entry Point Elevation for the ESF North Ramp"

9.11 NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada; NUREG-1347; August 1989; Comment 35

9.12 SAND 84-1076 "A Three-Dimensional Model of Reference Thermal/Mechanical and Hydrological Stratigraphy at Yucca Mountain, Southern Nevada" Ortiz, et al.

9.13 LTR, Shephard to McKenzie, September 15, 1993.

9.14 CRWMS B00000000-01717-5705-00009, "Repository Sub-Surface Layout Options and ESF Interfaces," (in process)

9.15 CRWMS B00000000-01717-0200-00096-00, "ESF North Ramp Layout Design Analysis." (In Process)

10. ANALYSIS

10.1 INTRODUCTION

10.1.1 Background and Overview

The Title I ESF Design (Reference 9.1) was derived from Option 30 (as revised by Reference 9.6 with favorable repository features of other options) of the ESFAS (SAND91-0025) (Reference 9.2). One of its primary features is a main drift connecting the lower ends of the north and south ramps in the TSL (Figure 1). This main drift is oriented at N34°E, coincident with the alignment of one of the repository main access drifts as shown in the Exploratory Studies Facility Technical Baseline (YMP/CM-0016) (Reference 9.3). The basic location and orientation of the main drift can be traced back to a study performed in 1984 on a phased repository approach (SAND84-1351) (Reference 9.4).

The main drift is positioned near the top of the TSw2 unit at its northern end and slopes at 4.7% upward to the south (against the dip of the formation) to intersect the lower end of the south ramp at a lower point in the TSw2 unit. It intersects the projected location of the Ghost Dance Fault at an oblique angle approximately 915 meters (3,000 feet) from the north end of the drift.

Recent work on the Advanced Conceptual Design (ACD) for the potential repository (Reference 9.14), coupled with concerns on the part of the NWTRB (Reference 9.5) and current project participants, has led to a proposed enhancement to the Option 30-based ESF/repository design. The revised ESF layout will result in a longer north ramp, a shorter south ramp, and a main drift of about the same length as the current layout (Figure 2). The main drift will be oriented approximately north-south and will run sub-parallel to, and west of, the Ghost Dance Fault, with a nominal 122 meter (400 ft) offset. The Main Test Area will be located in the same basic area as in the current layout. The initial "loop" will be approximately 7,791 meters (25,560 feet) in length, or about 200~~165~~ meters (650~~540~~ feet) shorter than with the Title I-based layout. Access to, and drifting in, the Calico Hills formation will be largely unaffected by this change.

The change will:

- Maintain the portal location and the horizontal alignment of the north ramp.
- Enhance the safety and overall operability of the ESF by flattening grades in the access ramps and upper level, and by avoiding penetration of the Ghost Dance Fault in the main TSL drift.

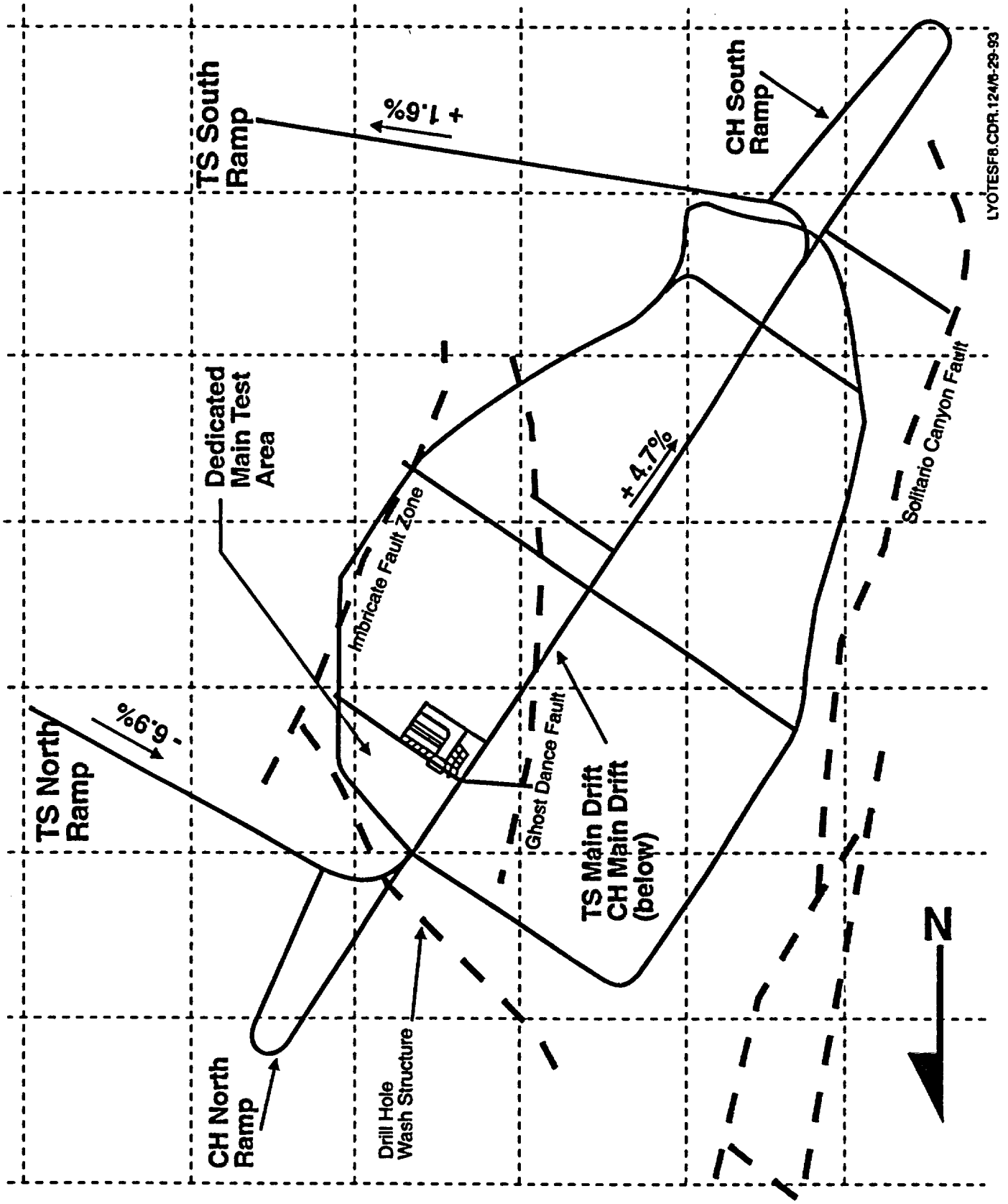

Figure 1. Baseline ESF Layout.

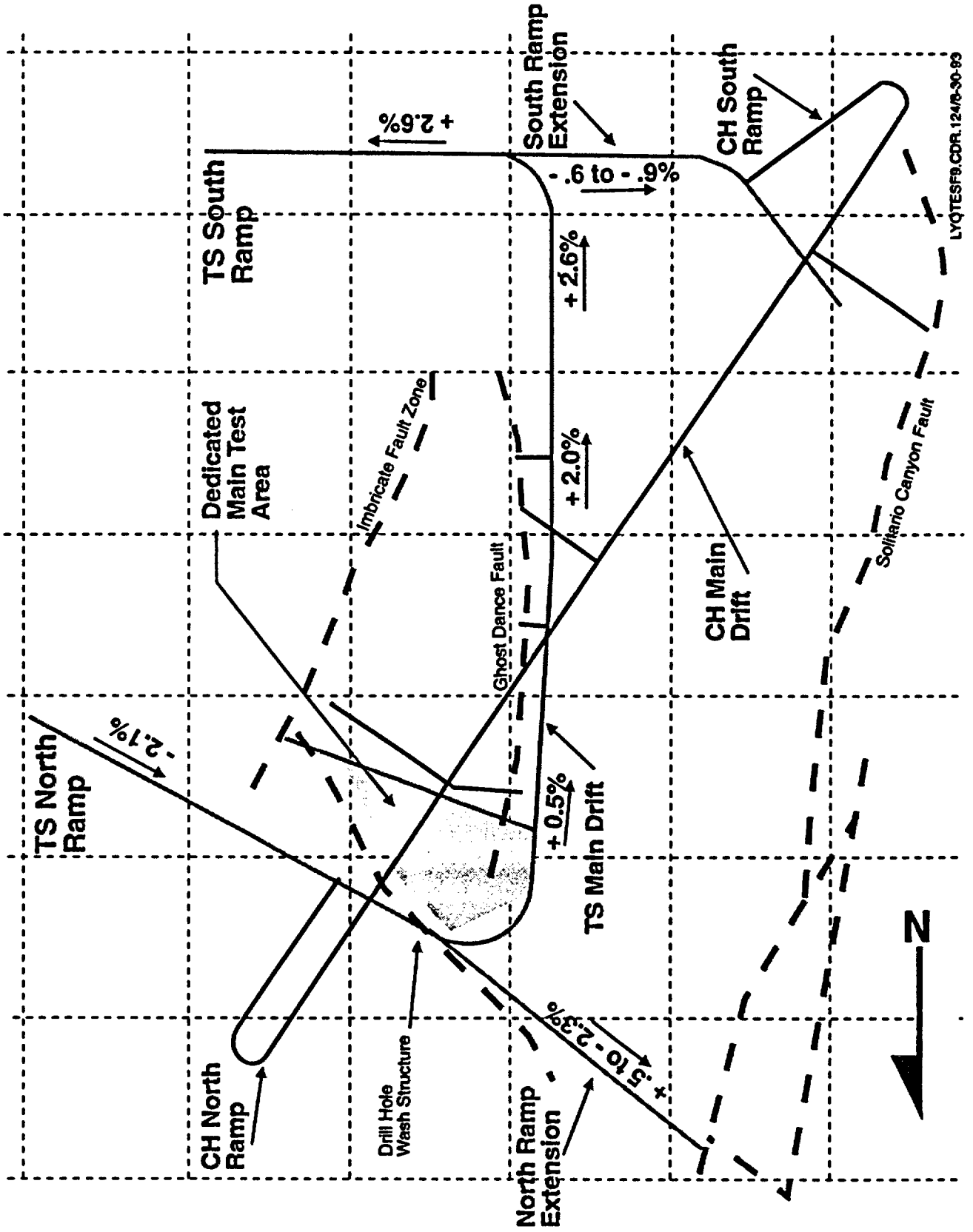

Figure 2. Enhanced ESF Layout.

- Result in having no grade in excess of 2.7% in the initial loop formed by the north ramp (surface to TSL), the main drift, and the south ramp (TSL to surface). This will allow the use of conventional rail transportation for the excavation in the TSL ramps and main drift, and will preserve the option to use conventional rail transportation in the potential repository. When used in this design analysis, the term "conventional rail" means standard friction rail systems similar to those used by U.S. railroads. No friction enhancing mechanisms, except the application of sand, are implied.

- Enhance repository layout flexibility to a much greater extent than the current orientation. Flexibility is enhanced because:

  - The main drift will cross the repository block at a point stratigraphically higher in the TSw2 unit, thereby allowing repository designers to situate drifts below this main drift if future repository design work indicates that the drift is not useful for incorporation into a repository design.

  - The main drift will be adjacent to the Ghost Dance Fault along much of its length. This portion of the block may be of limited value to the potential repository if it is determined that no waste can be emplaced in the fault zone. Therefore, placement of the main drift in this area saves other, possibly more suitable emplacement areas for a potential repository.

  - Cross drifting within the TSw2 is performed at the ends of the block--not through the center--where they could interfere with the future arrangement and orientation of potential repository main and emplacement drifts. This preserves the option for the repository designers to develop a wide range of concepts unhindered by the ESF drifts.

- Better accommodate repository layouts which: (1) have flat grades in emplacement drifts and 2% maximum grades in all other "in-block" drifts, (2) do not require emplacement drifts to cross the Ghost Dance Fault, and (3) will not preclude repository concepts identified in the development of Option 30 and enhanced following the ESFAS.

- Allow repository emplacement drifts, particularly in the primary block situated west of the Ghost Dance Fault, to be placed farther above the water table. This was identified as a Favorable Feature in the ESFAS; The Option 30-Based ESF/Repository pair did not have this feature.

- Maintain the full scope of site suitability and characterization testing provided in Option 30, and provide enhanced characterization opportunities in some areas. Critical characterization of the Ghost Dance Fault, at multiple points along the main drift, is easily provided for without compromising potential repository flexibility. The ability to characterize the TSw2 unit, and evaluate potential north-south trending features, is maintained at both the north and south ends of the block, with added potential to investigate the Solitario Canyon Fault within the potential repository horizon via an extension of the north ramp.

10.1.2 Background of the Development of the Baseline ESF Concept

The ESF concept presented in the Site Characterization Plan (SCP) (Chapter 8.4) consisted of two 3.7 meter (12-foot) diameter vertical shafts and approximately 1,830 meters (6,000 feet) of drifting in the TSL. The drifting was localized in the northeast quadrant of the potential repository block. A provision for 1,500 meters (5,000 feet) of additional drifting was included in the SCP design.

Comments from the Nuclear Regulatory Commission (NRC) and the NWTRB centered on the excavation method (drill and blast versus mechanical excavation), the NWTRB's preference for ramp access over shaft access, and the localized, limited nature of the at-depth drifting. (Reference 9.11)

During 1990, the YMP undertook the ESFAS to provide a comprehensive assessment of options for development of an ESF, and how those ESF options would fit into a potential repository. A total of 34 options were developed and evaluated. The options included shaft access, ramp access, and combinations of both. Repository concepts were developed for each option to ensure that the requirements of 10 CFR 60.21(c)(1)(ii)(D) were adequately addressed.

Option 30 emerged as the highest ranked option at the conclusion of the study. Following the completion of the ESFAS, several modifications to Option 30 were made, incorporating features of other highly ranked options. This process is described in "Documentation of the Evaluation of Findings of the ESFAS Used to Develop a Reference Design Concept" (YMP/91-28) (Reference 9.6). The resulting "Modified Option 30" formed the basis for the start of Title I Design. It is important to note that, in YMP/91-28, the following statement was included in order to prompt exactly the type of enhancements now being proposed:

"Option 30 did not rank high in the favorable feature of showing maximum distance from the waste emplacement level to the water table. The possibility of increasing the distance between the waste emplacement level and the water table will be addressed during the Title II Design. The favorable feature of avoiding emplacement drifts crossing Ghost Dance Fault was not marked high for this option; this will be addressed in the repository design."

10.1.3 Factors Contributing to a Proposed Revision

10.1.3.1 Repository Design Flexibility

The ACD of the potential repository began on October 1, 1992. Consideration of various conceptual repository layouts has led to the conclusion that an ESF main drift which runs parallel, and in close proximity to, the Ghost Dance Fault would be advantageous from a repository design standpoint. This arrangement would allow the repository designers increased flexibility with respect to alternative layouts, especially those layouts which allow flat (or nearly flat) slopes in the emplacement drifts and accesses, and those which avoid having emplacement drifts cross the fault.

10.1.3.2 Enhancement of the Conventional Rail Transportation Option

Members of the NWTRB have commented frequently, most recently in the NWTRB's "Sixth Report to the U.S. Congress and the U.S. Secretary of Energy," published in December 1992, that they feel the gradients in the Title I-based ESF are too steep, and that steps should be taken to reduce the slopes to those that can accommodate conventional rail transportation. This view is shared by the Management and Operating Contractor's (M&O) Design Group and Construction Management Organization (CMO).

10.1.3.3 New Information on TSw1 - TSw2 Contact Elevation

The current baseline ESF/repository layout has a "point of entry" into the potential repository boundary at the north end of N 767,500.00 E 564,053.00. This same point of entry has been used in the program since at least 1984. The elevation of this point is driven by the elevation of the overlying TSw1-TSw2 contact. The design method to determine the closest allowable approach of a drift to the contact has been to allow a five meter separation, or "standoff," supplemented by a further five meter standoff to account for uncertainty, between the contact and the highest point in the underlying drift. The elevation of the point of entry is important to the layout because the north end of the block is the lowest end, and therefore, the point of entry largely determines the resulting gradients of the ramps and main TSL drift.

Until late FY 1991, it was thought that the elevation of the TSw1-TSw2 contact at this point was approximately +3,158 feet Mean Sea Level (MSL). In late FY 1991, the Sample Oversight Committee (SOC) re-examined the drill core and data, and determined that the original determination of the TSw1 - TSw2 ~~elevation of the~~ contact had been made in error ~~above the point of entry should be approximately +3,298 feet MSL~~. The SOC's subsequent redefinition of the contact elevation in two holes resulted in a change in the elevation of contact above the point of entry from +3,158 feet MSL to +3,298 feet MSL. This finding enabled the ESF designers, Raytheon Services Nevada (RSN), to raise the point of entry 140 feet, thus lowering the gradients of the

north ramp and main TSL drift from -9.52% and 5.9% to -6.9% and 4.7% respectively (Reference 9.10). It is this change which is reflected in the Title I, Revision 1, drawings discussed in Section 7.

Drilling was conducted in FY 1992-1993, (specifically North Ramp Geologic (NRG)-6) and geologic data from that drill hole was incorporated into the IGIS network. The IGIS TSw1-TSw2 contact structure contour map shown as Figure A2-4 in Appendix 2, reflects the SOC's updated work previously described as well as the NRG-6 data. The proposed enhancement was developed using this structure information.

It is important to note that the ESF layout in the proposed enhancement does not use the same point of entry as the baseline layout. This is pointed out to avoid confusion in trying to compare the layouts, and particularly the elevations of the points of entry. The proposed new point of entry is slightly less than 640 meters (2,100 feet) west of the baseline point of entry, and approximately 80 meters (261 feet) higher in elevation (remember that the beds dip at approximately 8-10% down to the east).

10.2 DESCRIPTIONS OF THE BASELINE ESF CONCEPT AND THE REVISED ESF CONCEPT

10.2.1 Title I-Based ESF Description

The ESF design as it is described in the ESF Technical Baseline (YMP/CM-0016) consists of two inclined ramps, north and south, from the surface to the potential repository horizon, the TSw2. The north ramp slopes at -6.98% while the south ramp is at -1.8%. The bottoms of these two ramps are connected by a main TSL drift. This drift is oriented at N 34° E and slopes at +4.7% to the south. The Main Test Area (MTA) is located in the north end of the potential repository block on the east side of the Ghost Dance Fault. An exploratory drift is planned which will extend eastward from the MTA to the Imbricate Fault Zone, located east of the potential repository perimeter drift boundary. Two cross drifts are planned. The east cross drift will start from the TSL main drift, penetrate the Ghost Dance Fault, and extend slightly beyond the eastern conceptual perimeter drift boundary. The west drift will originate in the TSL main drift and extend beyond the west side of the potential repository block.

A second set of excavations is planned for exploration and testing in the underlying Calico Hills (CH) formation. These excavations will include two ramps, north and south, which originate in the lower reaches of the north and south TSL ramps. These two CH ramps will extend down to the CH level with a gradient currently planned to be -10%. The lower ends of these ramps will be connected by a main CH drift lying directly under the overlying TSL main drift. A total of four side drifts are planned to be driven off the CH main drift. The CH imbricate drift will underlie the TSL imbricate drift. Two drifts are planned to intersect the Ghost Dance Fault and one drift, located at the extreme southern end of the CH main drift, will explore the zeolitic-vitric contact in the Calico Hills formation and extend to the Solitario Canyon Fault.

While the configuration of the CH ramps and drifting was not appreciably changed in this exercise, it is probable that it will be revisited in ongoing Title II design. Both the gradient of the ramps and the location and extent of drifting are subject to revision.

Table 1 shows the approximate lengths of drifting in each segment, the planned cross-sectional dimensions, the approximate volume of material to be excavated, and the planned excavation mechanism as it was shown in the Title I design.

10.2.2 Revised ESF Description

The revised ESF layout is consistent with the Option 30-Based Layout in all important aspects, as will be shown below. It has north and south ramp accesses to the TSL, a main TSL drift, cross drifting, north and south ramps to the CH, and fault exploratory drifting in the CH. The currently planned underground testing program can be fully implemented in the revised layout, and in some areas can be significantly enhanced. Additionally, the enhancement provides repository designers with the opportunity to incorporate features which improve repository performance, as directed by 10 CFR 60.21 (c)(1)(ii)(D).

The north ramp, surface to TSL, is oriented on the same azimuth as the baseline layout. The slope of the ramp would be -2.05%. The length of the ramp to the beginning of the curve is 2,190 meters (7,175 ft). The length of curve is 610 meters (2,010 ft), and the radius of curvature is 305 meters (1,000 ft). The diameter of the TSL ramps and main drift is the same as the baseline layout or 7.62 meters (25 ft). The bearing of the main TSL drift varies from N3.8°E to due north. The main drift will run generally parallel to the Ghost Dance Fault in two straight segments connected by a short curve. The northern segment, at a bearing of N3.8°E will be 1,410 meters (4,635 ft) and the south segment, at a bearing of due north, will be approximately 1,740 meters (5,715 ft) in length. The main drift is to be located a minimum of 122 meters (400 ft) west of the projected location of the Ghost Dance Fault. The slope of the main drift will vary from +0.5 % to +2.63%. The length of curve for the south ramp is 470 meters (1,550 ft), with a radius of 305 meters (1,000 ft), and the distance from the curve to the surface is 1,360 meters (4,470 ft). The slope of the south ramp is -2.63% to the west. The main test area will be in the same area (Northeast quadrant) of the potential repository block as the baseline layout. The main drift is located higher in the TSw2 formation than the baseline layout, so the access drifts from the main drift to the MTA will slope down to the east. The Imbricate Fault drift will be in the same general area as in the current layout.

TABLE 1. SUMMARY OF BASELINE ESF DRIFTING

COMPONENT	LENGTH (METERS)	GRADIENT (%)	VOLUME (CUBIC METERS)	DRIFT CONFIG. (METERS)	DRIVEN BY
North Ramp, Surface to TSL	1,965	-6.9	89,613	7.62 Round	TBM
South Ramp, Surface to TSL	2,785	-1.6	127,009	7.62 Round	TBM
North Ramp to Calico Hills	2,049	-10/-6	48,441	5.49 Round	TBM
South Ramp to Calico Hills	2,240	-10/16	52,957	5.49 Round	TBM
TSL Main Drift	3,239	4.7	147,714	7.62 Round	TBM
TSL East Drift	981	-2.6	21,874	3.7x6.1	MM
TSL West Drift	1,082	2.1	24,126	3.7x6.1	MM
TSL Imbricate Drift	685	0.5	16,194	5.49 Round	TBM
Main Test Area	2,865	N/A	63,882	3.7x6.1	MM
CH Main Drift	3,462	3.8	81,847	5.49 Round	TBM
CH East Ghost Dance Drift	463	0.5	6,194	2.7x4.9	RH
CH West Ghost Dance Drift	328	0.5	4,388	2.7x4.9	RH
CH Imbricate Drift	658	0.5	8,803	2.7x4.9	RH
CH Solitario Drift	671	8.75/0	8,977	2.7x4.9	RH
TOTALS	23,473		702,020		

TBM: TUNNEL BORING MACHINE MM: MOBILE MINER RH: ROADHEADER

The east and west cross drifting in the TSL will be arranged as follows. The east cross drift will be replaced by two or more extended alcoves driven off the main drift. These alcoves need only be approximately 200-300 meters in length to penetrate the Ghost Dance Fault. Additional penetrations of the Ghost Dance may be readily driven if needed because of the close proximity of the main drift to the fault. Based on available surface fault trace information, this layout has the added advantage of not having to cross the fault zone in the main drift. The west cross drifting will be executed by extending the north and south TSL ramps to the west. The north ramp extension would be driven to the Solitario Canyon Fault located at the west boundary of the potential repository block. The south ramp extension would be driven 2,005 meters (6,580 ft), along the edge of the potential repository block at its southern extremity. This will provide cross drifting to explore for north/south trending structures along the north and south extremities of the block while leaving the main body of the block unpenetrated by drifting which would significantly restrict subsequent repository design flexibility. Another important aspect of these ramp extensions is that a large percentage of the vertical extent of the TSw2 formation will be traversed, providing the opportunity to test and evaluate throughout much of the unit. The north ramp extension would cover the upper half of the TSw2, while the south ramp extension will traverse almost the entire thickness of the TSw2. Extensive vertical coverage is an important feature, as almost any repository design concept, including the current baseline layout, will be forced to utilize a large portion of the thickness of the TSw2 due to the dip of the formation.

Drifting in the CH will be almost identical to the current layout. The concerns for restriction of the potential repository layout are not present in the CH and there is no reason to deviate significantly from the current plan. This orientation serves to transect the potential repository block in such a manner that any major north-south trending structural features not evident from the drifting carried out in the north and south ramp extensions (described above) should be discovered. Ramp access will be provided to reach the CH from the north and south. A main CH drift will connect the ramps and provide the starting point for drifting to the Imbricate Fault Zone, the Solitario Canyon Fault, and the Ghost Dance Fault. The north CH ramp will be somewhat longer than in the current layout, while the south CH ramp will be shorter. See Table 2 for tabulation of the revised drifting. The lengths and grades for the initial loop were determined by coordinate geometry calculation (Ref. 9.15). The balance of the drifting was quantified by graphic methods. This calculation was included in the 50 percent design review of Package 2, and is currently included in Package 2C, scheduled for release in June, 1994.

TABLE 2. ENHANCED LAYOUT DRIFTING

COMPONENT	LENGTH (METERS)	GRADIENT (%)	VOLUME (CUBIC METERS)	DRIFT CONFIG. (METERS)	DRIVEN BY
North Ramp, Surface to TSL	2,800	-2.05	127,693	7.62 Round	TBM
South Ramp, Surface to TSL	1,835	-2.63	83,685	7.62 Round	TBM
North Ramp to Calico Hills	2,295	-10/-6	54,257	5.49 Round	TBM
South Ramp to Calico Hills	1,805	-10/-6	42,673	5.49 Round	TBM
TSL Main Drift	3,155	+0.5/2.0/+2.63	143,883	7.62 Round	TBM
TSL North Ramp Extension	1,615	-1.0/+0.5	73,652	7.62 Round	TBM
TSL South Ramp Extension	2,005	-0.89/-0.77	91,438	7.62 Round	TBM
TSL Imbricate Drift	1,275	N/A	30,143	5.49 Round	TBM
TSL Ghost Dance Drifts (2)	420	+0.5	9,365	3.7x6.1	D&B
Main Test Area	2,865	N/A	63,882	3.7x6.1	MM
CH Main Drift	3,415	3.8	80,736	5.49 Round	TBM
CH East Ghost Dance Drift	465	0.5	6,221	2.7x4.9	RH
CH West Ghost Dance Drift	330	0.5	4,415	2.7x4.9	RH
CH Imbricate Drift	655	0.5	8,763	2.7x4.9	RH
CH Solitario	670	8.75/0	8,964	2.7x4.9	RH
TOTALS	25,605		829,768		

TBM: TUNNEL BORING MACHINE MM: MOBILE MINER RH: ROADHEADER D&B: DRILL & BLAST

10.3 ADVANTAGES OF THE REVISED ESF CONFIGURATION

10.3.1 Maximizes the Vertical Distance From Emplacement Drifts to the Water Table

The location of the main TSL drift as high as possible in the TSw2 formation will allow development of flat potential repository concepts which maximize the vertical distance from emplacement areas to the water table while satisfying the 200 meter cover limitation. This is especially evident in the primary block west of the Ghost Dance Fault. This was Favorable Feature No. 7 in the ESFAS, and was not present in the repository concept which accompanied Option 30 in the ESFAS. This feature is desirable because it would maximize ground water travel time from the emplacement area to the water table.

It is possible that, at some future point in the program, a determination could be made that raising the potential repository is not favorable. Such a conclusion could be due to thermal-hydrological-mechanical modeling results which might indicate negative effects on performance parameters. As stated earlier, the flexibility inherent in this proposed ESF enhancement will allow the program to adjust to developments of this kind much more readily than the current baseline design. Section 10.4 contains more information on this aspect.

10.3.2 Allows Potential Repository Layouts Which Avoid the Ghost Dance Fault

The orientation of the main TSL drift generally parallel to the Ghost Dance Fault would allow the development of repository concepts in which no emplacement drift crosses the Ghost Dance Fault. This was Favorable Feature No. 8 in the ESFAS, and was lacking in the repository layout which supported Option 30. This feature is desirable because it would negate potential performance concerns which relate to emplacement drifts intersecting faults.

10.3.3 Preserves the Conventional Rail Transportation Option

The option to utilize conventional rail transportation in the TSL ramps and main drift becomes feasible. This would be true during the construction and operation of the ESF, and becomes an even more important consideration in the construction and operation of a potential repository. The important factor is that, by providing tunnels with gradients less than 3%, the ESF would not preclude the use of rail transportation. It is not yet known what waste haulage concept will be selected for the potential repository, but, if the construction of ramps and drifts which could become a part of the potential repository is allowed to proceed at the currently designed gradients of 6.9% and 4.7%, the conventional rail transportation option will be excluded from consideration. Current waste package concepts are based on very large and heavy packages. The use of conventional rail becomes even more appropriate because of the ability of rail to handle waste package loads (100-200 tons) without extraordinary enhancement. Simply stated, the use of flatter grades opens the use of conventional rail transportation concepts, while the use of steeper grades precludes conventional rail. This concept is stated in the NWTRB's Recommendation No. 5 in its Sixth Report to Congress.

10.3.4 Preserves Potential Repository Design Flexibility

The orientation of the baseline ESF main drift is a product of earlier potential repository design arrangements in which the main entries parallel the long axis of the block, and in which the average slopes of both the main and sub-main drifts would be approximately the same. This arrangement allowed development of emplacement entries or panels of about the same length off each side of the mains, and tended to minimize the total length of main entry footage required. Orientation of the primary and secondary jointing systems was also a factor in the selection of the arrangement. The subject of drift orientation with joint structure is addressed in detail in Appendix 1. The location of the TSw2 entry point for the waste ramp and the orientation of the main drifts can be traced back to a study on a phased approach to repository construction which was performed in 1984 (SAND-84-1351).

This repository concept, however, does not consider the Ghost Dance fault to be a constraining factor in the development of the layout. Such a concept requires the Ghost Dance to be penetrated at least 50 to 60 times during the construction of a potential repository. In addition to imposing potential performance concerns, the emplacement entry footage in and near the fault may not be usable if it is decided to preclude emplacement in fault areas.

A potential repository concept, developed in conjunction with the proposed refinement to the current ESF layout and which does not require repeated penetrations of the Ghost Dance Fault is shown in Figure 3. This concept uses the western part of the potential repository block, lying between the Ghost Dance Fault and the Solitario Canyon Fault, as the primary emplacement area. If the Local Areal Power Density (LAPD) at the time of emplacement ultimately selected for the potential repository equals or exceeds 75 kW/acre (10 year old fuel), this portion of the block would suffice for the entire waste inventory. This compares to a LAPD at emplacement of approximately 70 kW/acre in the Site Characterization Plan - Conceptual Design Report (SCP-CDR) layout, and assumes the same 65,000 kW spent fuel waste stream used in the SCP-CDR. If the east portion of the block were needed, it would be developed from main drifts driven from the north and south ramps along the eastern side of the Ghost Dance, as shown in Figure 4 (Figure 5 shows Section A-A' indicated on Figure 4). This 2 block configuration would accommodate a LAPD at emplacement of approximately 60 kW/acre. This type of concept has been generally referred to in the program as a "step block" concept. It minimizes to a great extent the number of penetrations required through the Ghost Dance, can be developed at grades which would allow conventional rail transportation, and allows the emplacement drifts to be constructed at a horizontal grade, or at whatever slope is determined to be advantageous for drainage.

It is emphasized that the particular repository configurations shown in Figures 3 and 4 are conceptual and for reference only. In particular, other potential expansion areas will be investigated as design proceeds, and it should not be assumed that the area east of the Ghost Dance Fault will necessarily be utilized.

A key advantage is that the revised ESF layout does not preclude any known repository layout, haulage concept, or the implementation of any currently planned ESF testing activities. Conversely, the current layout does make conventional rail haulage unfeasible, it limits the ability to lay out a potential repository which avoids the Ghost Dance to the maximum extent, and it constrains development of potential repository layouts utilizing flat emplacement drifts, unless a large portion of the block (i.e.: the area crossed by the current main TSL drift and west cross drift) is removed from consideration.

10.3.5 Enhances ESF Constructability and Safety

The flatter grades provided by the proposed revision will improve constructability of the facility by allowing the use of conventional rail transportation for movement of personnel and supplies. Virtually all Tunnel Boring Machine (TBM) operations are supplied by conventional rail transportation systems, and there are no known instances of a TBM operation of this magnitude having been supplied exclusively by rubber tired vehicles.

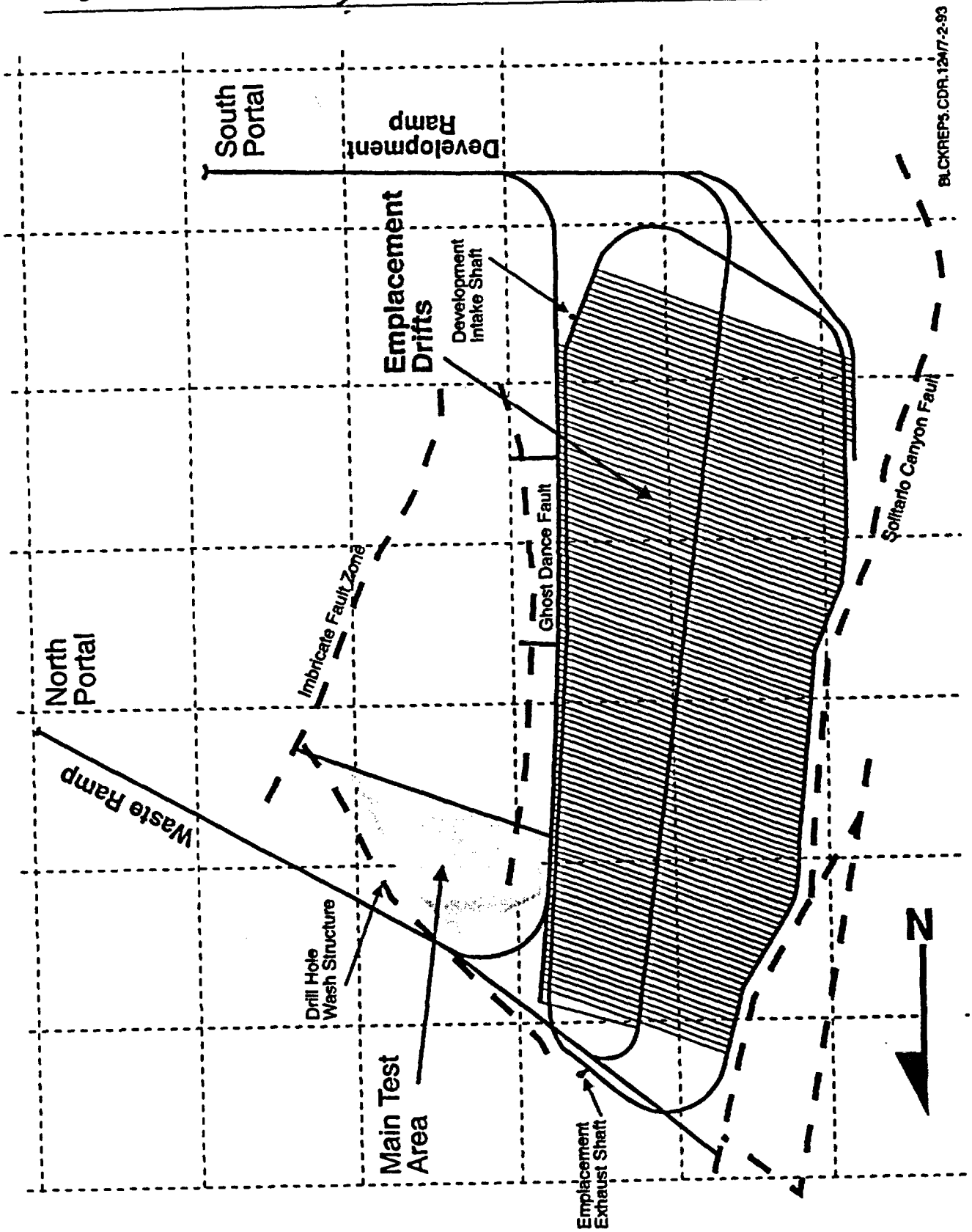

Figure 3. Single Block Repository Concept

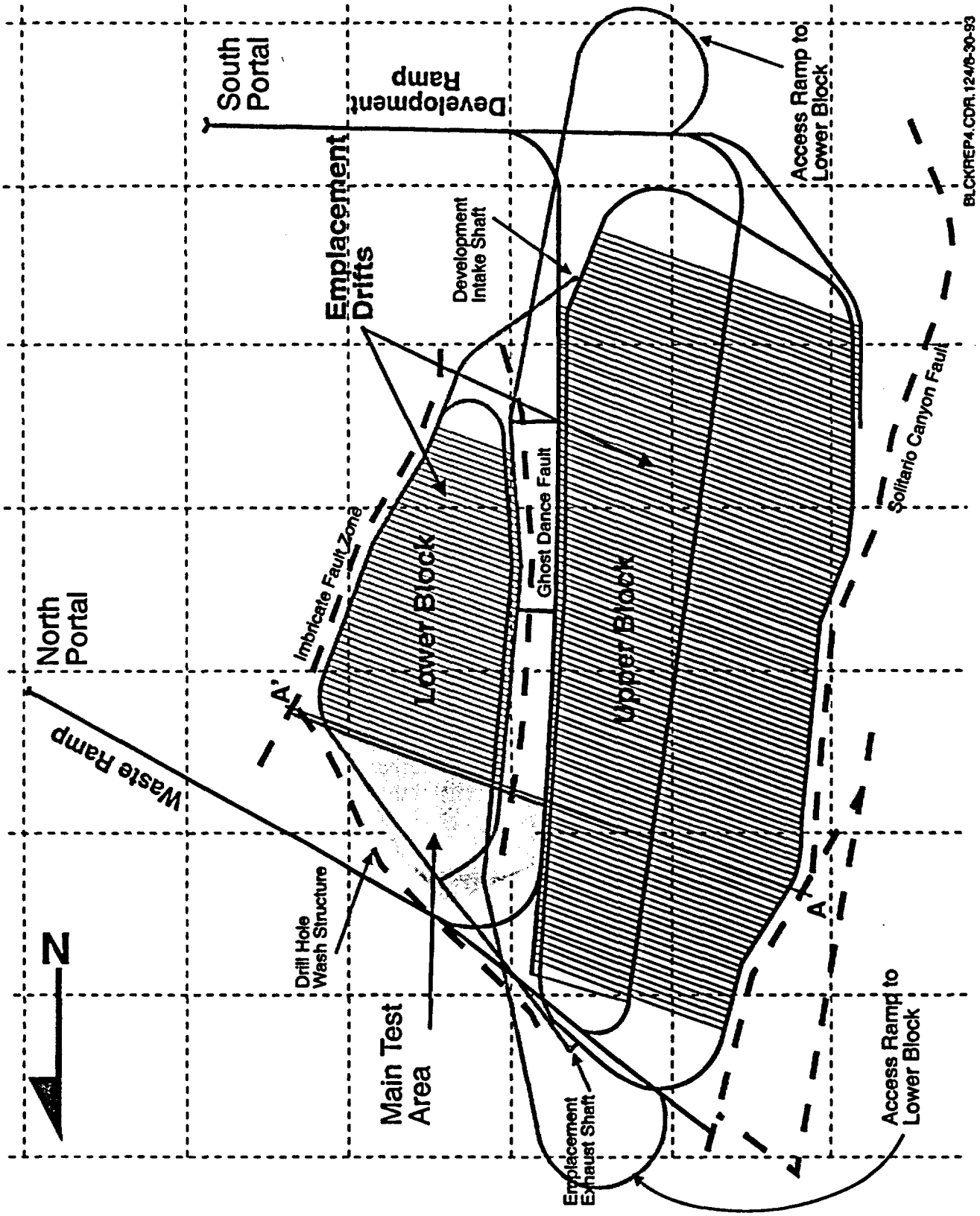

Figure 4. Two Block Repository Concept

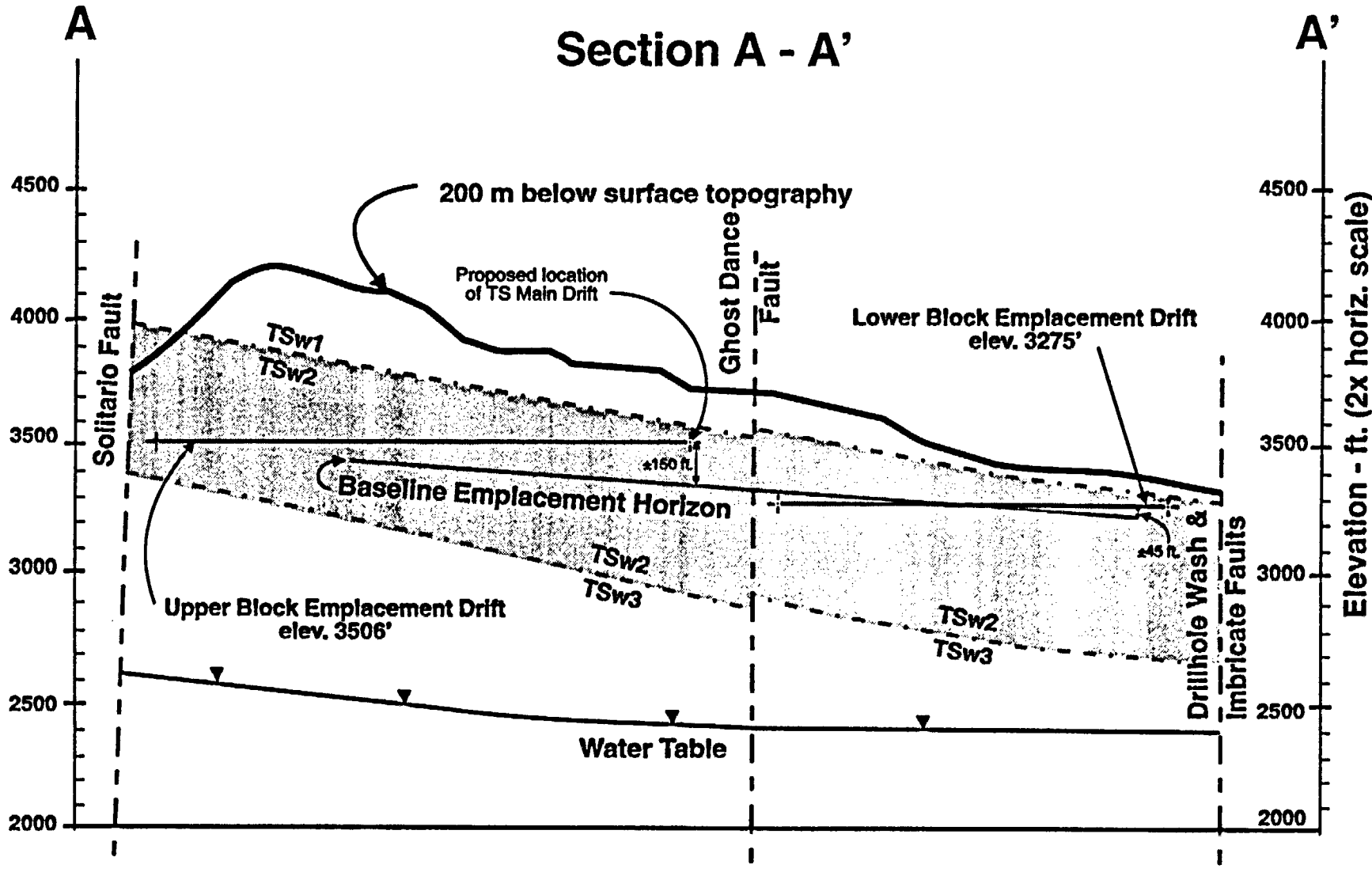

Figure 5 - Section A - A'

Note: Plane of section cuts through lowest emplacement drift in step-block layout.

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Safety of workers and visitors will be enhanced by the flatter grades. The likelihood and severity of runaway rolling stock accidents is reduced by flatter grades. A report on haulage accidents in English coal mines shows that 80% of "runaways" occur at grades of 3.3% or steeper (Reference 9.8).

10.4 POTENTIAL DISADVANTAGES OF THE PROPOSED ENHANCEMENT

The ESF/Repository concept described in the enhancement could possess disadvantages, including possible performance concerns and a potential cost impact.

10.4.1 Thermal-Hydrological-Mechanical Concerns

As alluded to in Section 10.3.1, it may be determined at some future point that raising the repository elevation is not desirable. Such concerns as "buoyant convection" and impacts on the duration of dryout could eventually prompt the repository designers to lower the elevation of the potential repository.

It is emphasized that the repository concept described in Section 10.3.4 is only one of many which could be implemented from the proposed enhanced ESF configuration. The flexibility provided by the proposed enhancement would be an important asset in adapting to such a change in repository design philosophy were it to occur.

10.4.2 Potential Cost Impact

The excavated length of the enhanced ESF layout is approximately 9% more than for the current baseline. If it were assumed that the cost per meter of excavation would be the same for either option, then it would follow that the enhanced ESF layout would have a 9% higher cost of excavation. If a cost of $6,440 per meter is used, the impact of the change would be an increase of approximately $14 million in cost. However; the enhanced version would have flatter grades and be supportable by rail transportation. The current baseline is not supportable with conventional rail. It is probable that the unit cost of the tunneling operation would be lower for the enhanced layout because it can be supported by conventional means, and therefore, that there would be little discernable cost differential.

10.4.3 Gaseous Emission

Maximizing the distance from the water table to the emplacement drifts necessarily tends to minimize the distance from the emplacement drift to the surface. If gaseous emission travel time is found at some point to be a more important factor than ground water travel time, it may become desirable to lower the potential repository elevation. Once again, the flexibility afforded by the proposed enhancement would accommodate this type of change much more readily than the baseline ESF layout.

11. CONCLUSIONS AND RECOMMENDATIONS

The enhancements to the baseline ESF layout will result in a design which possesses all of the favorable features embodied by Option 30, plus the two favorable features which Option 30 did not have (See Table 3). In addition, the primary TSL "loop" is arranged at grades which will allow the use of conventional rail transportation for construction and operation, and which enables the rail transportation option for a potential repository. It should also be noted that the overwhelming majority of TBM-driven tunnels utilize conventional rail transportation for transport of men and materials between the surface and the working face. The enhanced layout would have approximately 9% more excavation footage, however, cost and schedule impact of the change is expected to minimal.

Because of the added flexibility that this revised ESF configuration provides for potential repository layout and haulage system selection, it is recommended that the revised layout be adopted and the ESF Technical Baseline be changed to the revised layout. The ESF Subsurface Design group should proceed with design of the north ramp and other ESF subsurface design packages based on this revised arrangement. Potentially affected documents include the ESF Plan, the ESF Technical Baseline, the Repository Design Requirements Document, and the Site Characterization Program Baseline (SCPB). Also, while the number of planned test alcoves will not change, their locations will change with the new arrangement. Other effects could include a change to the conceptual perimeter drift boundary and the conceptual controlled area boundary.

It should be emphasized that the ESF enhanced layout if approved must undergo Title II design. No currently completed or ongoing Title II design would be impacted by this change. This change will require a change to the surface based drilling program related to the ESF. A critical early need will be a drill hole, roughly in the center of the block, to acquire geotechnical data and information on the TSw1-TSw2 contact as close as possible to, and on the west side of, the Ghost Dance Fault. This hole should also help in the location of the main TSL drift. Currently, hole SD-12 is planned to provide this information. A drill hole will also be required near the proposed entry point location at the end of the curve of the north ramp to verify the TSw1-TSw2 contact in this area. NRG-7 has been identified for this purpose. TSw1-TSw2 contact information is also needed near the south end of the main TSL drift where the drift exits the potential repository block. South Ramp Geologic (SRG)-4 should provide this information. The surface based drilling program in support of the ESF should be focused to provide this needed information for the revised configuration.

IDENTIFICATION OF FAVORABLE FEATURES IN HIGHLY RATED OPTIONS

RANK	TOP-RANKED OPTIONS: OPTION	1 NUMBER OF RAMP(S)	2 NUMBER OF SHAFT(S)	3 NUMBER OF ACCESSES	4 MTL LOCATION FLEXIBILITY	5 MECHANICAL MINED ACCESSES	6 NO GRAVITY FLOW PATHWAY FROM TS UNIT TO CHn	7 MAXIMIZE DISTANCE FROM EMPLACEMENT LEVEL TO WATER TABLE	8 AVOID EMPLACEMENT DRIFTS CROSSING GHOST DANCE FAULT	9 MAXIMIZE EXPOSED ROCK – ON AND OFF BLOCK	10 FLEXIBILITY FOR EARLY DRIFTING IN TS OR CH OR BOTH	11 2 INTERCEPTS OF GHOST DANCE FAULT IN TS	12 E-W DRIFT IN TS	13 LARGER MTL AREA TO AVOID INTERFERENCES
1	30	2	0	4	✔	✔	✔	○	○	✔	✔	✔	✔	✔
2	23	2	0	4		✔						✔	✔	✔
3	24	1	1	5		✔					✔	✔	✔	✔
4	13	2	0	4	✔	✔				✔	✔	✔	✔	✔
5	6	2	0	4		✔						✔	✔	✔
6	7	1	1	5		✔						✔	✔	✔
7	2	1	1	5								✔	✔	✔
8	19	1	1	5								✔	✔	✔
9	25	1	1	5		✔					✔	✔	✔	✔
10	4	1	2	5						✔	✔	✔	✔	✔
•	•													
•	•													
•	•													
20	15	1	1	4				✔	✔			✔	✔	✔

○ Additional Favorable Features

TABLE 3

12. ATTACHMENTS

12.1 **APPENDIX 1** - Specific Issues For Consideration in Connection With The ESF Change.

12.2 **APPENDIX 2** - Supplemental Figures.

APPENDIX 1

SPECIFIC ISSUES FOR CONSIDERATION IN CONNECTION WITH THE ESF ENHANCEMENT

Several issues, both technical and programmatic, have been raised regarding this proposed change to the Baseline ESF/Repository configuration. These issues are discussed individually below.

Consideration 1: Orientation of the ESF TS Main Drift generally parallel with the primary joint structure may result in adverse ground conditions in this opening.

Response:

Joint Data

Attitudes of steeply-dipping joint sets in the Topopah Spring member are listed in TABLE A1-1 based on limited data from borings Underground Southern Nevada - Waste (USW) G1, Underground Exploratory (UE) 25a-4, 5, 6, and 7, USW G-4, and USW GU-3. Strikes of the steeply-dipping sets fall into three general groups with trends: north, northeast, and northwest (Reference Figure A1-1). Dips generally range from 75^0 to 90^0. The steeply-dipping joints predominate as indicated by the data set from USW G-4 and USW GU-3 in which joints dipping from 60^0 to 90^0 account for 94% of the fractures (Lin, Hardy, and Bauer, 1992, Section 3.0). A fourth group of joint sets has low-angled dips with strikes from N85^{0}W to N5^{0}E.

The dominant trend for all joint data is the N-S trend of steeply-dipping sets. The NE trend is significant in the UE 25a holes and in GU-3 and also shows up in USW G-1 and USW G-4. The NW trend is generally a minor set although significant locally in USW G-4. For design analysis the SCP-CDR (SNL, 1987) recognizes sets at N12^{0}W (north trend) and N34^{0}E (northeast trend) as being significant, which agrees with the observations presented here.

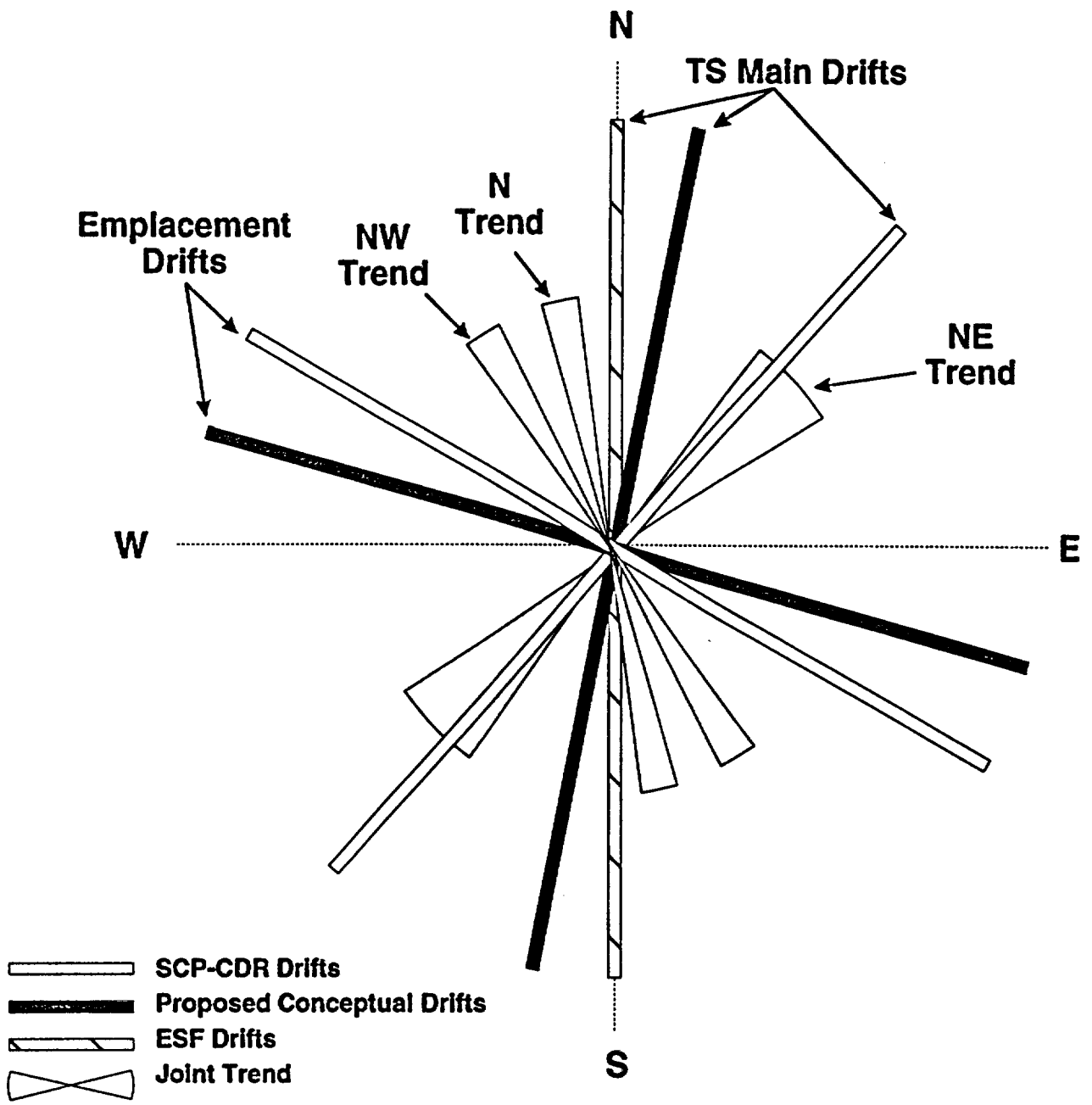

Figure A1-1. TS Main drift and emplacement drift alignments for design concepts in Table 2. Joint set trends are from Table 1. The preferred drift alignment is about E-W.

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TABLE A1-1. Strikes and Dips of Joint Sets in the Topopah Spring Member (data from Maldonado and Koether, 1983; Scott and Castellanos, 1984; Spengler, Byers, and Warner, 1981; Spengler and Chornack, 1984).

	N-trending sets with steep dips	NE-trending sets with steep dips	NW-trending sets with steep dips	Sets with low-angle dips
USW G-1	N5^{0}W; 61^{0}S	N28^{0}E; 64^{0}S	N33^{0}W;50^{0}S	---
UE 25a-4,5,6,7	N12^{0}W; 90^0	N37^{0}E; 90^0	(N40^{0}W; 78^{0}S)	N20^{0}W;10^{0}E
USW G-4	N5^{0}W; 90^0	(N30^{0}E; 90^0)	N40^{0}W; 90^0	EW;30^{0}N
USW GU-3	N10^{0}W; 90^0	N45^{0}E; 90^0	(N40^{0}W; 85^{0}N)	N28^{0}E;10^{0}E

( ) Minor joint set

In Situ Stress:

The maximum principal stress is the vertical stress due to lithostatic load, which at the potential repository horizon has an average value of 7.0 megapascals (MPa) (1000 psi). Horizontal stresses are expected to be lower with an average minimum of 3.5 MPa (500 psi) and an average maximum of 4.2 MPa (600 psi). Values of horizontal stresses could range from 2.1 MPa (300 psi) to 7.0 MPa (1000 psi). The in situ stress components are given in TABLE A1-2 (from SCP-CDR, SNL, 1987, Section 2.3.1.9).

The in situ stress values shown in TABLE A1-2 are generally confirmed by a stress profile calculated for the ESF test area (DOE, 1989, Section 1.2.10), which gives for the 300 m depth: vertical stress = 6.0 MPa, maximum horizontal stress = 4 MPa, minimum horizontal stress = 2 MPa.

TABLE A1-2. Average values and ranges for principal stresses at the proposed repository horizon (SCP-CDR, SNL, 1987, Section 2.3.1.9).

Parameter	Average Value	Range
Vertical Stress	7.0 Mpa	5.0 to 10.0 Mpa
Ratio Min. Horiz./Vertical	0.5	0.3 to 0.8
Ratio Max. Horiz./Vertical	0.6	0.3 to 1.0
Bearing Min. Horiz.	N57°W	N50°W to N65°W
Bearing Max. Horiz.	N32°E	N25°E to N40°E

Horizontal stresses are relatively low and imply that failure modes around underground openings will be structurally controlled (see for example Hardy and Bauer, 1991, Figure 12-5). Even though the total range of horizontal stresses from 2.1 to 7.0 MPa is fairly large, the minimum and maximum horizontal/vertical stress ratios are close and indicate minimal horizontal stress anisotropy. Consequently, lateral stresses should be approximately the same and the effects similar for all drift orientations.

Preferred Orientation of Drifts

In situ stress is low (see above), therefore jointing and gravitational loading, not stress magnitude and direction, will determine rock behavior in drift excavations. In this regard it is important where possible to minimize the amount of potentially unstable ground that would be encountered by drifts. Therefore, the preferred alignment for a drift is perpendicular to the strikes of joints and faults (SNL, 1987, Section 6.4.2). Likewise, the preferred alignment for a drift that crosses the intersection of a shallow joint set and a steep joint set is an alignment perpendicular to the line of intersection.

At drift/joint angles less than 90° a greater length of jointed ground will be encountered. For example, the length of jointed ground crossed by the drift is increased 1.4 times at 45°, 2 times at 30°, and 3 times at 20°. For intersections less than 20° the drift length in jointed ground increases rapidly until the drift parallels the joints, thereby increasing the likelihood of block failures. In the case of steep intersecting joint sets, the line of intersection will be steep, and the optimum orientation for drifts will be close to the bisector of the larger angle between the strikes of the joint sets (SNL, 1987, Section 6.4.2); that is, equidistant from the two joint sets.

Based on the above criteria, the most favorable drift orientations are generally east-west, between N70°W to S75°W. An orientation close to N12°E would be the better of either a north or a northeast alignment. All other drift orientations are considered less favorable, with the least favorable being those orientations parallel to any of the joint set trends.

Conceptual Design Orientations:

The orientations of repository main drifts and emplacement drifts for the SCP-CDR (SNL, 1987) and for the proposed conceptual repository design are given in TABLE A1-3. Also given are the orientation of the main drift and the orientation of the east-west exploratory drift for the proposed enhancement to the ESF.

Main drift orientations - The main drift orientations for all three concepts fall into the least favorable category. The SCP-CDR main is oriented close to the northeast joint set trend while the main drifts for both the proposed repository layout and the enhanced ESF design are close to the north trend. The change in orientation of the TS main exploratory drift from the SCP-CDR case to the proposed enhanced ESF case was done to avoid traversing the potential repository area. The control of ground conditions that may result from excavating parallel to a major joint set is expected to be similar to the conditions originally anticipated for the SCP-CDR case which also parallels a major joint set.

Current mapping by the United States Geological Survey shows a series of widely-spaced faults, about 150 feet apart, make up a zone at least 700 feet wide (Spengler, 1993) centered on and parallel to the Ghost Dance fault. Breccia associated with these faults occurs intermittently in zones from a few feet to at least 10 feet wide. The breccia appears as resistant outcrops, cemented by silica and/or calcium carbonate.

The main drift for the enhanced ESF design also parallels the Ghost Dance fault but standoff from that fault is expected to be sufficient to avoid the main portion of the zone of faulting. The north-south orientation of the main drift will enable exploration of the Ghost Dance fault by perpendicular drifting off the main rather than by a diagonal crossing of the main drift as would be the case with the SCP-CDR layout.

Emplacement drift orientations - Emplacement drift orientations for the SCP-CDR case are less favorable since they are close to the NW-trending joint sets. Emplacement drifts of the proposed conceptual repository in conjunction with the enhanced ESF design, are more favorably oriented, being closer to the optimum E-W direction. Moreover, the proposed emplacement drift orientation (enhanced ESF) can be reoriented to take advantage of future data on jointing and faulting.

TABLE A1-3. Alignments of Principal Drifts for Conceptual Design

Design Concept	Main Drift	Emplacement Drift (or other, as noted)
Baseline Conceptual Repository (SCP-CDR, Figure 4-30)	N34E	N56W (horizontal boreholes)
Proposed Conceptual Repository	N7E	N70W
Enhanced ESF	NS	

Conclusions:

Proposed emplacement drifts and E-W exploratory drifts are optimally oriented relative to joint set orientations. The SCP-CDR emplacement drifts have a somewhat less favorable orientation, being close to the northwest joint trend. Thus, an improvement is noted in changing from the SCP-CDR configuration to the current proposal.

Main drifts for the SCP-CDR case are oriented in the least favorable direction, parallel to a regional northeast joint trend. The presence of intersecting high- and low-angle joints could create blocks and wedges along the drift alignment.

Main drifts for both the enhanced ESF and proposed repository layouts are oriented N-S and will parallel the Ghost Dance fault and the dominant N-S regional joint strike. The N-S orientation is considered least favorable. However, excavations in or adjacent to the Ghost Dance fault zone are considered constructible because:

- Main drifts are offset to the west of the Ghost Dance fault, thereby avoiding a possible increase in fractured rock near the fault.
- The potential for blocky ground is minimized because faults of the Ghost Dance fault zone are widely spaced (at least 150 feet), relatively narrow (several feet to 10 feet), and may consist generally of dense, well-cemented breccia zones.
- Blocks and wedges formed by joint intersections can be controlled by the currently planned ground support methods, as in the case of the SCP-CDR mains.

Magnitude and orientation of horizontal in situ stresses indicate little or no effect on a change in drift orientation from the SCP-CDR case to the enhanced ESF orientation.

References:

U.S. Department of Energy (DOE), Yucca Mountain Project Reference Information Base, Version 4, YMP/CC-0002, February, 1989.

Hardy, M. P. and S. J. Bauer, 1991, Drift Design Methodology and Preliminary Application for the Yucca Mountain Site Characterization Project, SAND89-0837.

Lin, M., M. P. Hardy, and S. J. Bauer, 1992, Fracture Analysis and Rock Quality Designation Estimation for the Yucca Mountain Site Characterization Project, SAND92-0449, April.

Sandia National Laboratories (SNL), Site Characterization Plan Conceptual Design Report, Nevada Nuclear Waste Storage Investigations Project, compiled by MacDougall, H.R., L.W. Scully, and J.R. Tillerson, SAND84-2641.

Spengler, R. W., C. A. Braun, R. M. Linden, L. G. Martin, D. M. Ross-Brown, and R. L. Blackburn, 1993, Structural Character of the Ghost Dance Fault, Yucca Mountain, The 4th Annual International High-level Radioactive Waste Management Conference & Exposition, April 26-30, 1993, Las Vegas, NV.

Consideration 2: Raising the ESF/Repository layout to maximize distance to the water table may jeopardize the maintenance of the minimum 200 meter cover limit.

Response:

The work completed to this point using the IGIS model information shows clearly that all points in the emplacement areas of the potential repository layout are not less than 200 meters below the overlying surface. This criteria will continue to be checked as a matter of normal design practice during ongoing ESF design and repository ACD. The potential repository layout presented here was developed using the IGIS information, updated with the data from the NRG-6 drillhole. As new data become available, this information will be updated to help ensure that the 200 meter cover limit is not violated by any potential repository design. The 200 meter cover limit and post closure performance aspects will also be checked in the evaluation of all potential expansion areas.

Consideration 3: It may be desirable to provide for expansion of the potential repository to the north or south on the west side of the Ghost Dance Fault as opposed to using the lower block on the east side of the fault. Also, it is important to ensure that the new ESF/repository configuration possesses all the positive attributes (from the ESFAS) that the Option 30 based option had.

Response:

Repository ACD is in its early stages, and many options remain to be studied. It should be emphasized that the repository concepts shown in Figures 3 and 4 of this document are not the final result of ACD; rather they represent one concept which would mesh well with the enhanced ESF layout.

One of the strongest positive aspects of the enhanced ESF layout is the inherent flexibility that it gives the repository designer. All potential expansion areas will be evaluated during ACD.

While some of the favorable features of the ESFAS are very subjective, they all appear to be present in the enhanced ESF/repository configuration presented here. This includes the two favorable features which were not characterized by Option 30.

Consideration 4: It should be demonstrated that the number of accesses required to construct and operate the repository is minimized (i.e.: no more than four).

Response:

The repository concept shown in Figures 3 and 4 has been laid out to function with no more than four openings to the surface -- the same as in the reference case. Detailed analysis to confirm the adequacy of repository designs limited to no more than four access will be performed during subsequent ACD work.

There are two primary reasons why more than four openings could be required: (1) ventilation requirements which exceed the air carrying capacity of one or more of the openings, and (2) expansion into an area in which it becomes impractical to utilize the existing openings to maintain two separate ventilation systems.

Ventilation Requirements:

The concept shown in Figures 3 and 4 requires significantly less excavated tonnage than the current reference repository design, and it can be inferred from this that it should have a lower total development system airflow requirement than the baseline layout. Ventilation volume in the emplacement system of a potential repository is very sensitive to operational assumptions, including:

- Continuous ventilation of emplacement drifts. Would drifts be sealed after emplacement, or would some level of ventilation be maintained?

- Simultaneous retrieval and emplacement operations. Would retrieval (say, for performance confirmation) be carried out during ongoing emplacement operations?

These and other unknowns make it difficult to determine whether four openings would suffice from an airflow standpoint for any repository concept at this time. These parameters will be better defined during ACD. The potential long term performance impact of openings to the surface will be an important factor in the evaluation of the various repository features developed as ACD proceeds. It is worth noting that these uncertainties also exist for the reference layout.

Expansion Areas:

Another possible reason for having more than four openings would be expansion into an area where it would be impractical to operate two separate ventilation systems from the four original openings. This situation will have to be evaluated for each repository concept developed, and for each expansion area considered.

Consideration 5 The enhanced layout may not provide sufficient East-West drifting across the block. The ramp extensions may not satisfy the NRC as to representativeness of data.

Response:

While the enhanced layout does not include the original east-west cross drift, it does have sufficient cross block drifting to give reasonable assurance that major north-south trending features will be discovered. The timing of the cross drifting is not yet established, but if it were made a high priority, the north ramp extension could be completed earlier in the enhanced ESF construction sequence than the east or west cross drift could have been completed in the reference layout.

It is true that the ESF main drift remains close to the top of the TSw2 throughout its length. This is one of the reasons that the ramp extensions were conceived. They not only cross the block from east to west, but they traverse a large portion of the vertical extent of the TSw2. In addition, the Calico Hills main drift and lateral drifting will also provide the opportunity to discover major north-south trending structural features.

The entire question of representativeness of data (i.e.: drifting in the middle of the block as opposed to along the edges) must be balanced by the need to maintain the ability to design and construct a repository should the site be found suitable. It is desirable to avoid the excavation of drifts through the heart of the repository block when repository design is in its early stages. As repository design matures in parallel with ESF construction, it may well be possible to drive one or more cross drifts in the TSw2 with confidence that they will not detract from a potential repository. Cross drifting in mid-block should, however, be deferred until the repository design is sufficiently defined.

It is important to note that the NRC's concerns regarding representation of data were narrowly focused. They were based on the localized nature of the drifting in the SCP version of the ESF (Reference 9.11).

Consideration 6 The location of the ESF main TSL drift parallel to, and in close proximity to, the Ghost Dance Fault will make it difficult to know where to place the drift to avoid the fault. Also, the repository concept shown in Figures 3 and 4 appears to show development in an area (the Southeast Quadrant) which was avoided previously.

Response:

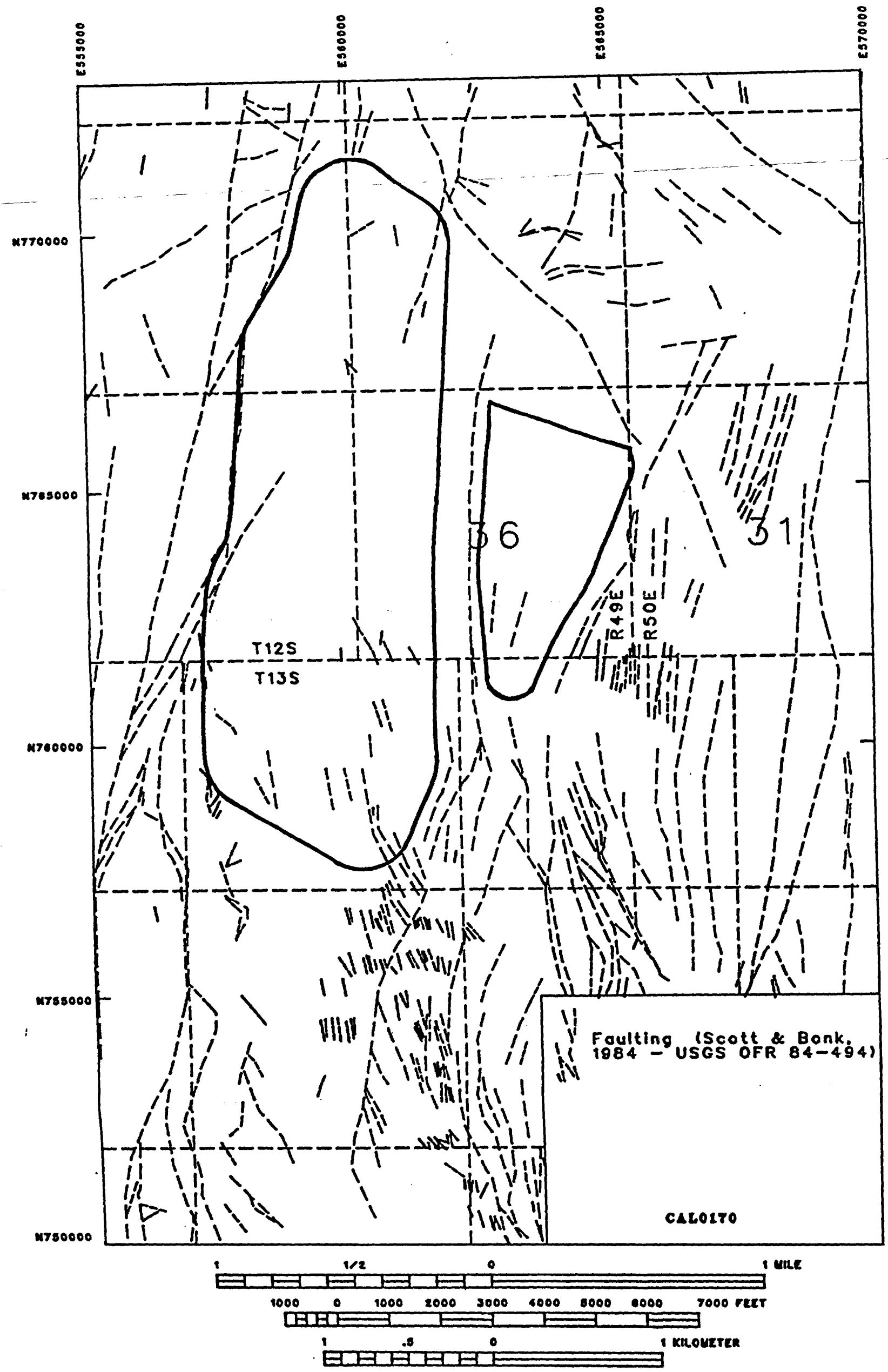
The location of the TSL Main Drift close to the Ghost Dance Fault does place a burden on ~~the~~ Surface Based Testing ~~Community~~ to provide reliable data via drilling to aid in the location of the tunnel. Planning for the acquisition of these data is underway, and these data should be available in a timely manner to support ongoing ESF design.

Figure A1-2 shows the proposed repository concept imposed on the Scott and Bonk structure map. This map provides the best available information on structure in and around the block. It is clear from this figure that the area in the Southeast quadrant utilized by the new concept avoids the significant structural traces indicated to be in this area. Only at-depth exploration (i.e.: drifting) will verify the validity of this, or any other, concept.

Consideration 7 The implementation of the test program, particularly those tests planned for the Main Test Area (MTA), may be more difficult due to the new arrangement.

Response:

Access to the MTA location under the enhanced layout will require ramps from the ESF main drift at approximately 10%. This will eliminate the MTA from rail access. However, this does not appear to be a major disadvantage as the extensive use of rail in the MTA would be difficult at best given the current configuration of this area. The primary advantage of rail in this application is its ability to carry heavy loads and support long TBM drives. The excavation/operation of the MTA would not appear to require these features, and should be supportable by equipment with rubber tires.



Scott & Bonk Structural Map with Emplacement Areas Shown **Figure A1-2**

It is also possible, given the presence of the two ramp extensions, that the concept of a centralized test area (the MTA) could be revised in favor of tests arranged along the north and south ramp extensions and the TS main drift. These drifts will provide access to a large percentage of the vertical extent of the TSw2 unit (the south extension comes within 5 meters of the basal vitrophyre). Also, location of the testing in the extensions would allow them to be spaced further apart than in the current MTA layout, thus reducing one of the NRC's original concerns regarding test-to-test interference. It should be noted that the enhanced layout described herein does not include elimination of the MTA. This development, if warranted, would be proposed at a future time.

Another NRC concern, related to the representativeness of data from tests located in a single area within the block, could also be alleviated by spreading the tests along the extensions and main drift.

Consideration 8 The east-west "step" in the potential repository layout shown in Figures 3 and 4 could cause thermal, hydrologic, and mechanical perturbations in the performance of the system.

Response:

The proposed ESF/Repository layout should have no more perturbation due to the presence of a "cool zone" at the Ghost Dance Fault than the current baseline concept. Emplacement of waste within the fault zone was not planned in the current baseline repository concept. Therefore, this layout would also have been subject to this condition. Note also that, at the higher thermal load scenarios (i.e.: LAPD) greater than 75 kW/acre), the new repository concept would not have this problem because, at the current 70,000 Metric Tons Uranium (MTU) inventory limit, emplacement would be entirely on the west side of the fault. If the thermal load is such that the east portion of the block were needed, the difference between the new flat layout and the inclined baseline concept should be minimal. This is because, while there would be a vertical offset of approximately 200 feet, the horizontal distance between the edges of the heated blocks would be at least 1,000 feet.

Consideration 9 The ESF concept entails exploration of the Topopah Spring Level first, while the Baseline Option 30-based ESF calls for early exploration of the Calico Hills. No formal documentation exists to explain this change.

Response:

The issue of whether or not to feature CH exploration early in the ESF execution is a valid one. However, this is not a discriminator between the Option 30-based layout and the proposed new layout. The two layouts are identical in their ability to accommodate early CH exploration. The issue of changing the baseline from early CH drifting to early emphasis on the TSL will be the subject of a Change Request to be submitted in the near future.

Consideration 10 The change in the ESF baseline must be properly managed and documented so as to maintain the NRC's confidence that the DOE is adhering to its commitments in the area of Design Control.

Response:

The objective of producing this Design Analysis (DA) and submitting it for review is to address this concern. This DA will serve as the documentation of the rationale for the adjustments to Option 30. As required, a Change Request will be prepared following review and acceptance of the DA. Once approved, the ESF Technical Baseline can be updated, and the proper "paper trail" will exist to document the change.

Summary

The above discussions have not provided complete resolution of the considerations raised, but have stated the position of the proponents of the change. In some cases, full response to a consideration will require design analyses which are a part of ongoing repository ACD and ESF Title II Design. In other areas it can be argued that, though the effects of the change cannot be quantified, there is insufficient information to conclude that the Baseline concept did not have the same potential condition.

The flexibility offered by the enhancements to the Option 30-based layout is a significant advantage. It accommodates the uncertainties inherent in the exploratory process better than the current layout. It is not such a radical departure from the Option-30 based concept that we must start over with the justification for the basic concept. The enhancements are a normal evolution in Title II design, and are being executed via the proper process.

The issue of delaying activities in the Calico Hills will be addressed in subsequent Change Control Board (CCB) interactions.

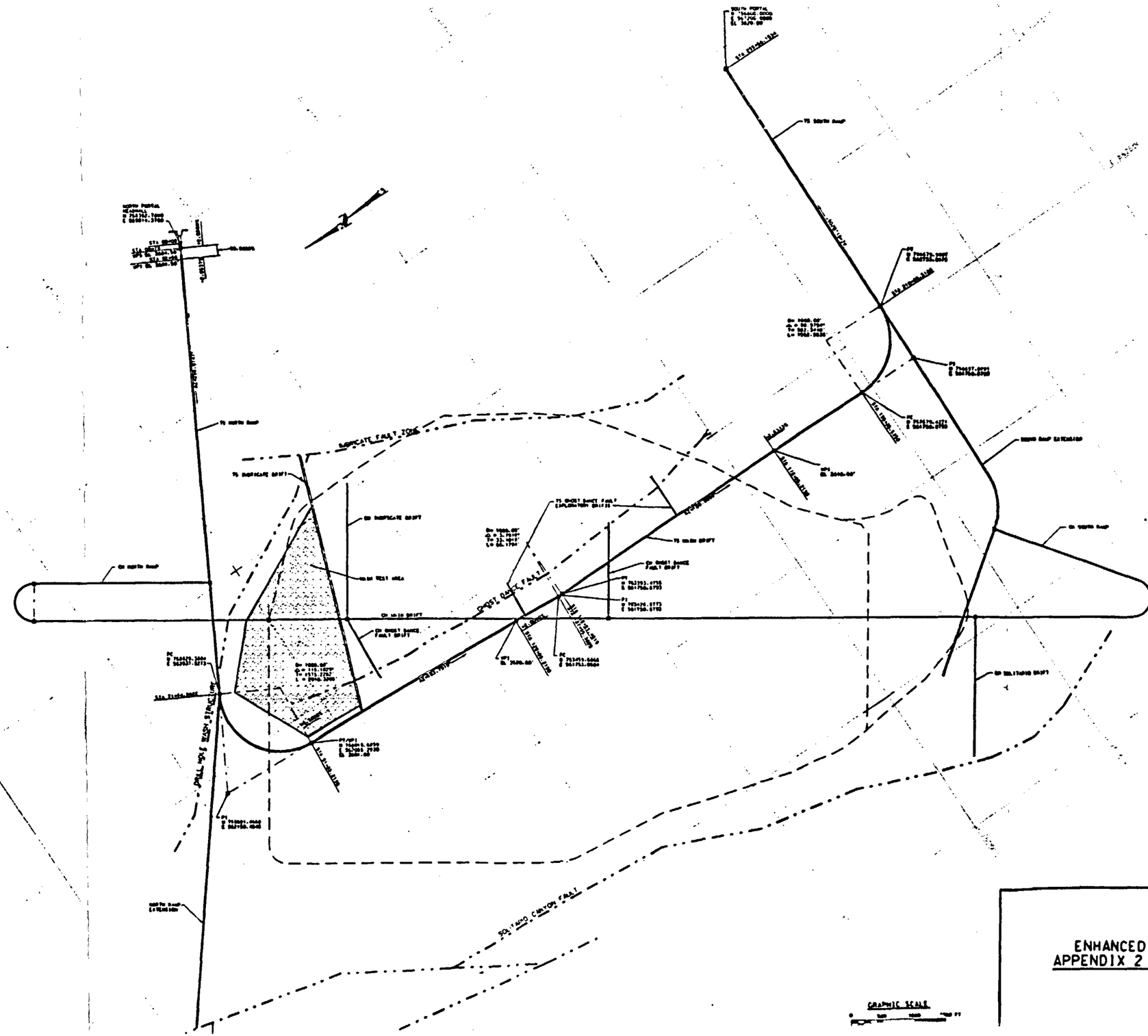
APPENDIX 2

SUPPLEMENTAL FIGURES

As noted in the "Purpose and Scope" section of the analysis, this appendix contains reduced size copies of the IGIS generated structure maps which were used to develop the ESF layout. Also included is a more detailed ESF layout showing spot elevations and grade breaks.

SUPPLEMENTAL FIGURES:

A2-1 Enhanced ESF Layout
A2-2 Two Block Repository With Elevation and Grade Data
A2-3 Surface Topography With Emplacement Areas Shown
A2-4 TSw1-TSw2 Contact With Emplacement Areas Shown
A2-5 Base of TSw2 With Emplacement Areas Shown
A2-6 Water Table Elevation With Emplacement Areas Shown


SOUTH PORTAL
TO SOUTH RAMP
SOUTH RAMP
NORTH PORTAL
TO NORTH RAMP
NORTH RAMP
TO NORTH RAMP
TO DOWNCLIMB DRIFT
DOWNCLIMB DRIFT
DOWNCLIMB DRIFT
DOWNCLIMB TEST AREA
DOWNCLIMB DRIFT
DOWNCLIMB FAULT ZONE
TO DOWNCLIMB DRIFT
TO SHORT SHOOT FAULT (EXPLORATORY DRILLING)
TO MAIN DRIFT
SHORT SHOOT FAULT DRIFT
SHORT SHOOT FAULT
TO MAIN DRIFT
MAIN DRIFT
MAIN DRIFT

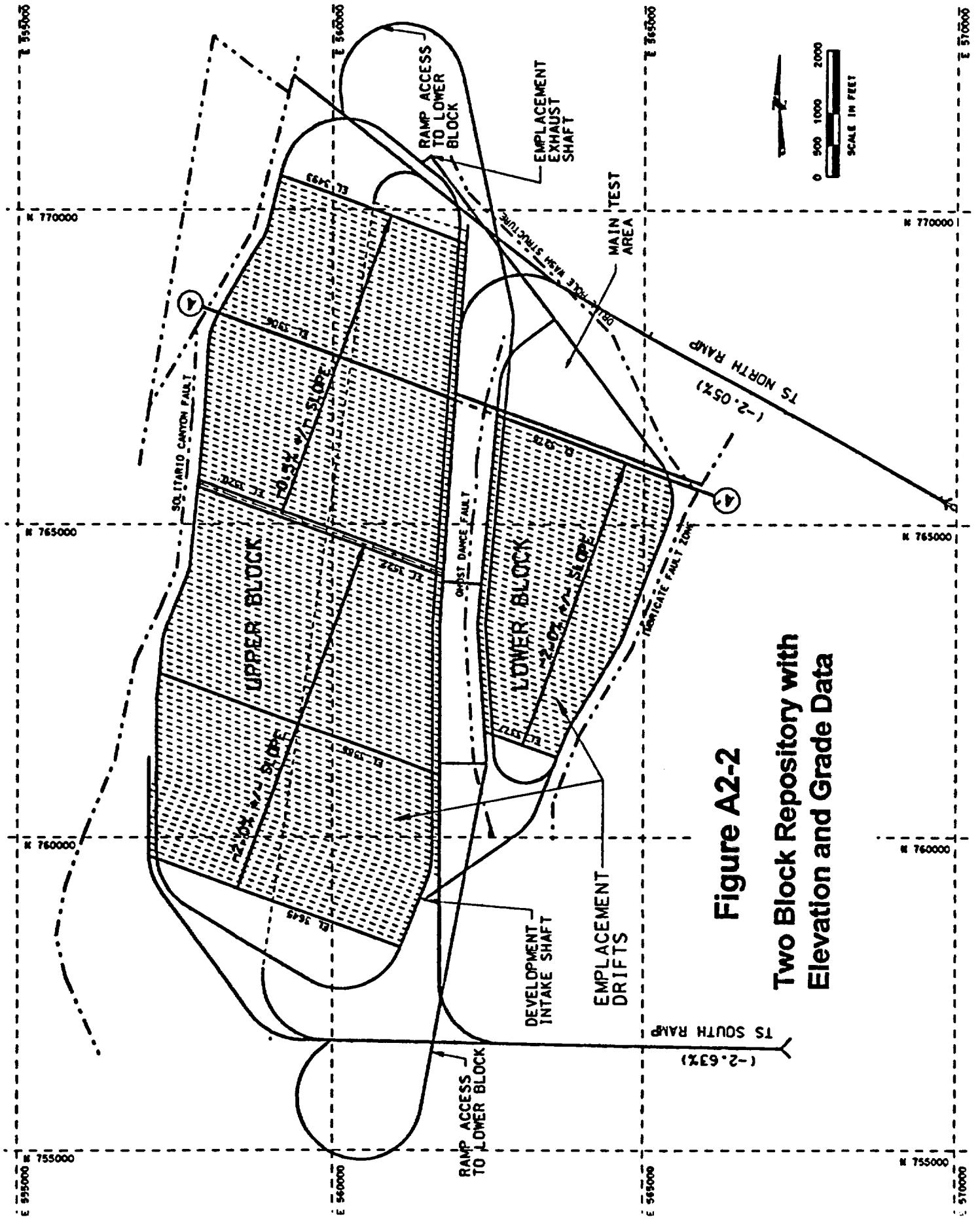
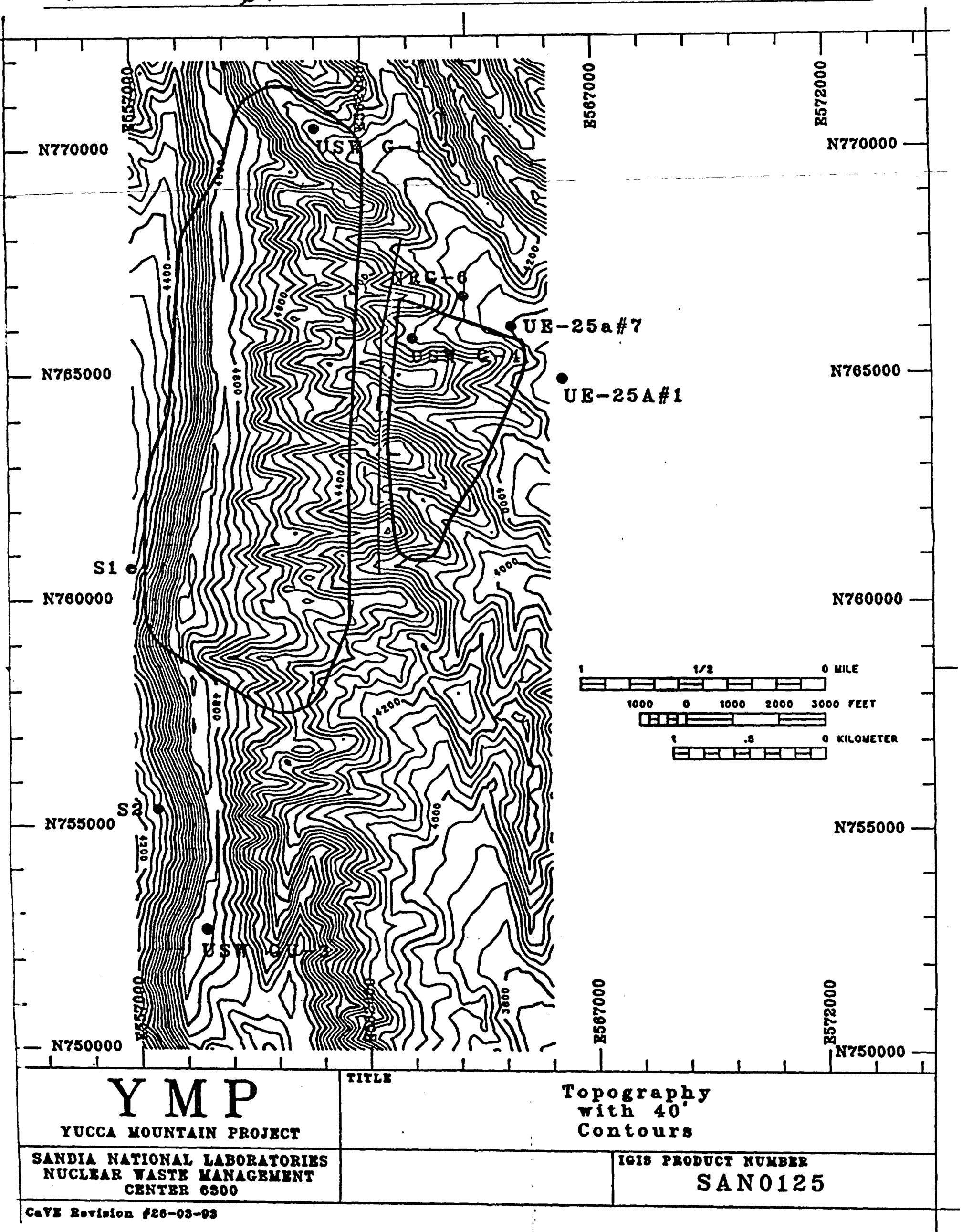
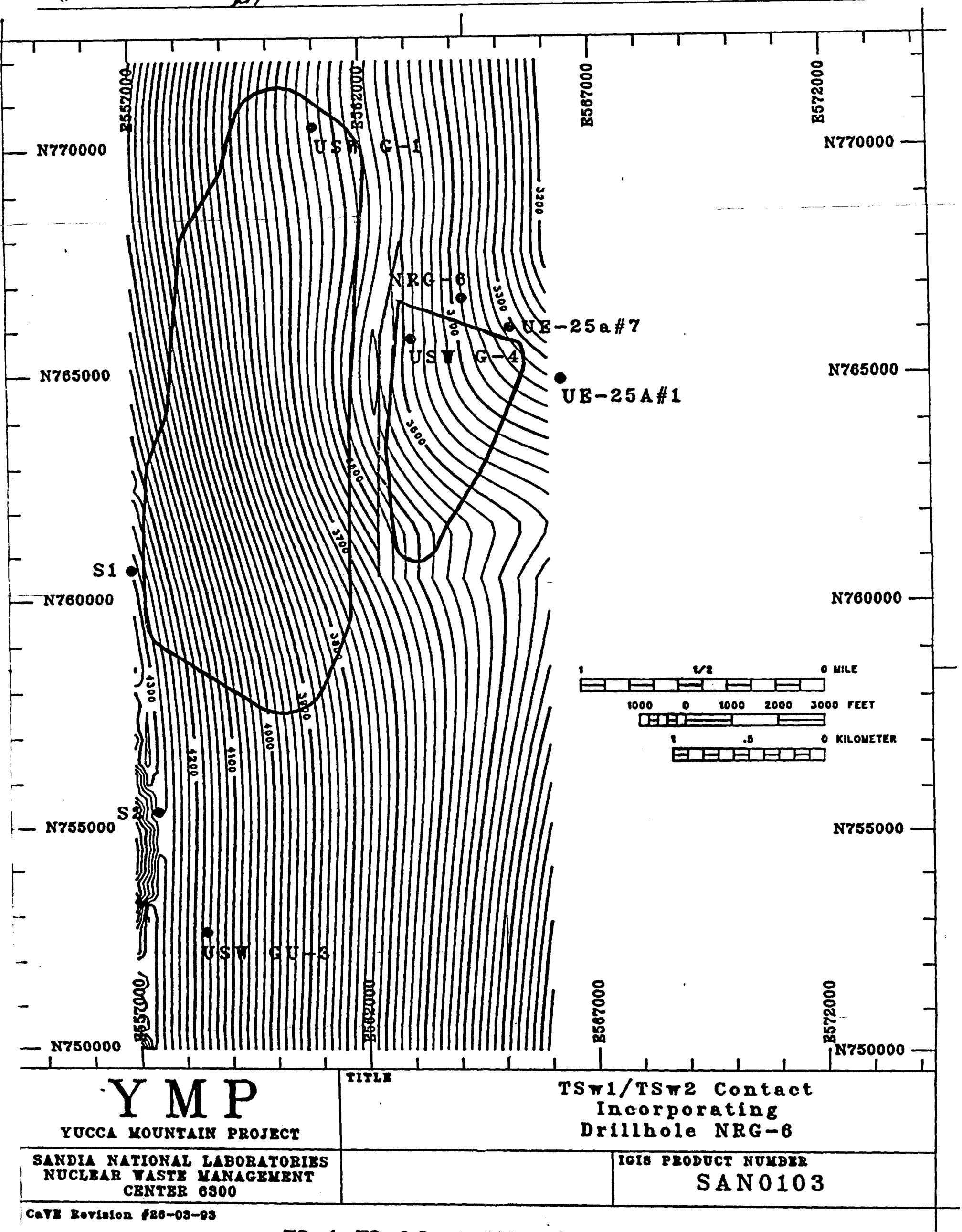


Figure A2-2
Two Block Repository with Elevation and Grade Data



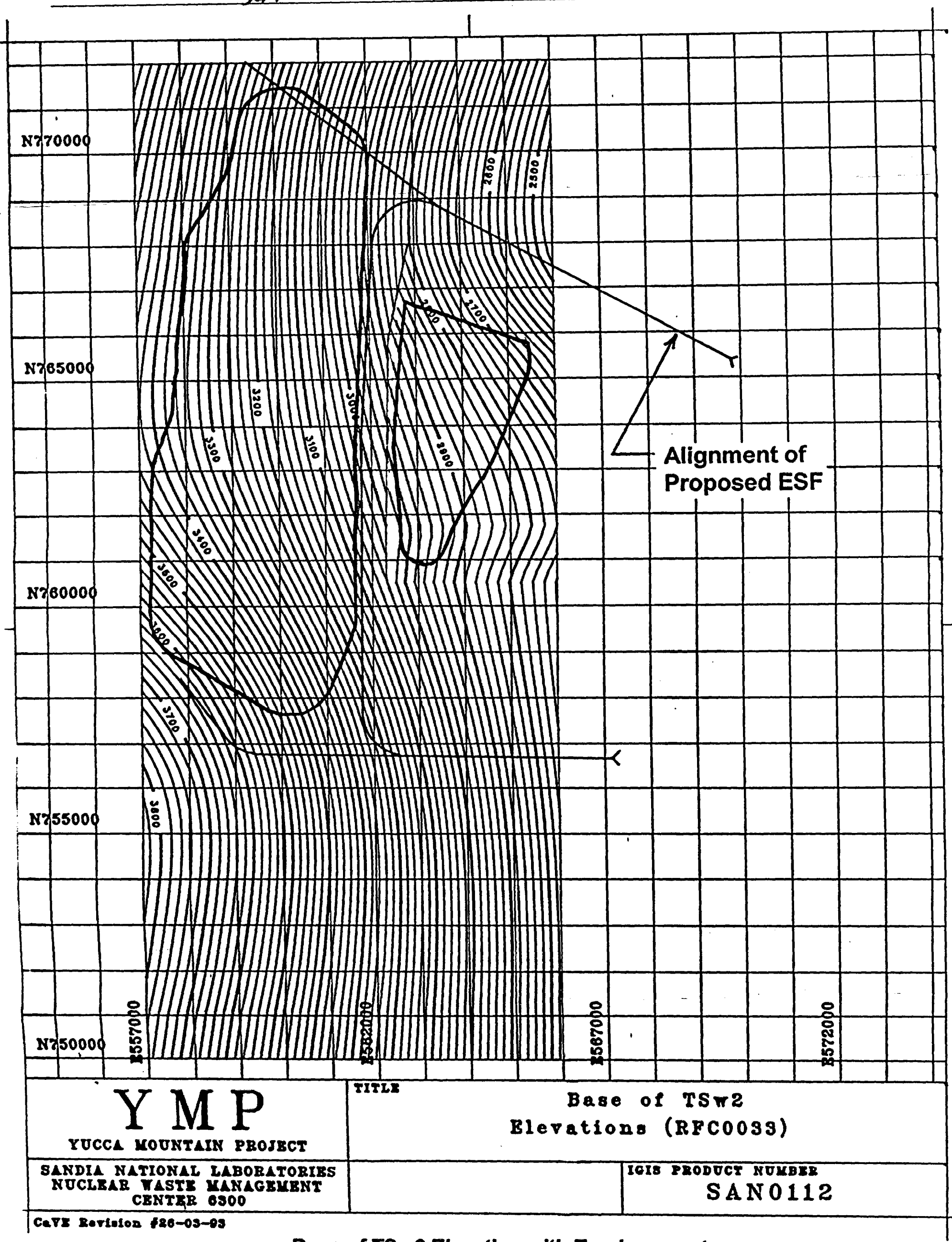
Surface Topography with Emplacement Areas Shown

Figure A2-3



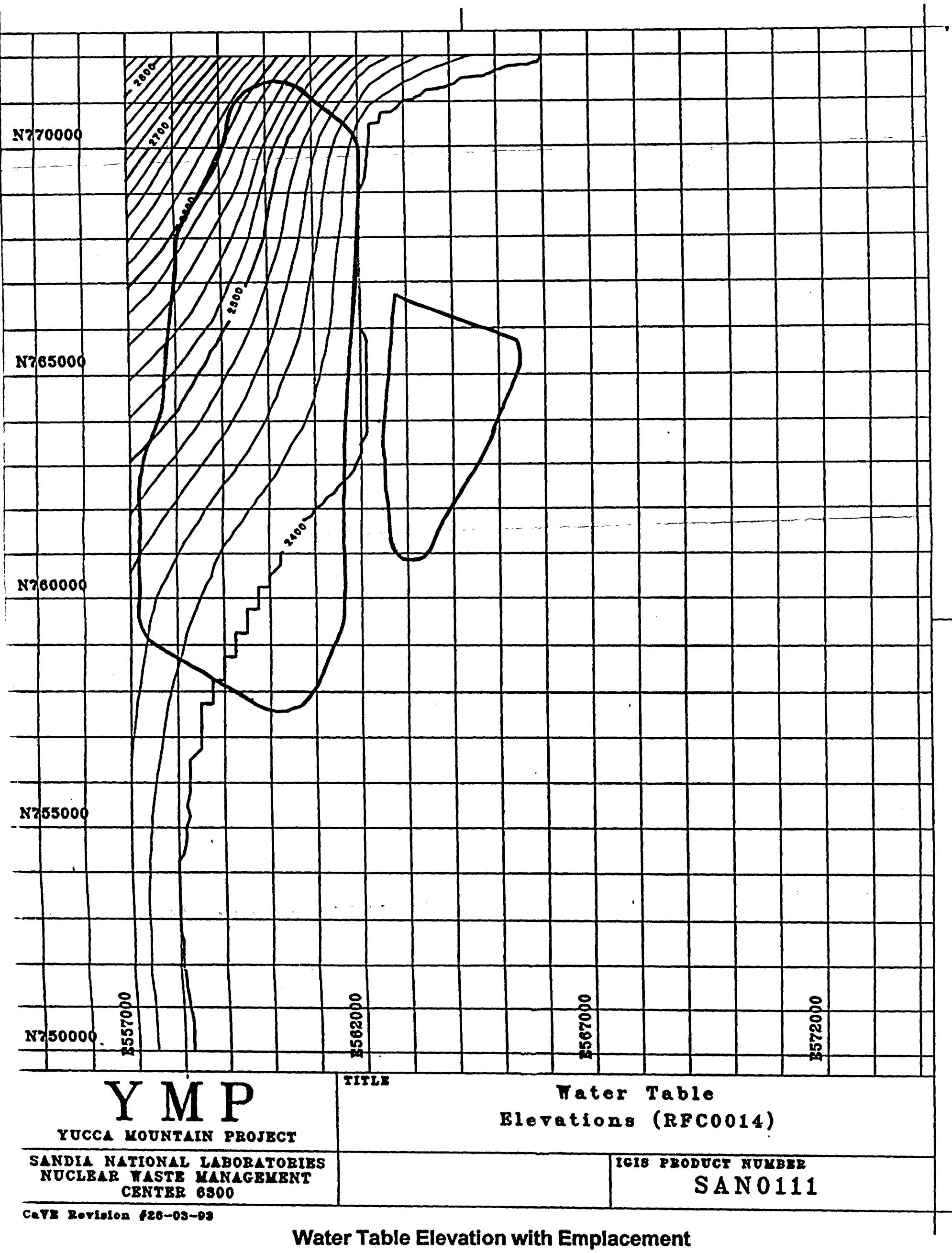
TSw1 - TSw2 Contact Map with Emplacement Areas Shown

Figure A2-4



Base of TSw2 Elevation with Emplacement Areas Shown

Figure A2-5



Water Table Elevation with Emplacement Areas Shown

Figure A2-6