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Turnout Drift Operating Envelope Calculation

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1. PURPOSE

The purpose of the *Turnout Drift Operating Envelope Calculation* is to identify the design parameters of the typical turnout drift and advance the preliminary design of the typical turnout drift.

The scope of this calculation requires the turnout drift geometry be identified in sufficient detail to provide input to develop a typical turnout drift design. This turnout drift design strategy will be used to develop a preliminary turnout drift design for each distinct grouping of turnout drift type.

The calculation will define the operating envelope of the relevant interfaces such as the turnout drift invert and the ventilation door. This information will be used to describe the space allocation of the turnout drift components and operating equipment.

The turnout drift is an elemental component of the subsurface repository design layout. Other elemental components are the emplacement drift, the access mains, the exhaust mains, and ventilation shafts. This calculation will describe the fundamental dimensions and geometry of a turnout drift and will serve as a basis for subsequent detailed design.

2. QUALITY ASSURANCE

All subsurface excavations outside the emplacement drifts are designated Conventional Quality in the *Q-List* (YMP 2001, p. A-4 and A-9) therefore, the turnout drift is not subject to Quality Assurance controls. This calculation has been prepared in accordance with AP-3.12Q, *Design Calculations and Analyses.*

3. USE OF SOFTWARE

Only commercial off-the-shelf software were used to produce this calculation. All computations were performed manually and they can be reproduced in a manual check. This satisfies the requirements of AP-3.12Q, Section 5.2.3 (g).

4. INPUTS

The turnout drift has several fundamental design features:

- The turnout drift is the connecting excavation between an access main and the emplacement drift described by a departure angle, a curve segment and a docking segment.
- The turnout drift serves as a construction area to launch a tunnel-boring machine to excavate the emplacement drift.
- A ventilation door to control access and airflow into the emplacement drift during the emplacement period is located in the turnout drift.
- The turnout drift will accommodate emplacement equipment and the support infrastructure such as electrical, communications and monitoring systems

4.1 TURNOUT DRIFT DESIGN

The turnout drift design has been described in existing documentation and the accepted preliminary design dimensions for the turnout drift geometry and the excavation interface with the emplacement drift are established. The accepted design features that will apply in this calculation are given in the following section along with design assumptions that are required to further advance the turnout drift design are presented.

4.1.1 Drift Diameter

The emplacement drift diameter is approximately 18' - ½" (5.5 meters) and the access main diameter is 25' - 0" (7.62 meters). The emplacement drift diameter and the access main diameter are consistent with the *Underground Layout Configuration* (BSC 2003a, Figure 5).

4.1.2 Turnout Drift Dimensions

The turnout drift is approximately 26' - 3" (8.0 meters) wide. The excavation springline is approximately 9' - 10" (3.0 meters) above the sill. The turnout crown section has a radius of approximately 13' - 1½" (4.0 meters). The turnout drift dimensions are consistent with the *Underground Layout Configuration* (BSC 2003a, Section 6.4).

4.1.3 Turnout Drift Benchmark Elevations

The height difference from the turnout drift sill to the emplacement drift's excavated invert is approximately 2' - 8" (0.8 meters). This is consistent with the *Underground Layout Configuration* (BSC 2003a, Section 6.6). The turnout drift top-of-rail to the emplacement drift top-of-rail is approximately 4' - 8" (1.42 meters). The depth of the emplacement drift top-of-rail to the emplacement drift's excavated invert is approximately 47 ¼" (1.2 meters). This is consistent with the *Gantry Structural/Control System Analysis* (BSC 2001, Figure 13).

4.1.4 Direct Line of Radiation

The direct line of radiation originates at the outer most edge of a waste package located approximately 5' - 0" (1.5 meters) inside the emplacement drift and is tangent to the inside radius of the turnout drift curve. The direct line of radiation is consistent with the *Underground Layout Configuration* (BSC 2003a, Section 6.4).

4.1.5 Turnout Drift Docking Length

The turnout drift transporter dock drift length is approximately 78' - 9" (24 meter) long on azimuth with the emplacement drift. This is consistent with the *Underground Layout Configuration* (BSC 2003a, Section 6.4).

4.1.6 Emplacement Drift Azimuth

The emplacement drift azimuth is 252°. This is consistent with the *Underground Layout Configuration* (BSC 2003a, Section 5.1.4). This is presented as information that can be used to construct the general arrangement drawings.

4.1.7 Main Access Azimuth Values

The repository primary block is subdivided into emplacement panels that are described by the access mains and the exhaust mains. The primary block, access main straight sections are characterized by three distinct azimuths. The three azimuths are 3°, 23°, and 355° (BSC 2003a, Attachment V, lalayout.dxf).

5. ASSUMPTIONS

5.1 TURNOUT DRIFT PRELIMINARY DESIGN ELEMENTS

5.1.1 English Units Applied Throughout

The design dimensions in this calculation are expressed in English units that have been rationalized into conventional industrial nomenclature.

BASIS: A project policy statement implies that the preferred units for design will be English units (Hamilton-Ray, B.V. 2002). The units derived from metric conversion to English units are adjusted to the nearest conventional civil-structural-architectural unit to simplify design dimensioning and to conform to conventional industrial practice. This assumption is used in throughout.

5.1.2 Representative Turnout Drift

The representative turnout drift in this calculation will be Panel 1, Turnout Drift 8.

BASIS: Panel 1, Turnout Drift 8, is selected since it is located in the first panel that will receive waste as described in the *Underground Layout Configuration* (BSC 2003a, Section 8.4.1). A representative turnout drift is used to accurately demonstrate a preliminary design. The design

strategy can then be applied to various turnout drift styles located throughout the repository. This assumption is used in Section 6.1.

5.1.3 Turnout Drift Approach

The typical turnout drift will approach the emplacement area at an obtuse angle.

BASIS: A turnout drift that forms an obtuse angle between the access main and the emplacement drift is favorable for track access from the main access to the emplacement drift. This assumption is used in Sections 6.1.1 and 6.2.

5.1.4 Turnout Drift Curve Radius

The centerline radius of the turnout drift curve is 200' - 0" (61 meter).

BASIS: The 200' - 0" centerline radius for the turnout drift curve supports track access to the emplacement area without placing restrictive constraints on any future waste transporter equipment design. This assumption is used in Sections 6.1 and 6.2.

5.1.5 Turnout Drift Departure Angle

The turnout drift departure angle from the access drift is approximately 12°.

BASIS: The departure angle is consistent with the *Minimum Specifications For Industrial Track Construction* (AREMA 2001, 4.1.3 (g)) that states that the maximum curvature is 12°. This assumption is used in Sections 6.1 and 6.2.

5.1.6 Turnout Drift Pillar

The pillar between the turnout drift and the main access drift will taper to approximately 6' - 6" (2 meters) in width.

BASIS: The pillar dimension is a function of rock properties and the roof span created by the intersection of the turnout drift and the access drift. Tapering the pillar design to a 6' - 6" width strikes a reasonable balance between the intersection roof span and the pillar width. It is beyond the scope of this calculation to perform a pillar stability analysis. Increasing the pillar width would not affect the excavation of a turnout drift. Increasing the pillar width would affect the ground support design. This assumption is used in Sections 6.1 and 6.2.

5.1.7 Turnout Drift Maximum Operating Envelope

The turnout drift maximum operating envelope is described by a plane that is approximately 1 foot (0.3 meters) inside the profile of the turnout drift excavation. The available space outside the maximum operating envelope is reserved for ground support and utilities.

BASIS: The space allocation for the operating boundary is consistent with the ground support allowance of 1 foot (0.3 meters) for non-emplacement drift areas as described in the *Yucca*

Mountain Science and Engineering Report (DOE 2001, Section 2.3.4.1.2.2). This assumption is used in Section 6.1.3.

5.1.8 Ventilation Door Location

The ventilation door is located in the curve segment of the turnout drift that describes the pillar.

BASIS: The ventilation door location is consistent with the *Underground Layout Configuration* (BSC 2003a, Section 6.4). The precise location of the ventilation door is beyond the scope of this calculation. This assumption is presented as information only that can be used to construct the general arrangement drawings.

5.1.9 Turnout Drift Transfer Dock

The turnout drift will have a transfer dock to facilitate the offloading of waste packages and gantry equipment at the emplacement drift. The transfer dock top-of-rail elevation and track gage would be the same as the top-of-rail elevation and track gage for the emplacement drift. This assumption is used in Section 6.1.4.

BASIS: The transfer dock is consistent with the proposed turnout drift docking component that is described in the *Gantry Structural/Control System Analysis* (BSC 2001, Figure 6).

5.1.10 Transporter Power Delivery System

The turnout drift electrical infrastructure will consist of an overhead trolley system that will be installed to the extent necessary in the turnout drift.

BASIS: This power system is consistent with the baseline design as described in the *Yucca Mountain Science and Engineering Report* (DOE 2001, Section 2.3.4.4.3.2). This assumption is used in Section 6.1.3 and to used to construct the general arrangement drawings.

5.1.11 Turnout Drift Ventilation Door

The ventilation door is supported by a wall that conforms to the turnout drift excavation contour. The ventilation door opening is 15' - 6" (approximately 4.72 meters) wide and 16' - 0" (approximately 4.88 meters) high. This is consistent with the *General Ventilation DWG #3 Emplacement Ventilation Door & Bulkhead Arrangement* drawing (BSC 2003b) and is used in Section 6.1.3.

5.2 CODES AND STANDARDS

There are no codes or standards used in the preparation of this document.

5.3 CRITERIA AND REQUIREMENTS

There are no applicable criteria or requirements for the turnout drift configuration. The geometry of the turnout drift is a design solution that will accommodate the emplacement drift operating elements.

6. CONCLUSIONS

In this section, the inputs that define the parameters for the operating envelopes of the turnout drift components and operating equipment are used to generate a series of figures that will illustrate the space allocation for these elements. Simple arithmetic is used to calculate unknown dimensions from known input values of the excavation geometry and equipment operating envelopes. The figures that are produced will be used to create the turnout drift general arrangement drawings.

6.1 REPRESENTATIVE TURNOUT DRIFT

A plan view of the representative turnout drift, Panel 1, Emplacement Drift 8 (Refer to Section 5.1.2), is shown in Figure 1. The design geometry is given in Table 1. The units of measure are derived from their metric source and they are expressed in English units that have been rationalized into conventional industrial nomenclature in accordance with Assumption 5.1.1

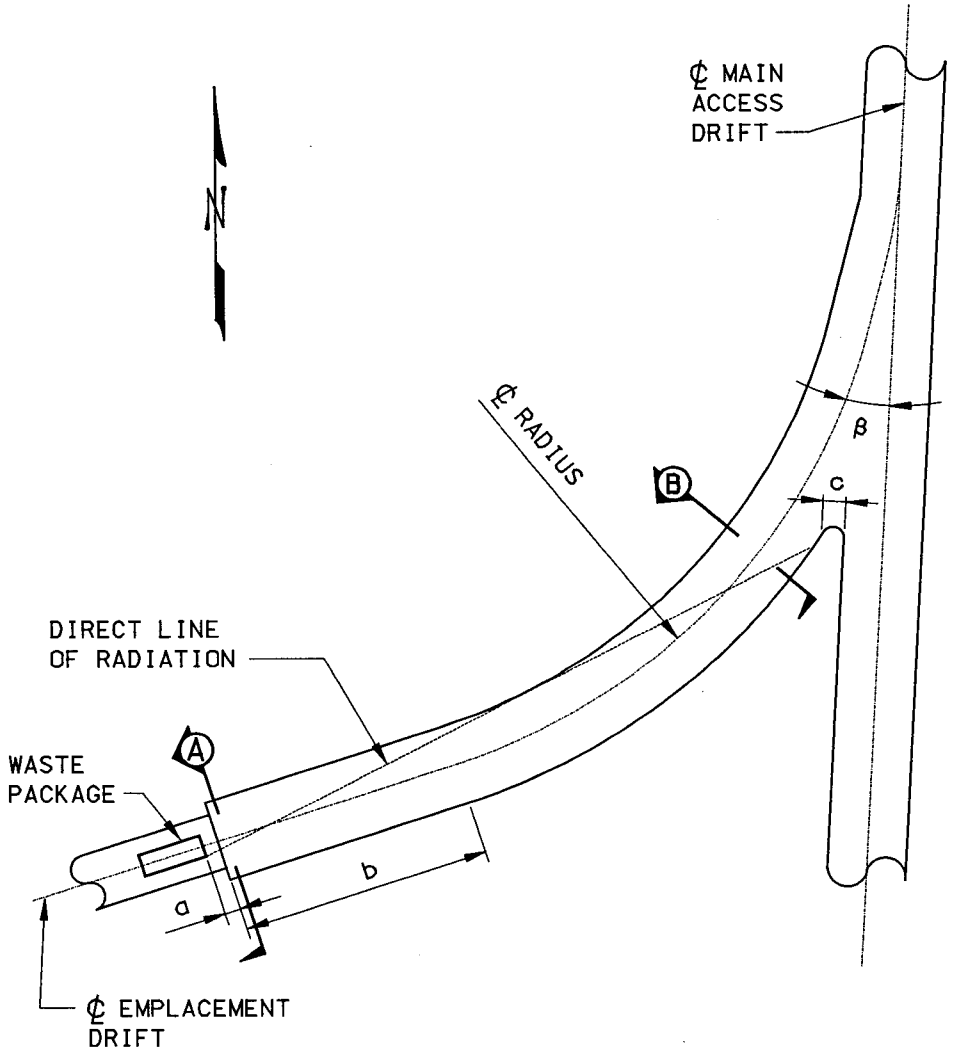
6.1.1 Turnout Drift Plan View

The plan view of the representative turnout drift is shown in Figure 1 and the corresponding dimensions are given in Table 1. The turnout drift forms an obtuse approach angle between the access main and the emplacement drift (Refer to Section 5.1.3).

Table 1. Turnout Drift Plan View Dimensions

Identifier Figure 1	Dimension Feet/Inch (approximate)	Description	Source Section
a	5' – 0"	Radiation Source Waste Package Offset	4.1.4
b*	80' – 0"	Turnout Drift Dock Segment	4.1.5
c**	7' – 0"	Pillar Width at Taper	5.1.6
¢ radius	200' – 0"	Turnout Drift Center Line Radius	5.1.4
β	12°	Turnout Drift Departure Angle	5.1.5

*Identifier Figure 1, b, Source Section 4.1.5 dimension 78' - 9" was rationalized to 80' – 0".
**Identifier Figure 1, c, Source Section 5.1.6 dimension 6' - 6" was rationalized to 7' - 0".



PANEL 1 TURNOUT DRIFT 8

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SECTION A IS SHOWN IN FIGURE 2
SECTION B IS SHOWN IN FIGURE 3

Figure 1. Representative Turnout Drift Plan View

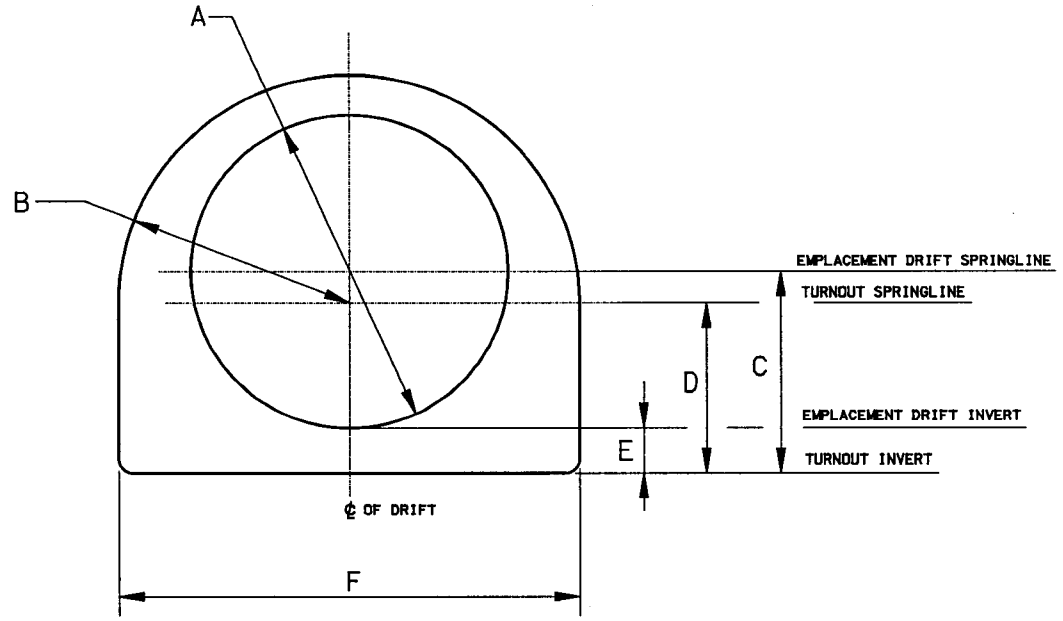
6.1.2 Turnout Drift and Emplacement Drift Interface View

Figure 2 shows the spatial relationship between the turnout drift and the emplacement drift in section view. The dimensions that describe the position of the emplacement drift and the turnout excavation are found in Table 2. The units of are expressed in English units that have been rationalized into conventional industrial nomenclature in accordance with Assumption 5.1.1

Table 2. Turnout Drift and Emplacement Drift Dimensions

Identifier (Figures 2 & 3)	Dimension Feet/Inch (approximate)	Description	Source Section
*A	18' – 0"	Emplacement Drift diameter	4.1.1
*B	13' – 0"	Turnout Crown Radius	4.1.2
C	11' - 8"	Emplacement Drift Springline	Calculated
*D	10' - 0"	Turnout Springline	4.1.2
E	2' - 8"	Invert Offset	4.1.3
*F	26' - 0"	Turnout Width	4.1.2

*Identifier **A**, Source Section 4.1.1, dimension 18' - ½" was rationalized to 18' - 0". Identifier **B**, Source Section 4.1.2, dimension 13' - 1½" was rationalized to 13' - 0". Identifier **D**, Source Section 4.1.2, dimension 9' - 10" was rationalized to 10' - 0". Identifier **F**, Source Section 4.1.2, dimension 26' - 3" was rationalized to 26' - 0".



SECTION A (FROM FIGURE 1)
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Figure 2. Turnout Drift and Emplacement Drift Interface View

6.1.3 Turnout Drift Elevation View at Ventilation Wall Structure

The schematic elevation view of the ventilation door structure is shown in Figure 3. The figure shows the turnout drift dimensions (Refer to Table 2), the allowance for the ventilation door opening (Refer to Section 5.1.11), the maximum operating envelope for equipment (Refer to Section 5.1.7) and the space allocation for the turnout drift invert (Refer to Figure 4).

The overhead trolley system (Section 5.1.10) is not shown in the figure since it would be installed short of the ventilation door so as not to interfere with the ventilation door opening. The continuation is located on the emplacement drift side to the extent necessary to deliver power to the transporter.

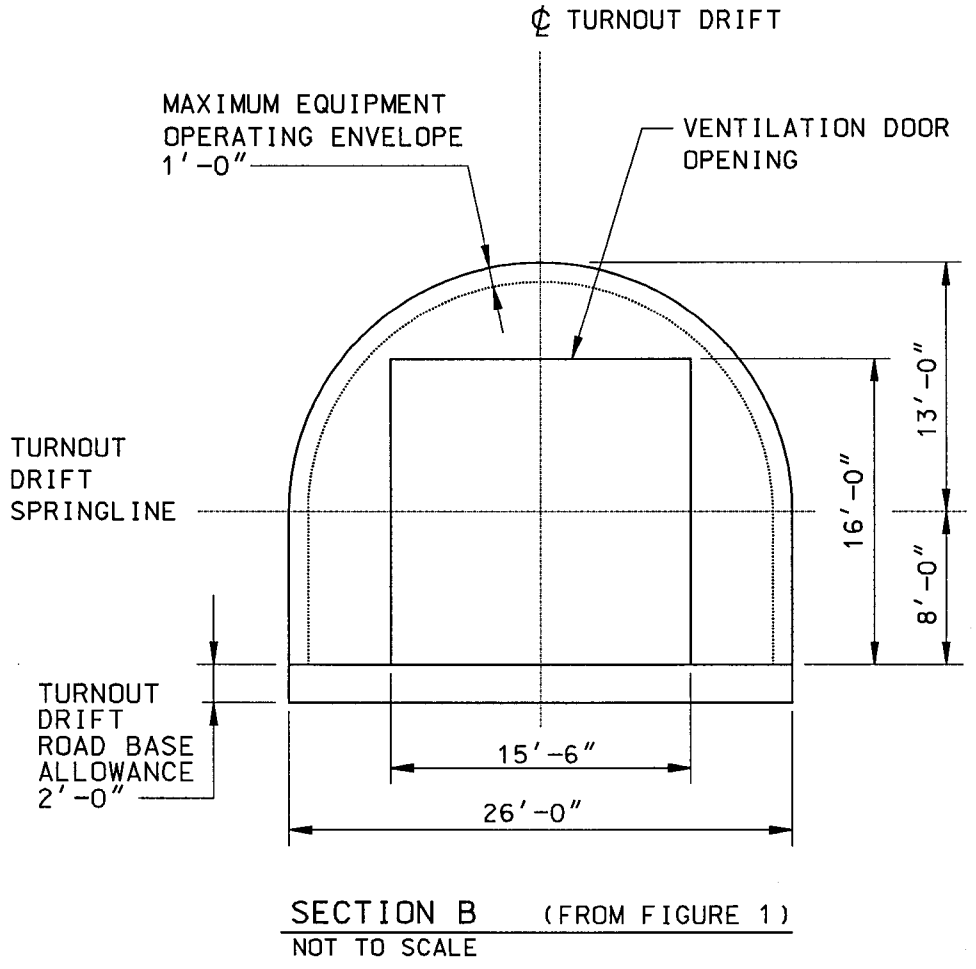


Figure 3. Turnout Drift Ventilation Door Elevation View

6.1.4 Emplacement/Turnout/Main Spatial Relationship

In the repository subsurface design, the emplacement drift is connected to the main access with a turnout drift. The spatial relationship amongst these three excavations is shown in Figure 4. (Note that Assumption 5.1.1 is invoked.) The fundamental elevations that serve to locate these excavations in relation to each other are:

- The top-of-rail elevation for the main access and the turnout drift is the same at their intersection.
- The emplacement drift excavated invert is 2' - 8" above the turnout drift sill (From Section 4.1.3).
- The top-of-rail of the emplacement drift is at the same elevation as the top-of-rail of the turnout drift dock (From Section 5.1.9).
- The top-of-rail in the emplacement drift is 4' - 0" above the emplacement drift excavated invert (47 ¼" from Section 4.1.3 that has been rationalized).
- The turnout drift springline is at 10' - 0" and the emplacement drift springline is 11' - 8" above the turnout drift sill (From Table 2).

By calculation, the following benchmark elevations shown in Figure 4 are determined:

1. The emplacement drift springline is 1' - 8" above the turnout drift springline.
2. Since the radius of the emplacement drift is 9' - 0" (From Section 4.1.1) the emplacement drift top-of-rail can be calculated as 5' - 0" below the emplacement drift springline.
3. The emplacement drift top-of-rail to the emplacement drift excavated invert is 4' - 0" and it is an additional 2' - 8" lower to the turnout drift sill. Since the top-of-rail elevation difference between emplacement drift and the turnout drift is 4' - 8" the turnout drift roadbed allowance is 2' - 0" in depth.
4. Given that the turnout drift springline is at 10' - 0" and the turnout drift roadbed allowance is 2' - 0" in depth, the turnout drift springline is 8' - 0" above the turnout drift top-of-rail.

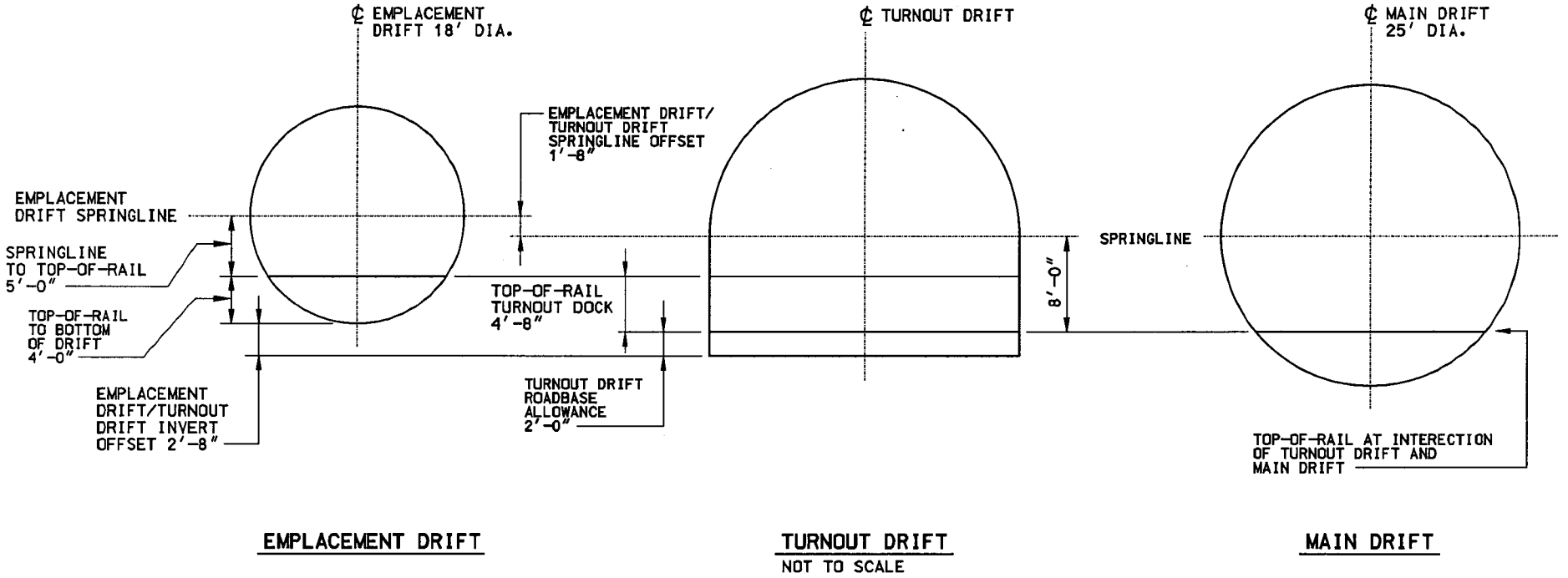


Figure 4. Emplacement Drift/Turnout Drift and Main Drift Spatial View

6.2 TYPICAL TURNOUT DESIGN APPLIED THROUGHOUT REPOSITORY

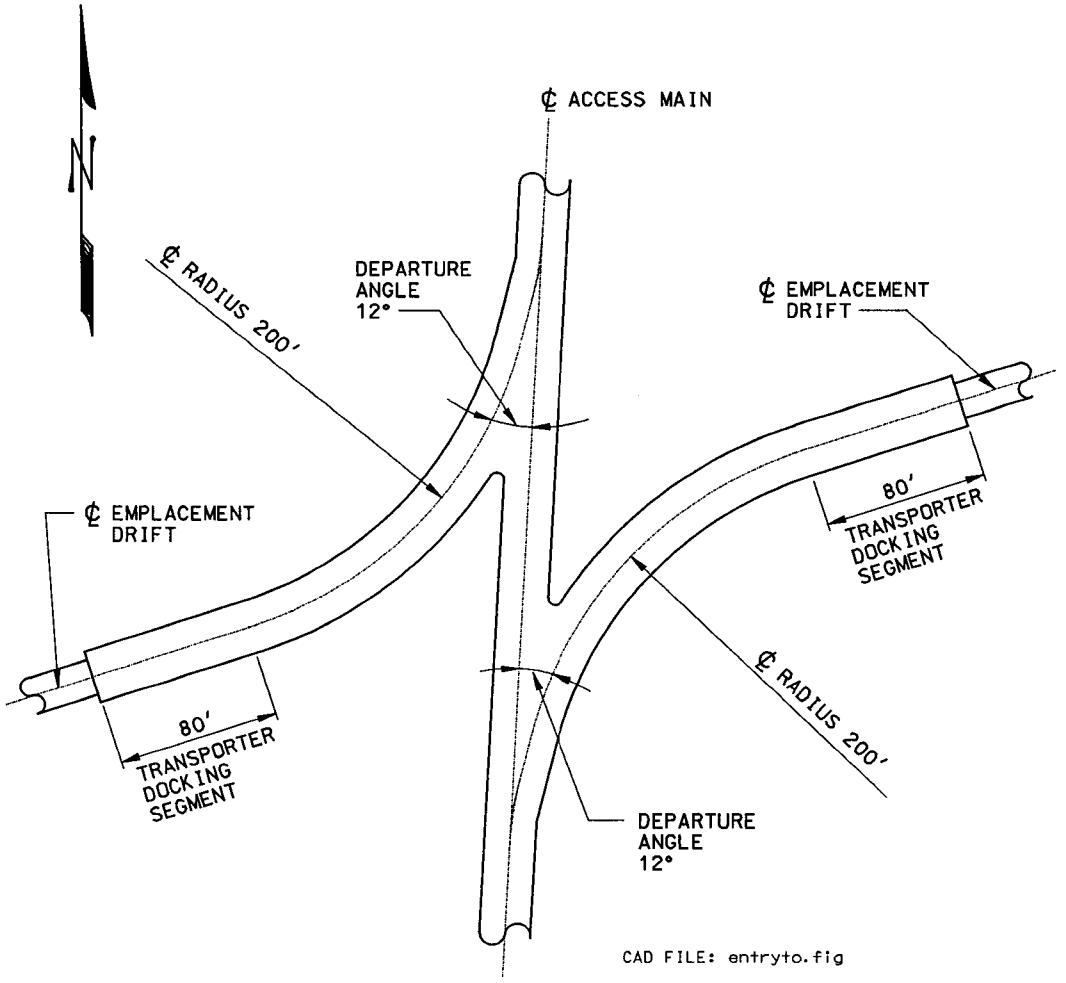
During the development of *Turnout Drift Operating Envelope Calculation,* five major turnout drift styles were identified. These five groupings are sorted according to the direction of their approach into the emplacement area and the azimuth of the main access from which the turnout drift originates. The representative turnout drift design shown in Figure 1 is typical of a west entry into the emplacement area originating from a main access on a 3° azimuth. The five turnout designs are described in the following sections.

6.2.1 East and West Entry From Access Main on 3° Azimuth

Turnout drifts that originate from an access main on a 3° azimuth (Refer to Section 4.1.7) may occur individually in the subsurface repository or they may be associated with a symmetrically opposed turnout drift. Both turnout drift types and the resultant intersection area are shown in Figure 5.

The turnout drift with a west entry into the emplacement area approaches from the north direction and turns west into the emplacement area. This is consistent with forming an obtuse angle between the main access and the emplacement drift relative to the approach direction (Refer to Section 5.1.3). The departure angle is 12°, the centerline radius of the curve is 200', and the transporter dock segment is 80' (Refer to Table 1).

The turnout drift with an east entry into the emplacement area approaches from the south direction and turns east into the emplacement area. The basic design geometry is the same as the turnout drift with a west entry into the emplacement area.



TURNOUT FROM ACCESS MAIN
@ AZIMUTH 3°
NOT TO SCALE

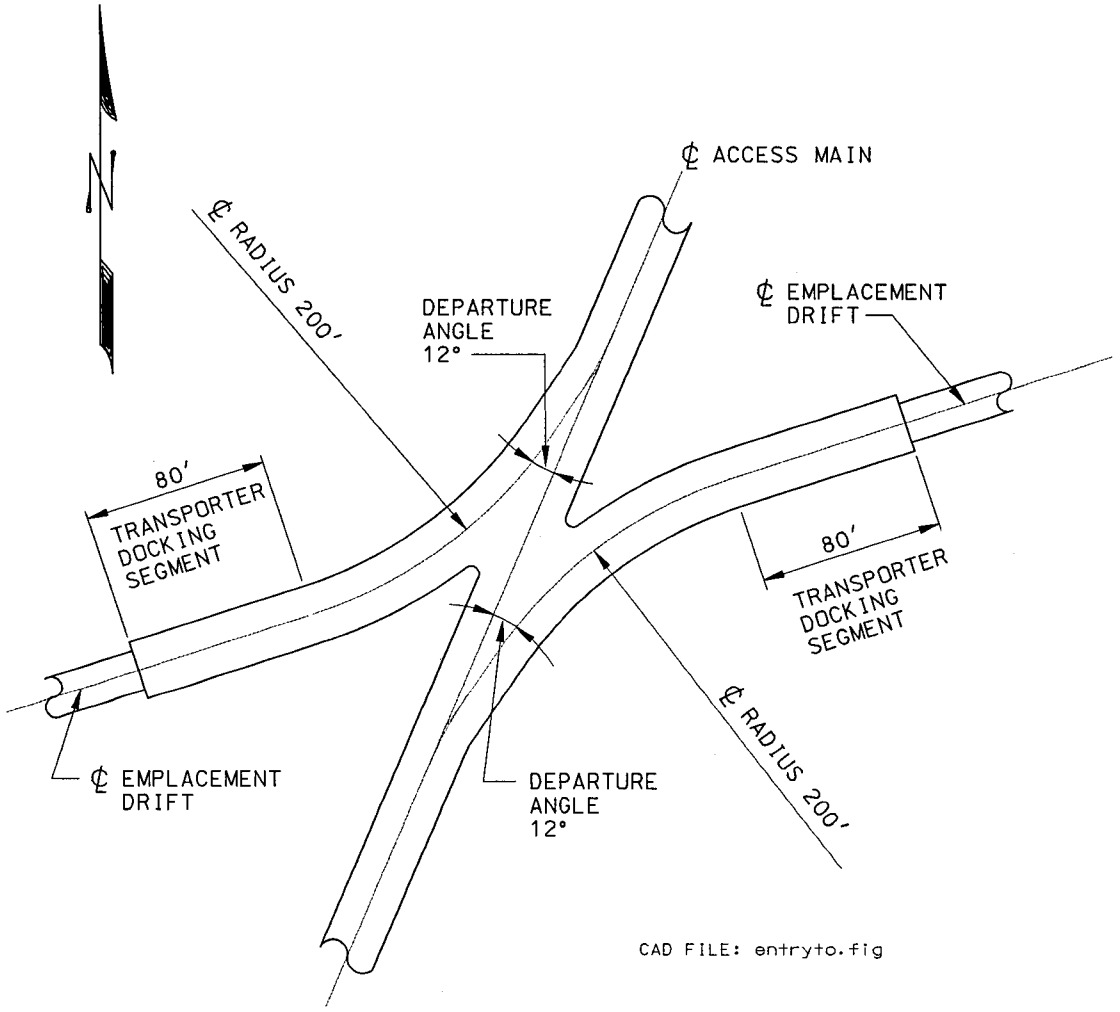
Figure 5. Turnout Drift from Main Access at 3°

6.2.2 East and West Entry From Access Main on 23° Azimuth

Turnout drifts that originate from an access main on a 23° azimuth (Refer to Section 4.1.7) may occur individually in the subsurface repository or they may be associated with a symmetrically opposed turnout drift. Both turnout drift types and the resultant intersection area are shown in Figure 6.

The turnout drift with a west entry into the emplacement area approaches from the north direction and turns west into the emplacement area. This is consistent with forming an obtuse angle between the main access and the emplacement drift relative to the approach direction (Refer to Section 5.1.3). The departure angle is 12°, the centerline radius of the curve is 200', and the transporter dock segment is 80' (Refer to Table 1).

The turnout drift with an east entry into the emplacement area approaches from the south direction and turns east into the emplacement area. The basic design geometry is the same as the turnout drift with a west entry into the emplacement area.



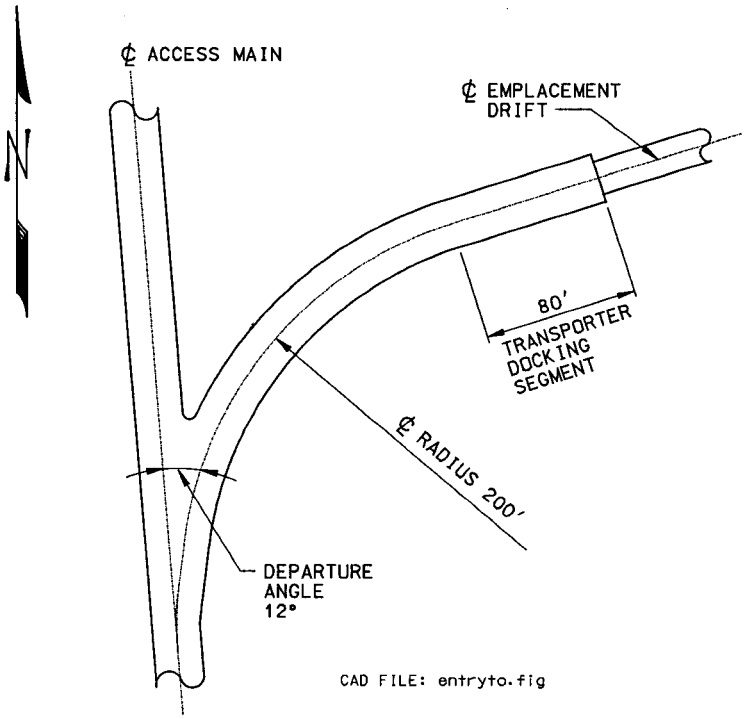
TURNOUT FROM ACCESS MAIN
@ AZIMUTH 23°
NOT TO SCALE

Figure 6. Turnout Drift from Main Access at 23°

6.2.3 West Entry From Access Main on 355° Azimuth

Turnout drifts that originate from an access main on a 355° azimuth (Refer to Section 4.1.7) only occur in isolation in the subsurface repository. The basic design geometry is shown in Figure 6.

The turnout drift approaches from the south direction and turns west into the emplacement area. This is consistent with forming an obtuse angle between the main access and the emplacement drift relative to the approach direction (Refer to Section 5.1.3). The departure angle is 12°, the centerline radius of the curve is 200', and the transporter dock segment is 80' (Refer to Table 1).



TURNOUT FROM ACCESS MAIN @ AZIMUTH 355°
NOT TO SCALE

Figure 7. Turnout Drift from Main Access at 335°

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7.2 STANDARDS AND PROCEDURES

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