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Design Analysis Cover Sheet

Complete only applicable items.

(1.) QA: L

2. DESIGN ANALYSIS TITLE			
East -West Cross Drift Starter Tunnel Layout Analysis			
3. DOCUMENT IDENTIFIER (Including Rev. No.) BABEAF000-01717-0200-00008 REV 01			4. TOTAL PAGES 14
5. TOTAL ATTACHMENTS 2	6. ATTACHMENT NUMBERS - NO. OF PAGES IN EACH Attachment I, pages 1 - 8; Attachment II, page 1 -2		

	Printed Name	Signature	Date
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9. Lead Design Engineer	William Kennedy	WR Kennedy	1/7/98
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11. REMARKS

1. TBV included in this analysis TBV- 227, TBV-229 ,TBV -230

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Design Analysis Revision Record

Complete only applicable items.

(1.)

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BABEAF000-01717-0200-00008 REV 01

4. Revision No.	5. Description of Revision
REV 00	Initial Issue
REV 01	Corrected coordinate Northing value of terminal end of drift to 232,816.548 on page 2 of 8 and page 3 of 8 of Attachment I. Also corrected same coordinate value on Figure 1 page 10 of 14 and Attachment I Figure 1, page 8 of 8. Incorporated editorial corrections made to Revision 00.

1.0 PURPOSE

The purpose of this analysis is to develop a layout configuration and location for the E-W Cross Drift with the objective to meet repository, testing, and construction requirements.

2.0 QUALITY ASSURANCE

A classification analysis for main access openings was completed that determined alignment controls would be required on the excavation of the E-W Cross Drift (Ref 5.9). There are no applicable DIE controls for the excavation layout design of the starter tunnel (Ref 5.2). Based on the required controls from the QA classification analysis the classification of this analysis is QA: Q. DIE QA controls related to the E-W Cross drift bored tunnel are To Be Determined (**TBD-231**). Although a potential for future repository uses exists for the E-W Cross Drift, the current functional purpose of the drift is site characterization and the drift and starter tunnel fall under CI: BABEAF000. The classification analysis for test support areas was reviewed and added no controls to this design (Ref 5.16). This analysis has been evaluated in accordance with QAP-2-0 (Activity Title: TR6612FB1 Title II EWX Starter Tunnel Design, ECRB- Phase I) and found to be applicable to the QA program.

3.0 METHOD

This analysis develops design strategy for the configuration and location of the E-W Cross-Drift and starter tunnel considering health and safety and minimization of excavation. Design requirements from the constructor, testing and repository organizations were used in the determination of the necessary layout and location of the starter tunnel and E-W Cross-drift. The drift was laid out graphically based on these requirements and parameters were then graphically obtained from the layout to perform coordinate geometry calculations and define vertical and horizontal alignment.

4.0 DESIGN INPUTS

4.1 DESIGN INPUT PARAMETERS

4.1.1 A 15 to 20 meter sill height is required between the proposed repository drifts and the E-W Cross Drift (Ref 5.5). **TBV-230**

4.1.2 The repository layout parameters for configuration and location of the repository block (Ref 5.13) **TBV-229** Input parameters from Reference 5.13 are as follows:

Emplacement drifts slope up from the main drifts to the center at 0.5% slope
Emplacement drift azimuth 288.0000 degrees

Emplacement drift to Main Drift offset =1.433 m
C5-PI, N 232777.08 E170013.34
C6-PI, N230659.18 E170348.79
C11-PI, N233977.76 E 170728.65
C12-PI, N232580.32 E 170618.90

4.1.3 The terminal end point of the E-W Cross Drift will be located at approximately N232817 and E 169660 (Ref 5.3)

4.1.4 The E-W Cross Drift will cross the West Main Drift at approximately N 232,750 and E 170,010 (Ref 5.3). **TBV-229**

4.1.5 The E-W Cross Drift will slope downward to the southwest at a grade of approximately 3%, as soon as practical after crossing the Repository West Main Drift (Ref 5.3)

4.1.6 The E-W Cross Drift will pass 50 to 100 meters (horizontally) from the Thermal Testing Facility. (Ref 5.3)

4.1.7 The configuration of the starter tunnel as provided by the constructor (See Attachment II, page 2 of 2) includes the width and height of the starter tunnel opening, length of starter tunnel drift for each given width and height, concrete slab thickness, angle of departure from North Ramp centerline, chamfer dimensions on inside corner of starter tunnel, length from centerline intersection to the start of 0% rail slope in the North Ramp, and invert offset between starter tunnel and bored tunnel. (Ref 5.8)

4.1.8 Layout parameters for the ESF Main Drift are as follows (Ref 5.1).

Offset point coordinate North Ramp = N233331.870, E173584.197
Vertical Point of Intersection (VPI) in North Ramp at station 01+62.500 and elevation 1121.763 m
Azimuth of North Ramp = 298.974722
Slope of North Ramp = 2.149%
VPI at station 28+04.323 at elevation 1065 m and N 234087.742, E171313.778
Main Drift slope = 1.35 %
Main Drift Azimuth = 183.0000 degrees

4.1.9 The existing invert segment plus rail height is .633 (segment) +.146 (rail) = .779 m (Ref 5.4)

4.1.10 Diameter of emplacement drifts = 5.5 m (Ref 5.12)

4.1.11 The drainage of the cross-drift invert should be designed with a consistent positive slope from the North Ramp to the western edge of the planned repository upper block in order to provide gravity drainage with minimal ponding.(Ref 5.5)

4.1.12 The cross drift should conform to the projected profile of the repository openings. (Ref 5.5)

4.1.13 The 200 meter overburden requirement is not applicable to the E-W Cross Drift or starter tunnel. (Ref 5.6)

4.1.14 150 meters of straight bored tunnel is required after launch of the TBM. (Ref 5.8)

4.2 CRITERIA

The following applicable requirements for the starter tunnel and E-W Cross Drift were identified in (Ref 5.7) and are to be verified **TBV-227**.

4.2.1 The Enhanced Repository Block Characterization (ECRB)/ E-W Cross Drift has been coordinated with the repository design. The design and location of the repository layout is unqualified. Verification of the location of the repository block vertical separation from the E-W Cross Drift is required prior to approval of final repository layout design and thus to be verified **TBV- 229**. [ESFDR 3.7.2.1.2.B]

4.2.2 The ECRB E-W Cross Drift shall be designed, constructed, and insitu testing shall be planned to support the required tests identified in Appendix B of the Exploratory Studies Facility Design Requirements (ESFDR) Document(Ref 5.18), [ESFDR 3.7.2.5.1.C] [ESFDR 3.7.2.1.2.B]

4.2.3 The ECRB Cross Drift shall be designed and constructed in compliance with all applicable Determination of Importance Evaluations and Classification Analysis. [Derived]

4.2.4 All coordinates shall be in accordance with the Nevada State Plane Coordinate System and be traceable to existing first-order control points in or around Area 25. [ESFDR 3.7.2.1.1.D]

4.2.5 All excavation blasting shall be designed to control overbreak to minimize impacts to waste isolation and/or site characterization testing.[ESFDR 3.2.1.2.3.G]

4.2.6 Appropriate gravity drainage shall be incorporated for draining water away from testing areas and other work areas to suitable collection points for further treatment and/or disposal. [ESFDR 3.7.2.1.2.D]

4.2.7 The construction of the E-W Cross Drift shall incorporate use of mechanical excavation or controlled drill and blast methods [ESFDR 3.7.2.1.2F]

4.2.8 The E-W Cross Drift design basis shall be consistent with the results of site characterization. [ESFDR 3.7.1.2. A]

4.2.9 The E-W Cross Drift design shall be consistent with the quality controls and record keeping requirements expected for permanent items.[ESFDR 3.7.2.1.2.C]

4.3 ASSUMPTIONS

Not used

4.4 CODES AND STANDARDS

Not Used

5.0 REFERENCES

5.1 ESF Layout Calculation, BABEAD000-01717-0200-00003, REV 04

5.2 Determination of Importance Evaluation for the East-West Cross Drift Starter Tunnel, BABEAF000-01717-2200-00010 REV 01

5.3 Revised Transmittal of design and Test-Related information on the East-West Cross Drift, LA-EES-13-LV-06-97-014, Design Input Transmittal, from Hollins to Kimura, accepted June 6, 1997

5.4 Rail Placement Invert Segment - B Plan & Sections, BABFCC000-01717-2100-40178 Rev 02

5.5 Repository Layout Design, Design Input Transmittal, from McKenzie to Kimura, accepted Sept 15, 1997

5.6 E-mail from General Counsel, Design Input Transmittal, from Ashe to Kimura, accepted June 5, 1997

5.7 Enhanced Characterization of the Repository Block Requirements Document, BAB000000-01717-5705-00013, Rev 00 Design Input Transmittal, from Rindskopf to Kimura, accepted June 13, 1997

5.8 ECRB Starter Tunnel and Cross drift Plan and Sections, Figure 1, Design Input Transmittal, from Dresel to Kimura, accepted Oct 15, 1997

5.9 QA Classification Analysis of Main Access Openings, BABEAD000-01717-2200-00002 Rev 04

5.10 Rock Conditions in the Vicinity of the East-West Drift/North Ramp Intersection, memo, LV.ESSD.RCD.9/97-081, Dow to Goodin, Dated September 25, 1997

5.11 Determination of Available Volume for Repository Siting, BCA000000-01717-0200-00007, Rev 00

5.12 Repository Subsurface Layout Configuration Analysis, BCA000000-01717-0200-00008 Rev 00

5.13 Subsurface Repository Slopes, BCAA00000-01717-0200-00007 Rev 00

5.14 Subsurface General Construction Specification, BAB000000-01717-6300-01501 Rev 05

5.15 Subsurface Drilling and Blasting Specification, BABEA000-01717-6300-02313 Rev 01

5.16 QA Classification Analysis of Test Support Areas, BABEAF000-01717-2200-00001, Rev 00

5.17 TS Main Drift Thermal Testing Facility Alcove Plan Sht. 1 of 3, BABEAF000-01717-2100-40230-01

5.18 ESFDR YMP/CM-0019, Revision 2, ICN 1.

6.0 USE OF COMPUTER SOFTWARE

Not Used

7.0 DESIGN ANALYSIS

Design calculations for the horizontal and vertical layout provided in this section are given in Attachment I. All design elevations are at excavated invert. Standard trigonometric calculations are employed to develop the coordinate geometry for the layout of the E-W Cross Drift starter tunnel and drift. The coordinates and distances determined by this calculation are based on the Nevada State Plane Coordinate System, Central Zone, North American Datum of 1927 (NAD 27) converted to meters. As such, the actual ground distances are greater than the calculated grid distances and surveyors will need to apply correction factors when laying out construction lines or survey control points, or when measuring distances (Ref 5.1).

7.1 DESIGN GOALS

In addition to the design input the following design goals were determined to be important in developing the layout configuration and location of the starter tunnel and E-W Cross Drift.

Design Goals

1. The starter tunnel should breakout of the North Ramp where ground support conditions are favorable

2. Design of the E-W Cross Drift should minimize excavation length

3. The design of the E-W Cross drift should be consistent with the ECRB working group consensus option.

7.2 DESIGN CONFIGURATION

7.2.1 E-W CROSS DRIFT PLAN LAYOUT

A positive slope is designed along the starter tunnel and E-W Cross Drift from the beginning of the tunnel and across the proposed repository block until it crosses over the West Main Drift of the repository (Input 4.1.11). At this point the drift slope is directed downward. Sloping the drift downward on both sides of the repository block prevents water that is intercepted by the tunnel outside the repository block from being transported by the tunnel over the planned repository.

The 200 meter minimum overburden regulatory requirement was determined to not be applicable to the starter tunnel and the E-W Cross Drift. This design input (Input 4.1.13) allowed the breakout station of the starter tunnel to be located anywhere along the North Ramp alignment without concern of the starter tunnel or E-W Cross Drift being less than 200 meters below the ground surface.

The location of testing boreholes was reviewed to prevent interference with the boreholes due to excavation of the starter tunnel or E-W Cross Drift. The appropriate analysis was reviewed (Ref 5.11) and showed that the location of existing holes would not cause interference in the layout of the drift or starter tunnel.

To meet testing requirements, the E-W Cross Drift must pass a minimum of 50 meters and a maximum of 100 meters from the south east side of the Thermal Testing Facility (TTF), cross the west Main at approximately N232,750 and E170,010 (Input 4.1.4) and maintain an alignment that is consistent with the terminal end point of the drift at N232,817 and E169,660 (Input 4.1.3 and 4.1.6) (See Figure 1). Additionally, a curve radius of 305 m was selected to facilitate the use of conventional belt conveyors for muck haulage.

The alignment of the E-W Cross Drift was determined graphically by using the requirements given by the repository and testing organizations. The segments of repository drifts that were used for layout of the E-W Cross Drift in the analysis were located directly from plotting the calculated northings and eastings which defined these lines. Coordinate geometry for location of these lines is given in Input 4.1.2.

A horizontal alignment was selected for the E-W Cross Drift which allowed the drift to pass by the TTF at a distance of approximately 53 meters, as measured from right rib of the E-W Cross Drift to the closest location of the TTF. The alignment then proceeds over the repository block, and crosses the West Main Drift at approximately the required point.

Based on these requirements a drift alignment with an azimuth of 229.0000 degrees was selected to pass by the TTF and cross the proposed repository block. Next, the location of the starter tunnel was selected based on the required alignment of the E-W Cross Drift and the design requirement from the constructor that a minimum of 150 meters be provided to insure operator familiarity with the TBM, prior to entering any horizontal or vertical curves (Input 4.1.14). This located the intersection of the centerline of the starter tunnel and the North Ramp at North Ramp station 19+92. This starting point allows a straight portion of the tunnel from the point of launch of approximately 152 meters prior to reaching the beginning of the first horizontal curve. A distance of 250 meters between Station 0+00 and the intersection of the 229.0000° azimuth alignment (PI #1)was selected which provided the required distances.

The terminal end point coordinate of the drift was plotted and an alignment of 289.0000 degrees was selected that directed the drift west across the Solitario Canyon Fault from a selected point of intersection (PI #2) with the 229.0000 azimuth alignment. The 305 m radius horizontal curve was then used to join the alignments and cross the West Main at approximately the required coordinates. The location of PI #2 and the lengths of the lines were selected based on trial and error to provide a terminal end point within 1 meter in northing and easting from the required approximate terminal point and to cross the West Main at the given approximate coordinates. A distance between PI #1 and PI #2 was graphically determined as 2249 m and the distance between PI #2 and the terminal end point was graphically determined at 359 meters.

The distance between the vertical offset from the repository block was established based on the requirement to maintain a sill height between drifts of between 15 and 20 meters (Input 4.1.1). The midpoint of this distance was selected at 17.5 meters. Maintaining this offset from the

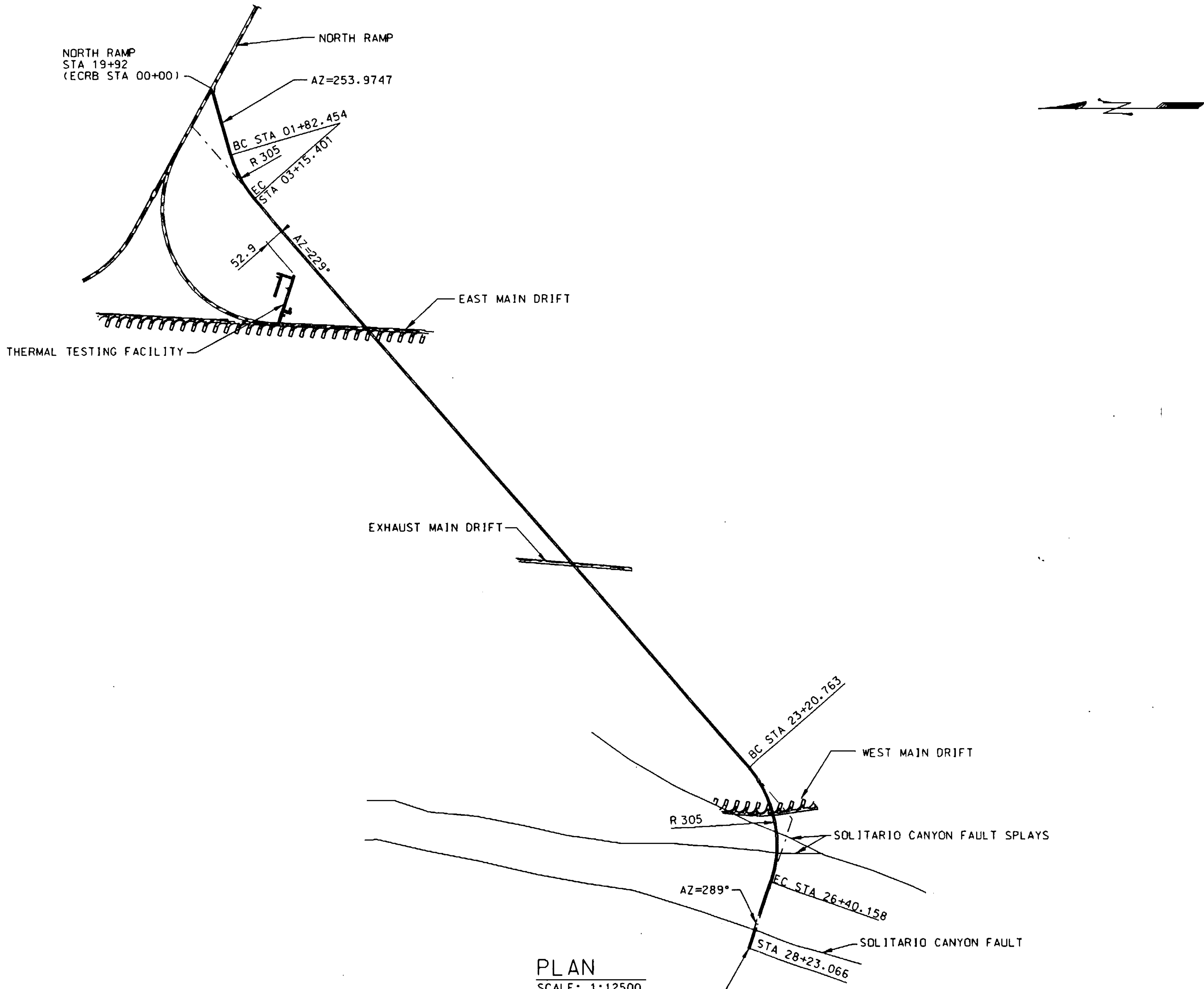


FIGURE 1
E-W CROSS DRIFT
PLAN

repository and E-W cross drift allowed the drift to conform to the repository layout (Input 4.1.12) and at the same time maintain a positive slope upward as the tunnel proceeded (Input 4.1.11). Vertical intersection point (VPI) locations were selected at or near points of plan view intersection of the E-W Cross Drift and the repository East Main drift, apex line of the emplacement drifts and West Main Drift. These locations were selected to provide consistent sill thickness across the repository block. The elevations of each VPI were then calculated based on selected locations determined from the configuration of the Main Drift (Input 4.1.8) and the repository drifts (Input 4.1.2), as shown in Figure 1 of Attachment I.

A Q-control on alignment of the E-W Cross-Drift has been established by Classification Analysis (Ref 5.9). A tolerance on tunnel alignment of one half tunnel diameter has been used in the past for ESF tunneling with TBM machines (Ref 5.14) however, a more conservative tolerance will be used on the E-W Cross Drift of 2.0 meters that will allow for vertical curve locations above the repository drifts without exceeding the 15 to 20 meter required offset by repository design. The 2.0 meter horizontal Q alignment tolerance will also maintain the required 50 meter offset from the TTF. Thus, a design distance of approximately 53 meters from the TTF and a 17.5 meter sill height between the E-W Cross Drift and repository drifts both have at least a distance of 2.0 meters in excess of the required offsets of 50 m and 15 - 20 m, respectively. This insures that required clearances from these areas will be met unless the Q control is exceeded. This control is required from the start of the bored tunnel to the terminal end of the drift and was accounted for in minimum standoff distances of the drift from the TTF and the planned repository drifts. Thus, a Q-control tolerance of 2.0 m will be used for line and grade for the bored tunnel.

The North Ramp geology near the intersection of the North Ramp and the selected alignment for the drift was reviewed. The zone of the intersection identified between Station 19+80 to 20+10 by the A/E showed high Q values for the rock and ground conditions that were favorable to breakout from the North Ramp. The Q value is used to represent the relative quality of the rock mass. A site visit was made to this location in the North Ramp by geotechnical staff that verified that the ground in this area was favorable for the intersection of the two drifts (Ref 5.10).

7.2.2 EXCAVATION METHODS

The method of excavation to be used to mine the starter tunnel portion of the E-W Cross Drift will be determined by the constructor. The two methods that can be used are mechanical mining using a roadheader type machine or conventional mining methods using controlled drill and blast techniques. Cross-sectional excavation tolerances for mechanical excavation will be the same as previously used in mechanical excavation of alcoves which is - 0 + 300 mm (Ref 5.17). The deviation from the designed alignment for the starter tunnel excavation shall not exceed 500 mm in the horizontal direction and 300 mm in the vertical direction at any point along centerline and is based on previous design tolerances for alcove excavation (Ref 5.17). For drill and blast excavation the cross-section tolerance requirements are provided in the Specification 02313 (Ref

5.15).

The construction tolerances for line and grade departure given in Reference 5.14 were adequate for previous ESF TBM excavation and thus will continue to be used for the excavation of the E-W Cross Drift, as follows. Construction tolerance for TBM excavation shall not exceed a maximum departure of 300 mm from established line and grade, as shown on the approved A/E design drawings. Laser corrections applied to return to established line and grade shall not exceed an average rate of 300 mm per 100 meters of tunnel.

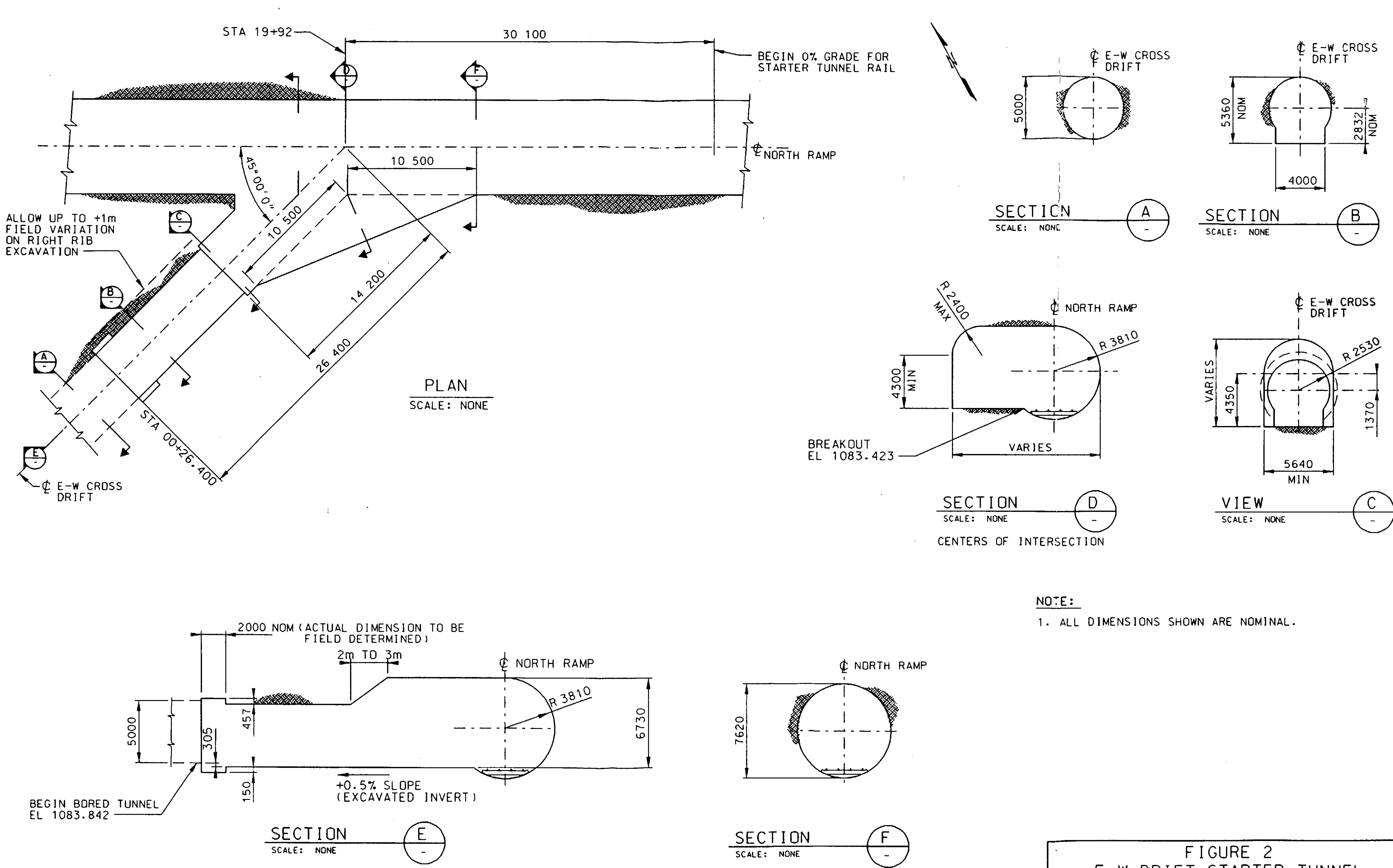
7.2.3 STARTER TUNNEL DESIGN

The starter tunnel design was based on design input provided by the constructor (Input 4.1.7). The grade of the starter tunnel excavated invert was selected at +0.5%.This will provide drainage toward the North Ramp and also meet constructor needs for TBM assembly. The location of tunnel breakout from the North Ramp was chosen to minimize excavation length, locate tunnel breakout in good ground as discussed above, and meet constructor design input requirements (Input 4.1.14). Constructor requirement for 150 m length of straight tunnel located the tunnel intersection at Station 19+92 in the North Ramp, as discussed above (Figure 2). The right rib of the starter tunnel can be mined beyond the design width shown, up to 1 meter by the constructor, as determined necessary during field assembly of the TBM and conveyor (Input 4.1.7). The starter tunnel will depart from the North Ramp at a 45 degree angle which is an azimuth of 253.9747° and terminate at Station 00+26.400 m (Input 4.1.7) (Figure 2). The elevation at breakout from the North Ramp was calculated at 1083.423 meters and the elevation of the start of the bored tunnel at launch at 1083.842 meters and were based on the selected location and slope of the starter tunnel and constructor input (Input 4.1.7). The starter tunnel will be initially mined up to approximate station 00 +14.200 with vertical ribs and an arched back as shown in View C of Figure 2. The launch portion of the starter tunnel will be circular with the lower portion of the ribs mined vertical to provide a flat invert as shown in View C.

A 305 mm offset (Input 4.1.7) has been required by the constructor as shown in Figure 2 between the launch excavated invert and the bored invert. The back of the starter tunnel will transition between the 6730 mm (Input 4.1.7) high drift and the 5360 mm (Input 4.1.7) high drift over a length of between 2 to 3 meters to prevent an abrupt brow from being formed.

7.2.4 E-W CROSS DRIFT DESIGN

Elevations of VPI's for the layout of the drift were calculated based on design input provided by Repository Design Department. This input provided the planned repository design layout and the required vertical offset of the E-W Cross Drift relative to the repository drifts (Input 4.1.2). After selection of the VPI locations and calculation of required elevation the slopes required between the VPI's were then calculated, Attachment I. Calculations and the layout design of the E-W Cross Drift are given in Attachment I. The drift is a 5 .0 m diameter bored tunnel that starts at



NOTE:

1. ALL DIMENSIONS SHOWN ARE NOMINAL.

ALL DIMENSIONS ARE SHOWN IN MILLIMETERS UNLESS OTHERWISE NOTED

FIGURE 2
E-W DRIFT STARTER TUNNEL
PLAN & SECTIONS

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the end of the starter tunnel station 00+26.400 and proceeds along an azimuth of 253.9747 degrees to the beginning of the first horizontal circular curve at Station 1+82.454.The tunnel continues along the horizontal curve to the end of curve at station 3+15.401. The tunnel proceeds along an azimuth of 229.0000 degrees to station 3+25.401 at which point VPI #1 was located. The drift then continues at a +1.846 % slope along a 229.0000 degree azimuth to the location of VPI #2 at station 7 +72.661. VPI #2 is located at the plan view intersection of the E-W Cross Drift and the East Main Drift center lines. VPI # 2 is located at an elevation of 1093.592 m which provides the required sill height between the drifts of 17.5 m. From this point, the drift slopes at a +1.488 % and continues along the 229.0000 degree azimuth to the location of VPI #3 at station 16+02.05 m. VPI # 3 is located at an elevation of 1105.931 m which provides the required sill height between the planned emplacement drifts and the E-W Cross Drift of 17.5 m. The drift continues, from this point, at a slope of +.886 % and 229.0000 degree azimuth to the beginning of the second horizontal curve at station 23+20.763. The drift continues along the curve at +.886 % slope to VPI #4 located at station 24 +67.146. VPI #4 elevation is 1113.597 which provides the required sill height between the cross drift and the West Main Drift. The drift then continues from this point at a slope of -3.0 % to the end of horizontal curve #2 located at station 26 +40.158 m. From the end of curve #2 the drift continues at a -3.0% slope and along a 289.0000 degree azimuth to the terminal end of the drift located at station 28 +23.066. The invert elevation at the terminal point is 1102.919 m.

8.0 CONCLUSIONS

The geometric parameters which define the starter tunnel and E-W Cross drift have been defined in Section 7 of this calculation. Pertinent coordinate geometry data from the preceding calculation and dimensions are shown in Figure 2 and Attachment I, Figure 1.

The actual ground distances are greater than the calculated grid distances and surveyors will need to apply correction factors when laying out construction lines or survey control points, or when measuring distances.

TBV-229 and TBV-230 require verification of the repository drift excavation layout design and the sill thickness between the E-W Cross Drift and repository drifts, respectively. Verification of these items will be done by the Repository Design Department. TBV-230 can be verified by the repository design department after the construction of the drift is complete but prior to completion of repository layout final design and does not have to be carried down to the design drawings. TBV-227 and 229 are required to be carried down to the design drawings.

9.0 ATTACHMENTS

Attachment I - Coordinate Geometry Calculations
Attachment II - Design Input 4.1.7 Starter Tunnel Layout

ATTACMENT I

COORDINATE GEOMETRY CALCULATIONS AND FIGURE

ATTACHMENT I

COORDINATE GEOMETRY CALCULATIONS

SELECTED DRIFT AZIMUTHS

253.974722°
229.0000°
289.0000°

CALCULATE COORDINATES

Coordinate of North Ramp Offset Station 1+08.750, N 233,331.870, E 173,584.197 (Input 4.1.8)
Coordinate of North Ramp Station 19+92 (Station 0+00 E-W Cross Drift)
Northing = 233,331.870 + [Sin (298.974722 - 270) x 1883.250] = 234,244.161 m
Easting = 173,584.197 - [Cos (298.974722 - 270) x 1883.250] = 171,936.667 m

Calculate Coordinate of PI #1
Selected distance along azimuth = 250 m
N = 234,244.161- [Cos (298.974722 - 45 - 180) x 250] = 234,175.146
E = 171,936.667 - [Sin (298.974722 - 45 - 180) x 250] = 171,696.382

Calculate Coordinate of PI #2
Selected distance along azimuth = 2249 m
N = 234,175.146 - [Cos (229 - 180) x 2249] = 232,699.669
E = 171,696.382 - [Sin (229 - 180) x 2249] = 169,999.040

Calculate Coordinate of terminal end of drift
N = 232,699.669 + [Sin (289 - 270) x 359] = 232,816.548
E = 169,999.040 - [Cos (289 - 270) x 359] = 169,659.599

CALCULATION FOR HORIZONTAL CURVES

Δ= central angle
T = Tangent length
R = Radius
L = Length of Curve

Curve # 1

Radius = 305 meters

North Ramp Azimuth = 298.974722
298.974722 - 45 = 253.974722 °

Δ = 253.974722 - 229.0000 = 24.974722°

T = R x TAN ½ Δ (Ref 5.1) = 305 x TAN ½ (24.974722°) = 67.546 meters

$$L = \pi(R)(\frac{\Delta}{180}) = \pi(305)(\frac{24.974722}{180}) = 132.947 \ meters$$

Curve # 2

Radius = 305 meters

Δ = 289.0000 - 229 = 60.0000°

T = 305 x TAN ½ (60.0000°) = 176.092 meters

$$L = \pi(R)(\frac{\Delta}{180}) = \pi(305)(\frac{60.0000}{180}) \doteq 319.395 \ meters$$

STATIONING

North Ramp Station 19+92 = E-W Cross Drift Station 0 +00
and

Horizontal Curve #1

BC = 250 - 67.546 = 1+82.454
EC = 182.454 + 132.947 = 3 +15.401

Horizontal Curve #2

BC = 315.401 + (2249 - 67.546 - 176.092) = 23+20.763
EC = 2320.763 + 319.395 = 26+40.158

Terminal Point Station

$$\sqrt{(232816.548-232699.669)^2+(169999.040-169659.599)^2} = 359m$$

Station = 359.000 - 176.092 + 2640.158 = 28+23.066

Vertical Curve #1 is a 20 meter curve and the VPI was graphically located at Station 3+25.401which allowed the vertical curve to begin at the end of the horizontal curve to separate the vertical and horizontal curves.

Vertical Curve #2 is a 20 meter curve and the VPI was graphically located at the approximate centerline intersection point of the East Main Drift and the E-W Cross Drift 3+15.401 +524.806 - 67.546 = Station 7+72.661

Vertical Curve #3 is a 20 meter curve and the VPI was graphically located at the approximate centerline intersection of the Repository Exhaust Main Drift and the E-W Cross Drift 772.661 + 829.391 = Station 16+02.052

Vertical Curve #4 is a 30 meter curve and graphically located on the curve 15 meters past the centerline intersection of the West Main Drift and the E-W Cross Driftas measured along the curve. The station was calculated as follows:

The angle between the BC of Horizontal Curve #2 and the VPI was graphically measured at 28.6637 °. The length of curve to the VPI was then calculated

$$L = \pi(R)(\frac{\Delta}{180}) = \pi(305)(\frac{27.4988^o}{180}) = 146.383 \ meters$$

VPI #4 Station = 2320.763 + 146.383 = 24+67.146

ELEVATION CALCULATIONS

Station 0+00 of E-W Cross Drift

Elevation of VPI @ North Ramp Station 1+62.500 (Input 4.1.8) = 1121.763 m (Input 4.1.8)

Distance to Station 19+92 (start of breakout) = 1992 - 162.500 (Input 4.1.8) = 1829.500 m

Delta elevation = 1829.500 x - .02149 (Ref 5.1) = -39.316 m

Invert elevation @ station 19+92 = 1121.763 - 39.316 = 1082.447 m

Elevation at top of existing invert segment = 1082.447 +.715(invert segment height)= 1083.162m

Invert elevation at Station 1961.9 (Start 0 % rail slope in North Ramp) =1121.763 - [.02149 x

((1992 - 30.1) - 162.5)] = 1083.094 m

Height of existing invert segment plus rail = .779 m (Input 4.1.9)
Height of constructor mud slab and rail = .450 m (Input 4.1.7)

Breakout elevation at Station 19+92 = 1083.094 + .779 - .450 = 1083.423 m

Comparison of the elevation of top of invert segment at Station 19+92 to breakout elevation shows breakout .261 m above the invert segment which is ok

Distance from intersection point to breakout

middle ordinate = m = 1083.423 - 1082.447 = .976 m

$$\frac{1}{2}C = \sqrt{2mr - m^2} = \sqrt{(2)(.976)(3.81) - (.976)^2}$$

$$\frac{1}{2}C = 2.546\ m \qquad x = \frac{2.546}{COS\ 45} = 3.601\ m$$

END OF STARTER TUNNEL

1083.423 +(.005 x (26.4 - 3.601)) = 1083.537 m

START OF BORED TUNNEL

1083.537 +.305 = 1083.842 m

VPI #1

1083.842 + (325.401 - 26.4) x .005 = 1085.337 m

VPI #2

Elevation of North Ramp Station 28+04.323 = 1065.000 (Input 4.1.8)

Graphically determined distance from Station 28+04.323 to intersection of E-W Cross Drift and East Main Drift = 257.2 m

Slope of East Main Drift = 1.35 % (Input 4.1.8)

Elevation of East Main Drift invert at intersection = 1065.000 + (257.2 x .0135) = 1068.472 m

Elevation of E-W Cross Drift invert at intersection point (VPI #2) = 1068.472 + 7.62 (Input 4.1.8) + 17.5 (Input 4.1.1) = 1093.592 m

VPI #3

To determine the elevation a line was drawn parallel to the planned emplacement drifts that passed through VPI #3 and intersected the East Main Drift.

The graphically determined distance from Station 28 + 04.323 to intersection of this line and the East Main Drift is 993.3 m

The elevation of the intersection point in the Main Drift = 1065 + (993.3 x .0135) = 1078.410 m

The vertical offset between inverts is 1.433 (Input 4.1.2) meters with an emplacement drift slope of + 0.5 %

Graphically determined distance between intersection point at the East Main Drift and VPI #3 is 617.6 m

The elevation of VPI #3 = 1078.410 + 1.433 + (617.60 x .005) + 5.5(Input 4.1.10) + 17.5 = 1105.931 m

VPI #4

Scaled distance between Station 28+04.323 and point in East Main Drift = 1729.2 m
Scaled distance between apex of emplacement drifts and East Main Drift = 634.0 m

Elevation of E-W drift invert at intersection with West Main = 1065 +(1729.2 x .0135) + 1.433 + (634.0 x +.005) + (634.0 x -.005) - 1.433 + 7.62 + 17.5 = 1065.000 + (1729.2 x .0135) + 7.62 + 17.5 = 1113.464 m

The distance from the BC of horizontal curve #2 and the intersection point of the cross drift and West Main Drift was determined by graphical measurement of the angle between the two points and calculation of the curve length as follows:

Measured angle (See Figure A1) = 27.4988 degrees

$$L = \pi(R)(\frac{\Delta}{180}) = \pi(305)(\frac{27.4988}{180}) = 146.383 \ meters$$

Distance from beginning of curve to the intersection of the E-W Cross drift and the West Main = 146.383 - 15 = 131.383

The required invert slope between VPI #3 and intersection of E-W Cross Drift and the West Main Drift = (1113.464 - 1105.931)/ (894.803 -176.092 +131.383) = 0.886 % and

Elevation VPI #4 = (.00886 x 15) + 1113.464 = 1113.597 m

Terminal end of Drift

Angle between VPI#4 and EC = 60.0 ° - 27.4988 ° (measured) = 32.5012°

$$L = \pi(R)(\frac{\Delta}{180}) = \pi(305)(\frac{32.5012}{180}) = 173.0122 \textit{ meters}$$

Elevation = 1113.597 - .03 x [173.0122 + (sta 28+23.066 - sta 26+40.158)] = 1102.919 m

SLOPE CALCULATIONS

Station 0+00 to VPI #1 (Station 3+25.401)

Slope = 0.5 %

VPI #1 to VPI #2 (Station 7+72.661)

(1093.592 - 1085.337) / 447.260 x 100 = 1.846 %

VPI #2 to VPI #3 (Station 16+02.05)

(1105.931 - 1093.592) / (1602.050 - 772.661) x 100 = 1.488 %

VPI #3 toVPI #4 (Station 24+67.146)

See elevation calculation for VPI # 4 = .886 %

VPI #4 to terminal end of drift (28 + 23.066)

- 3.0 % (Input 4.1.5)

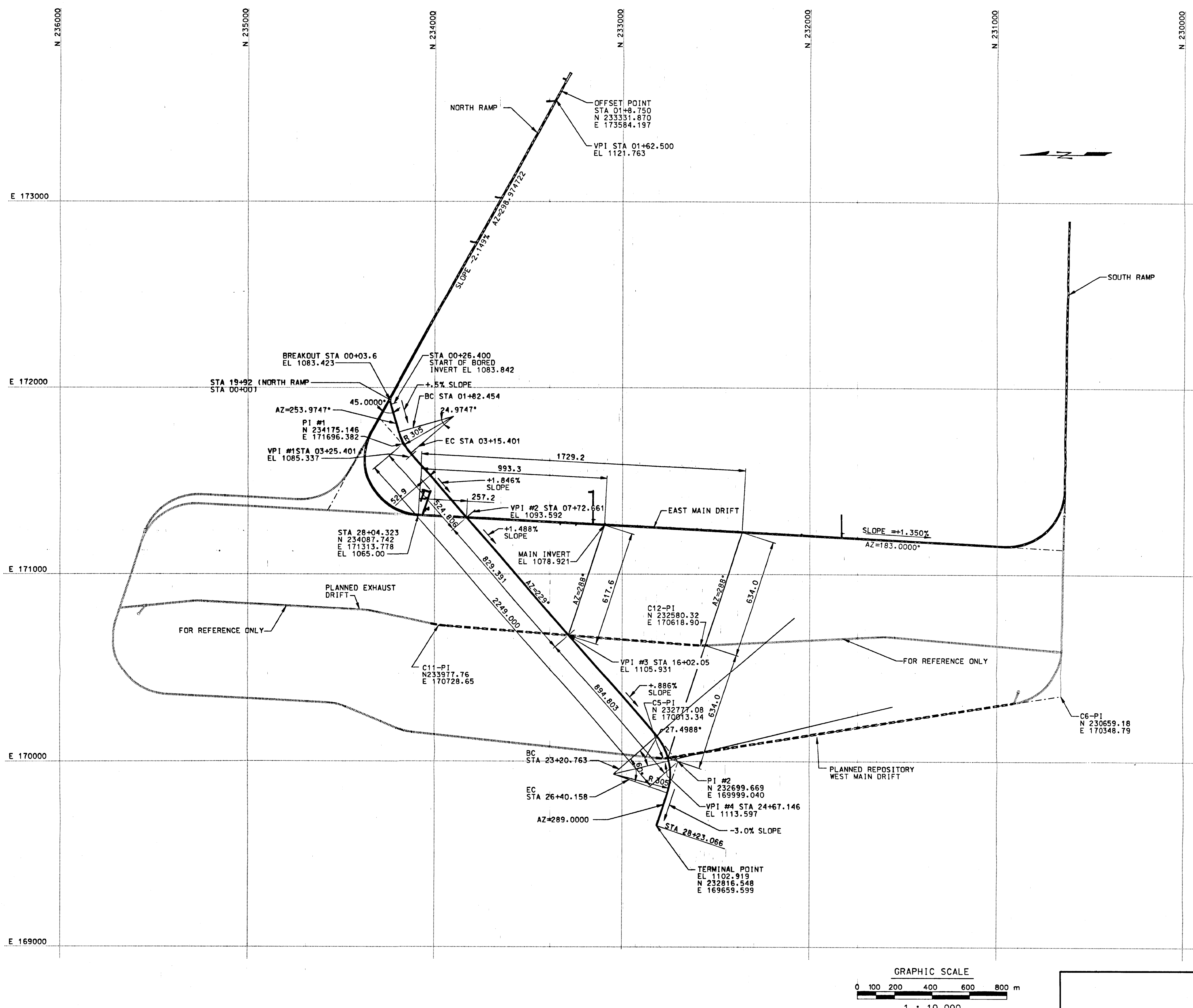
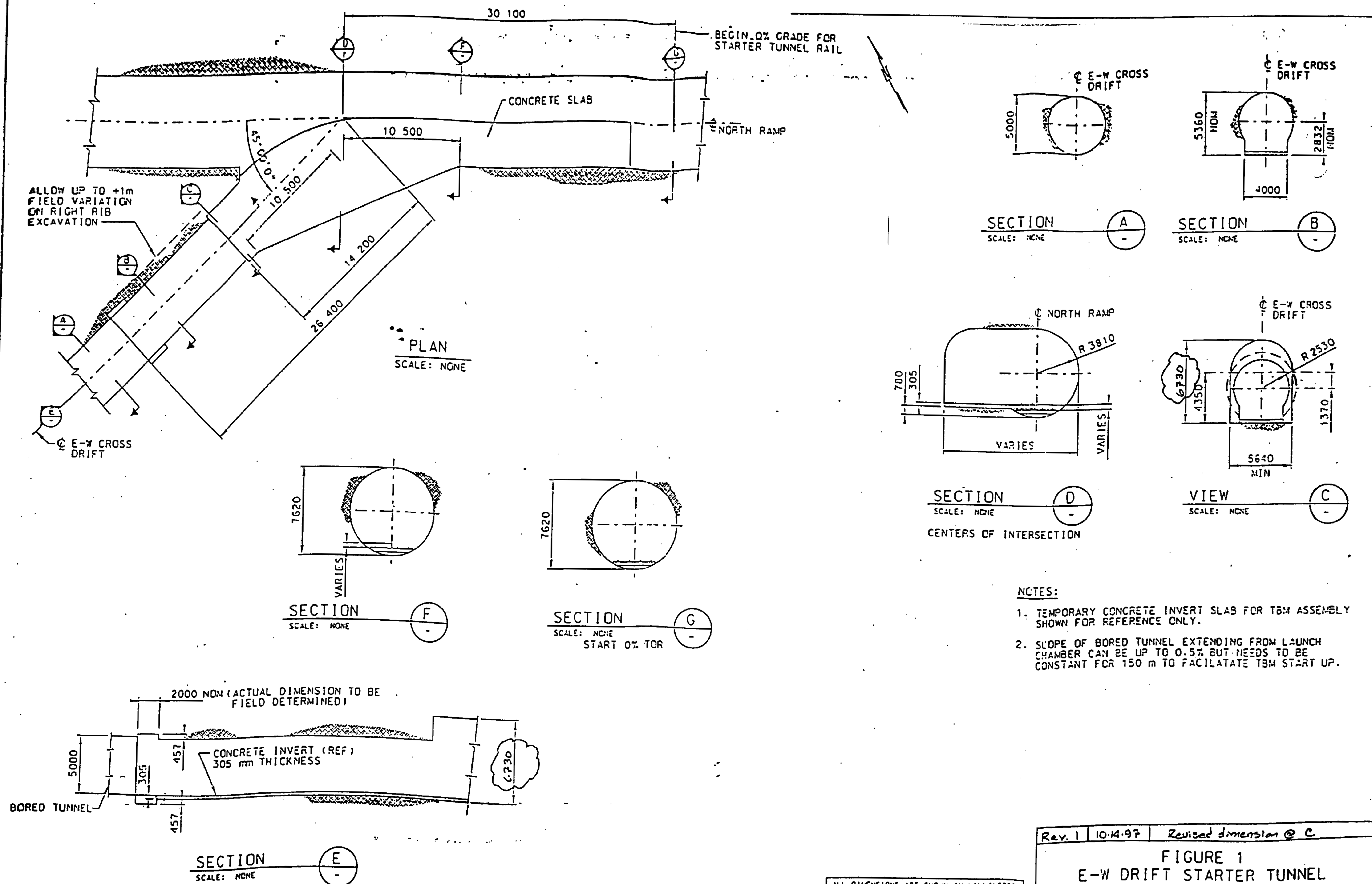

N 236000
N 235000
N 234000
N 233000
N 232000
N 231000
N 230000
E 173000
E 172000
E 171000
E 170000
E 169000
NORTH RAMP
OFFSET POINT
STA 01+8.750
N 233331.870
E 173584.197
VPI STA 01+62.500
EL 1121.763
SLOPE -2.149%
AZ=298.974722
SOUTH RAMP
BREAKOUT STA 00+03.6
EL 1083.423
STA 00+26.400
START OF BORED
INVERT EL 1083.842
STA 19+92 (NORTH RAMP
STA 00+00)
+.5% SLOPE
BC STA 01+82.454
45.0000°
AZ=253.9747°
24.9747°
PI #1
N 234175.146
E 171696.382
R 305
EC STA 03+15.401
VPI #1STA 03+25.401
EL 1085.337
1729.2
993.3
+1.846%
SLOPE
257.2
VPI #2 STA 07+72.661
EL 1093.592
EAST MAIN DRIFT
SLOPE =+1.350%
AZ=183.0000°
STA 28+04.323
N 234087.742
E 171313.778
EL 1065.00
+1.488%
SLOPE
MAIN INVERT
EL 1078.921
521.9
524.806
829.391
AZ=229°
AZ=288°
617.6
AZ=288°
634.0
2249.000
PLANNED EXHAUST
DRIFT
FOR REFERENCE ONLY
C12-PI
N 232580.32
E 170618.90
C11-PI
N233977.76
E 170728.65
VPI #3 STA 16+02.05
EL 1105.931
FOR REFERENCE ONLY
894.803
+.886%
SLOPE
C5-PI
N 232777.08
E 170013.34
27.4988°
634.0
C6-PI
N 230659.18
E 170348.79
BC
STA 23+20.763
PLANNED REPOSITORY
WEST MAIN DRIFT
R 305
PI #2
N 232699.669
E 169999.040
EC
STA 26+40.158
VPI #4 STA 24+67.146
EL 1113.597
AZ=289.0000
-3.0% SLOPE
STA 28+23.066
TERMINAL POINT
EL 1102.919
N 232816.548
E 169659.599
GRAPHIC SCALE
0 100 200 400 600 800 m
1 : 10 000

FIGURE 1

ATTACHMENT II

DESIGN INPUT 4.1.7 STARTER TUNNEL LAYOUT



NOTES:

1. TEMPORARY CONCRETE INVERT SLAB FOR TBM ASSEMBLY SHOWN FOR REFERENCE ONLY.
2. SLOPE OF BORED TUNNEL EXTENDING FROM LAUNCH CHAMBER CAN BE UP TO 0.5% BUT NEEDS TO BE CONSTANT FOR 150 m TO FACILATATE TBM START UP.

ALL DIMENSIONS ARE SHOWN IN MILLIMETERS UNLESS OTHERWISE NOTED

Rev. 1	10-14-97	Revised dimension @ C

FIGURE 1
E-W DRIFT STARTER TUNNEL
PLAN & SECTIONS