Appendix E: G2T Tunnel Separation Criteria
Technical Memorandum

Prepared by:
Jacobs Associates
1109 First Avenue, Suite 501
Seattle, WA 98101
1 Introduction

This memorandum presents the results of an evaluation of the minimum separation required to maintain a zone of undisturbed rock between the existing Gorge Power Tunnel and the new Gorge 2nd Tunnel (G2T). During construction of G2T, the existing power tunnel will be in operation. The separation between the tunnels must be wide enough so that construction of the new tunnel does not impact the integrity of the existing tunnel. This separation will be used for the preliminary design layout of the G2T alignment.

2 Stress Field Interaction

As G2T is excavated, the stresses in the rock will redistribute around the opening. The redistribution of stress will be more pronounced near the opening and diminish radially as the distance from the opening increases. Altered stress fields can result in local instabilities and increased stresses around the tunnel. The separation between tunnels must be adequate so that local instabilities in the new tunnel do not impact the stability of the rock around the existing tunnel.

The zone of altered stresses (stress field) around G2T was evaluated to predict the zone of stress redistribution around the circular tunnel opening. The rock along the G2T alignment consists of gneiss—a strong, widely jointed rock. Upon excavation, this rock is expected to exhibit linear-elastic behavior. Plastic behavior is not expected due to the high strength relative to the in situ stresses. The assumption of linear elastic behavior allows for the use of a Kirsch equation, a plain strain equation for stresses around a circular opening, to determine minimum acceptable tunnel separation.

Figure 1 shows the stresses around a circular hole in an isotropic, linearly elastic, homogeneous continuum and demonstrates how the stresses will redistribute around the circular tunnel opening. As indicated on Figure 1, for a $K_0$ value of 1 (ratio of horizontal to vertical stress), the stresses at the springline and invert (or crown), of the opening become two times the vertical pressure, then dissipate to their original stress.
conditions with distance. At a distance of about 3.5 to 4.0 times the radius, or 1.75 to 2.0 times the tunnel diameter, the stresses revert to the in situ state. Figure 1 also indicates that the greatest magnitude of stress change occurs within one radius of the tunnel opening. Based on this evaluation, it is expected that providing a minimum tunnel separation of 1.75 to 2.0 times the tunnel diameter will isolate the existing power tunnel from the stress influence of the new excavation.

3 Summary

The stress field interaction analysis provides a separation range of 1.75 to 2.0 times the excavated tunnel diameter. For an assumed tunnel diameter of 18 feet, this gives an “unfactored” separation range of 31.5 to 36.0 feet. It is appropriate to provide some additional clearance to this range.

Based on previous investigations and the objective of limiting interaction effects between the tunnels, a separation of 50 feet is recommended for the preliminary design layout of the G2T alignment. This separation is based on maintaining a minimum separation of 2.5 tunnel diameters, measured from wall to wall, and a maximum excavated diameter of 18 feet.

The selected minimum separation of 2.5 tunnel diameters will provide an additional buffer separation of an 0.5 tunnel diameter outside of the potential zone of stress redistribution. This will take into account any local instabilities or weakened zones of rock that may exist around the existing power tunnel (see Figure 2). Additional evaluations will be necessary to verify that this separation is sufficiently adequate to control leakage from the existing tunnel into the G2T tunnel excavation. These evaluations will be performed as geologic data become available.
Figure 1. Stresses around a circular hole in an isotropic, linearly elastic, homogeneous continuum (from Goodman, 1989).
Figure 2. Suggested clearance between adjacent tunnels.