Gorge 2nd Tunnel

Appendix F: G2T Portal Evaluation Technical Memorandum

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PROJECT MEMORANDUM

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From:	Mark Havekost and Sue Bednarz, Jacobs Associates
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Subject:	Gorge 2nd Tunnel: Portal Alternative Evaluation

1 Introduction

This memorandum presents an evaluation of potential portal sites for construction of the Gorge 2nd Tunnel (G2T). The portal will be located at the base of the mountainside on the north side of the existing Gorge Power Tunnel adit. Tunneling will be carried out from this portal, initially by drill-and-blast methods for the starter tunnel, and then by tunnel boring machine (TBM) for the new tunnel. Construction staging for these activities will occur in the area between the portal and the Skagit River.

The recommendation for the G2T portal location is based on an evaluation of the following parameters:

- Maintaining portal safety by reducing potential for rockfall hazard
- Minimizing the cost of rockfall protection (slope stabilization) above the portal
- Reducing site impacts (tree removal)
- Initiating the starter tunnel in competent bedrock with minimum rock cover for "turning under"
- Optimizing construction costs by reducing the curve and length of the starter tunnel downstream of the connection to the existing tunnel
- Providing contractor flexibility for portal site layout

2 Site Description

The portal area is characterized by numerous rock outcrops and varying amounts of talus (loose boulders) on the slope. The outcrops are cut by joints (fractures) and some of the outcrops have been undercut at the base to form overhanging blocks. Both adverse jointing (fracture planes dipping out of slope) and overhanging outcrops create potentially unstable blocks that could be dislodged during construction. The size and apparent stability of these blocks vary across the portal area. The slope is populated with trees.

3 Tunnel Portal Reconnaissance

On March 10, 2009, a geologic reconnaissance was conducted across the portal area by geologists from Jacobs Associates and Aspect Consulting to identify potential portal locations. Six potential portal alternatives were identified (1, 1A, 2, 3, 4, 5) between the existing tunnel adit and the north end of the Skagit River (on the north end of the field). Figure 1 shows the location of these alternative portal sites. At each location, rock slope stability was evaluated, potentially unstable blocks were identified, and site impacts such as tree removal were assessed.

3.1 Rock Slope Stability

The spacing and orientation of rock jointing visible in rock outcrops were documented during the reconnaissance to evaluate the stability and size of rock blocks that could, if not supported, fall onto the portal area. Major joint orientations observed included a gently dipping joint set that followed the foliation (mineral layering) within the orthogneiss bedrock. This foliation joint is exposed (daylights) and dips out of the face of the outcrop. Foliation joints and the abundant near-vertical joints combine to form blocks of various sizes within the outcrop.

Large, potentially unstable blocks, some with a significant overhang, were also observed above Portals 1 and 1A and the Gorge Powerhouse Extension. The blocks above the Gorge Powerhouse Extension have been stabilized with large steel cables; however, the large blocks above the proposed G2T portal area have not been stabilized. It is speculated that undercutting of these large blocks was formed by freeze–thaw action.

A large fault was identified in the talus slope between Portals 4 and 5 during the reconnaissance. The northward projection of this fault is visible on aerial photographs of the project area (beneath the transmission lines on the hillside north of the portal) and on the south side of the Skagit River channel and adjacent hillside (as visible from Highway 20).

4 Portal Alternatives

The alternative portal sites are described below. Table 1 summarizes the advantages and disadvantages of each of these portal alternatives.

4.1 Portal 1

Portal 1 is located in the slope directly east of the existing Gorge Powerhouse upper parking lot (Figures 1 and 2).

The critical feature of Portal 1 is the extremely large (30-ft high and 50-ft wide) unstable outcrop block that is located directly upslope of the portal. The outcrop has a 30-degree sloping overhang that ranges from 10 to 20 feet in length. Figures 3 and 4 include photographs of this outcrop block. Although the block is still connected to the underlying rock, the significant downslope overhang makes this block susceptible to sliding or rolling downhill into the portal. Vibrations created during the excavation of the starter tunnel could cause this block to fail.

4.2 Portal 1A

Portal 1A, which partially overlaps Portal 1 (Figures 1 and 5), will require less tree removal during construction than Portal 1. Portal 1A is still located within the trajectory of the extremely large, potentially unstable block discussed in Section 3.1.

4.3 Portal 2

Portal 2 is located in the slope north of Portal 1A, beneath a large, near-vertical rock outcrop (Figures 1 and 6).

Relatively closely spaced jointing within the outcrop forms moderately sized blocks that are generally less than 8 ft in maximum length. The majority of these blocks could be stabilized using rock bolts and welded wire mesh. One approximately 8 x 10 ft block that appears to be resting on the sloped upper surface of the outcrop would either require stabilization or removal.

4.4 Portal 3

Portal 3 is located beneath a nearly 120-ft-high rock outcrop to the north of Portal 2 (Figures 1 and 7).

Although the joint spacing is generally greater than in the outcrop above Portal 2, one large block (15 ft high x 25 ft wide) is exposed in the upper portion of the outcrop above the portal. Open joints that surround this block indicate that it is potentially unstable and would require stabilization or removal prior to portal construction in this area.

4.5 Portal 4

Portal 4 is located within a talus slope on the north side of the outcrop above Portals 2 and 3 (Figures 1 and 8). This slope is covered with an unknown thickness of boulder and cobble-sized angular blocks.

While this location is devoid of large, unstable blocks that could fall into the portal area, portal excavation could destabilize the talus slope above the portal. Additionally, the talus slope overlies a large fault that cuts approximately north-south across the

mountainside (beneath the transmission lines). Bedrock in the vicinity of this fault is expected to be highly fractured and potentially sheared.

4.6 Portal 5

Portal 5 is located on the north side of the large field at the base of the hillside and also northwest of the large fault (Figures 1 and 9).

The portal is situated in stable orthogneiss bedrock, and no talus removal or rock-slope stabilization is required; however, the alignment crosses the large fault in an area of limited tunnel cover. This will complicate construction of the starter tunnel.

5 Tunnel Alignment Considerations

A straight departure is desirable at the portal for launching the TBM. At the end of this straight tunnel section, the tunnel alignment will require a curve to transition to an alignment that parallels the existing tunnel. Generally, portal sites closer to the existing tunnel (e.g., Portals 1, 1A, and 2) are more favorable because they allow for a shorter curved section and therefore a quicker transition to the parallel tunnel alignment.

The actual length of the starter tunnel, as compared to the TBM-driven tunnel, will depend on several factors, including timing of TBM delivery and tunnel connection details. Again, portal sites closer to the existing tunnel are considered more favorable.

6 Conclusions

The portal evaluations indicate that Portal 2 is the best alternative for the G2T portal location. The selection of Portal 2 reduces the starter tunnel length and amount of curved tunnel required for connection to the existing tunnel, while still being out of the trajectory for the extremely large block that is located above Portals 1 and 1A.

Rockfall mitigation for the outcrop in the slope above Portal 2, while still required, is significantly less than any mitigation that would be required to stabilize blocks above Portals 1, 1A, and 3. Since Portal 2 is located significantly south and to the side of the portal area fault, sheared rock is not expected within the portal excavation.

Portals 4 and 5 are not desirable because they would require a long curved alignment transition and because they are space constrained due to being located in the north corner of the portal construction site.

Table 1 G2T Portal Alternatives: Evaluation Matrix

Portal Alternative	Advantages	Disadvantages
Portal 1	• Shallow bedrock—limited talus • Shortest tunnel downstream of connection to G1T • Adjacent to existing Gorge Powerhouse parking lot	• Portal is located beneath an extremely large, potentially unstable rock block • Six trees (up to 30 inches in diameter) must be removed
Portal 1A	• Shallow bedrock—limited talus • Less tree removal than Portal 1 • Second-shortest tunnel downstream of connection to G1T	• Portal is located beneath an extremely large potentially unstable rock block • Three trees (up to 30 inches in diameter) must be removed
Portal 2	• Potentially unstable blocks on lower face of outcrop are relatively small and suitable for stabilization • Third-shortest tunnel downstream of connection to G1T • Portal is located out of the trajectory of the large block above Portals 1 and 1A	• One 8 x 10 ft unstable boulder on upper portion of outcrop above portal will require removal or stabilization • Abundant rockfall at base of slope will require removal as part of portal development • Seven trees (up to 48 inches in diameter) must be removed
Portal 3	• Portal is located out of the trajectory of the large block above Portals 1 and 1A	• Large potentially unstable block exposed in rock face above portal • Three trees (up to 30 inches in diameter) must be removed • Abundant rockfall at base of slope will require removal as part of portal development
Portal 4	• Less tree removal required (only two 24-in.-diameter trees, with the remaining trees about 12-in. diameter or less) • Portal is located out of the trajectory of the large block above Portals 1 and 1A	• Located on south side of a large fault—highly fractured bedrock expected in portal • Large talus slope will require stabilization to construct portal • Difficult to tunnel into talus—distance to competent bedrock unknown • Second longest tunnel downstream of connection to G1T • Constrained space at north end of site
Portal 5	• Competent bedrock exposed at base of slope—no talus to remove • Bedrock outcrop above portal is stable • Portal is located out of the trajectory of the large block above Portals 1 and 1A	• Located on north side of large fault—highly fractured bedrock expected during initial tunnel excavation • Shallow cover above tunnel ground • Depth of talus in fault zone unknown—may enter tunnel zone • Longest tunnel downstream of connection to G1T • Ten trees (up to 18 inches in diameter) must be removed for portal construction • Most constrained space in north end of site.

Figures

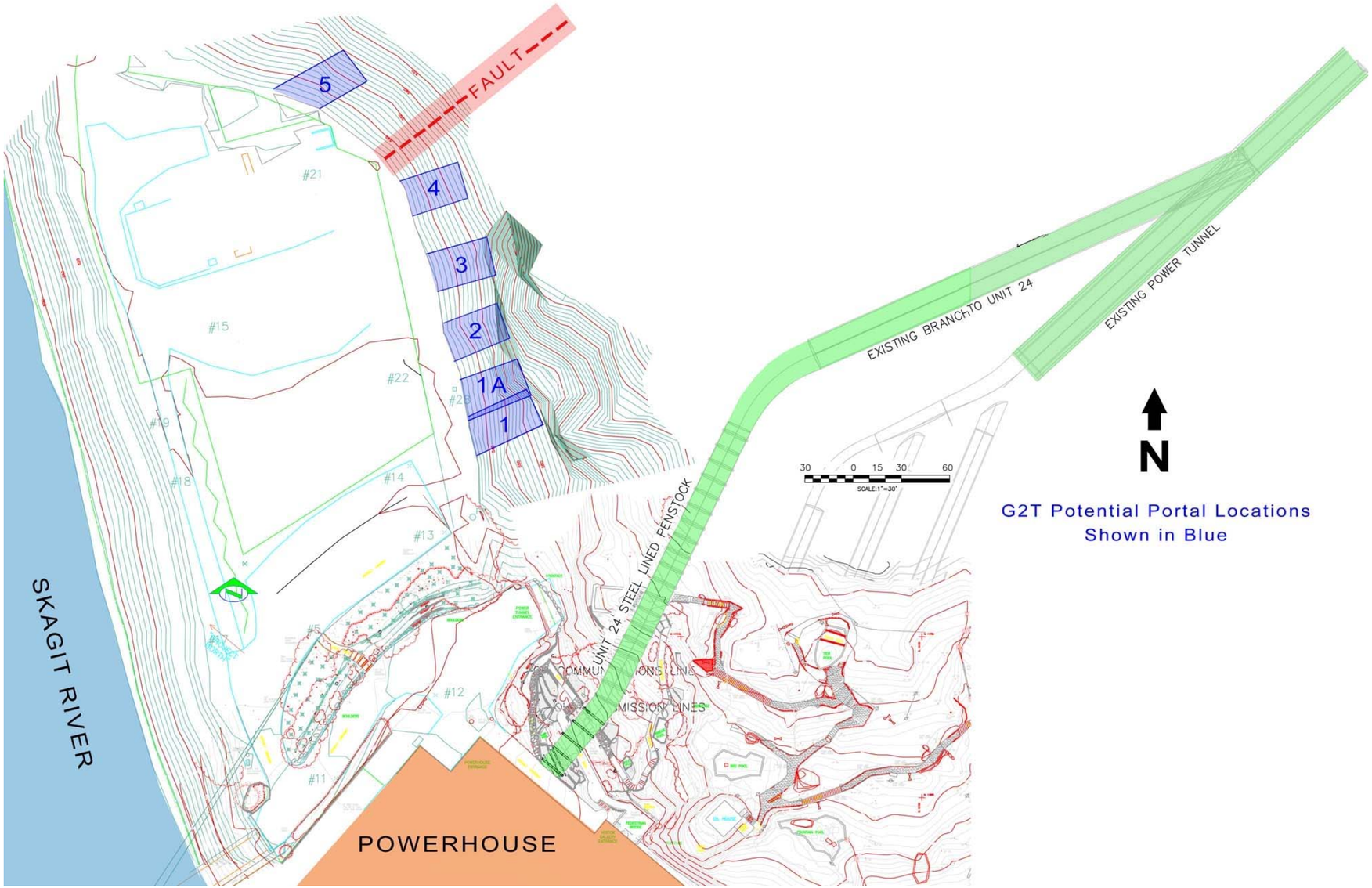

Figure 1. G2T potential portal locations

Figure 2. Portal 1 location

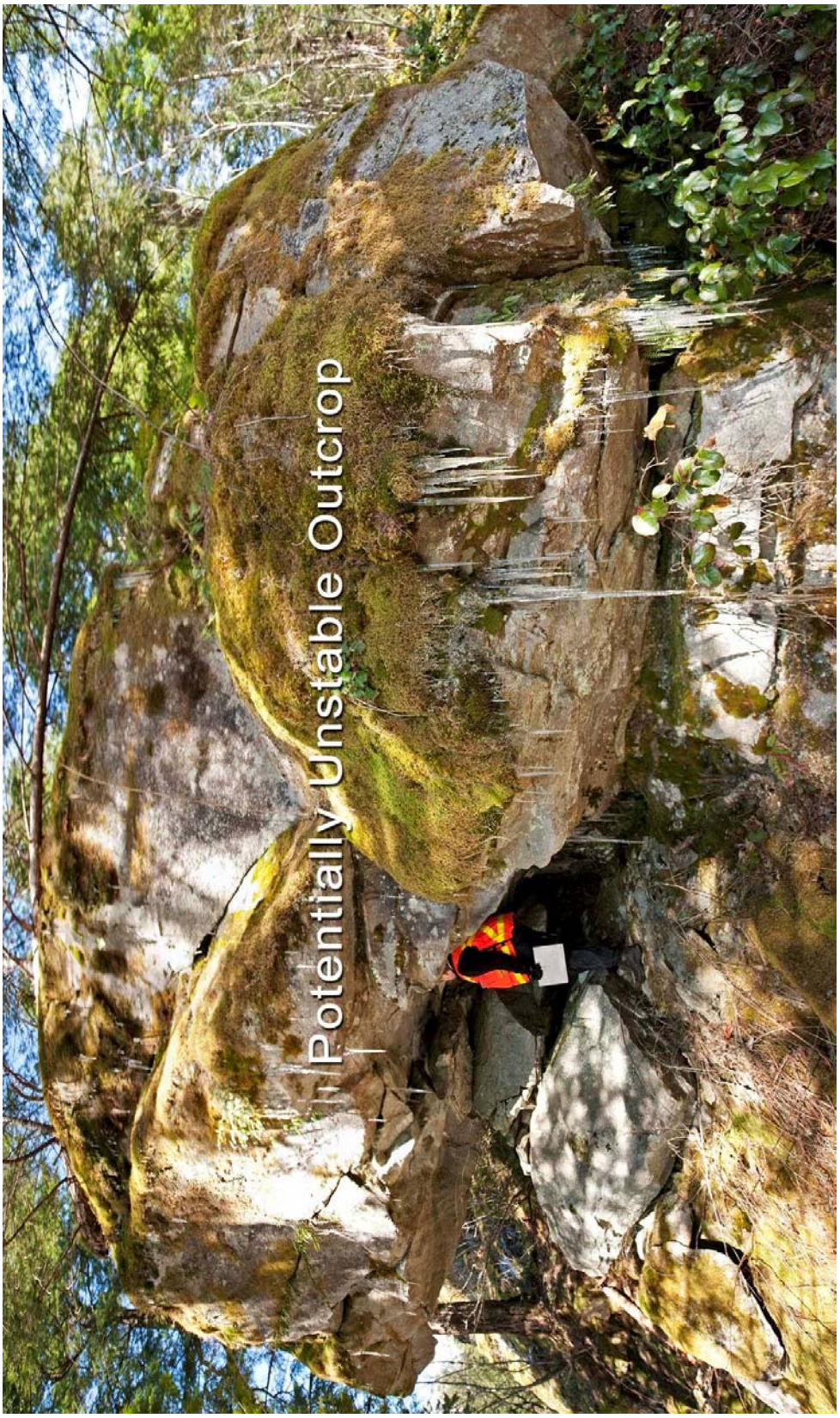

Figure 3. Overhanging potentially unstable rock outcrop above Portal 1

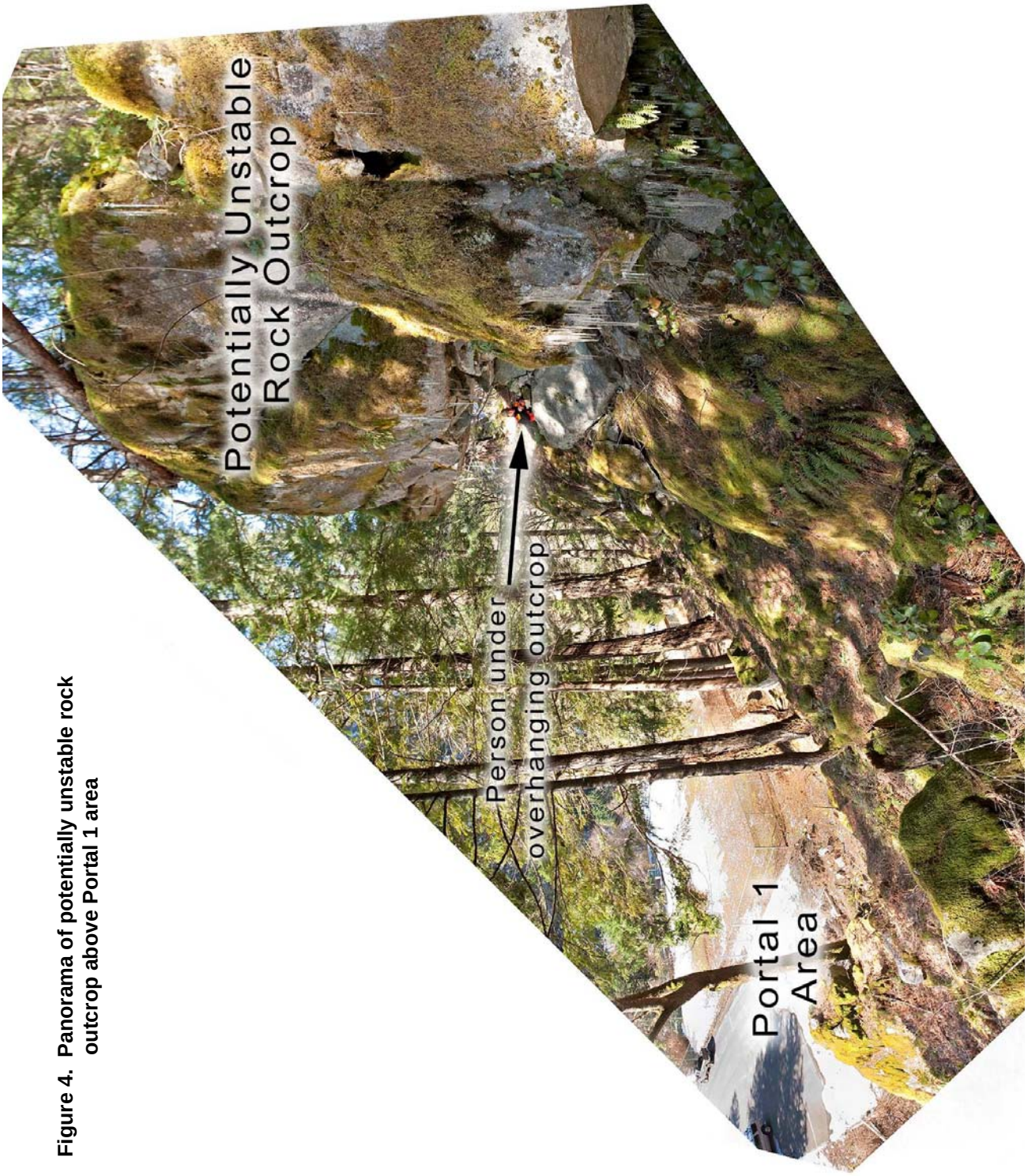

Figure 4. Panorama of potentially unstable rock outcrop above Portal 1 area

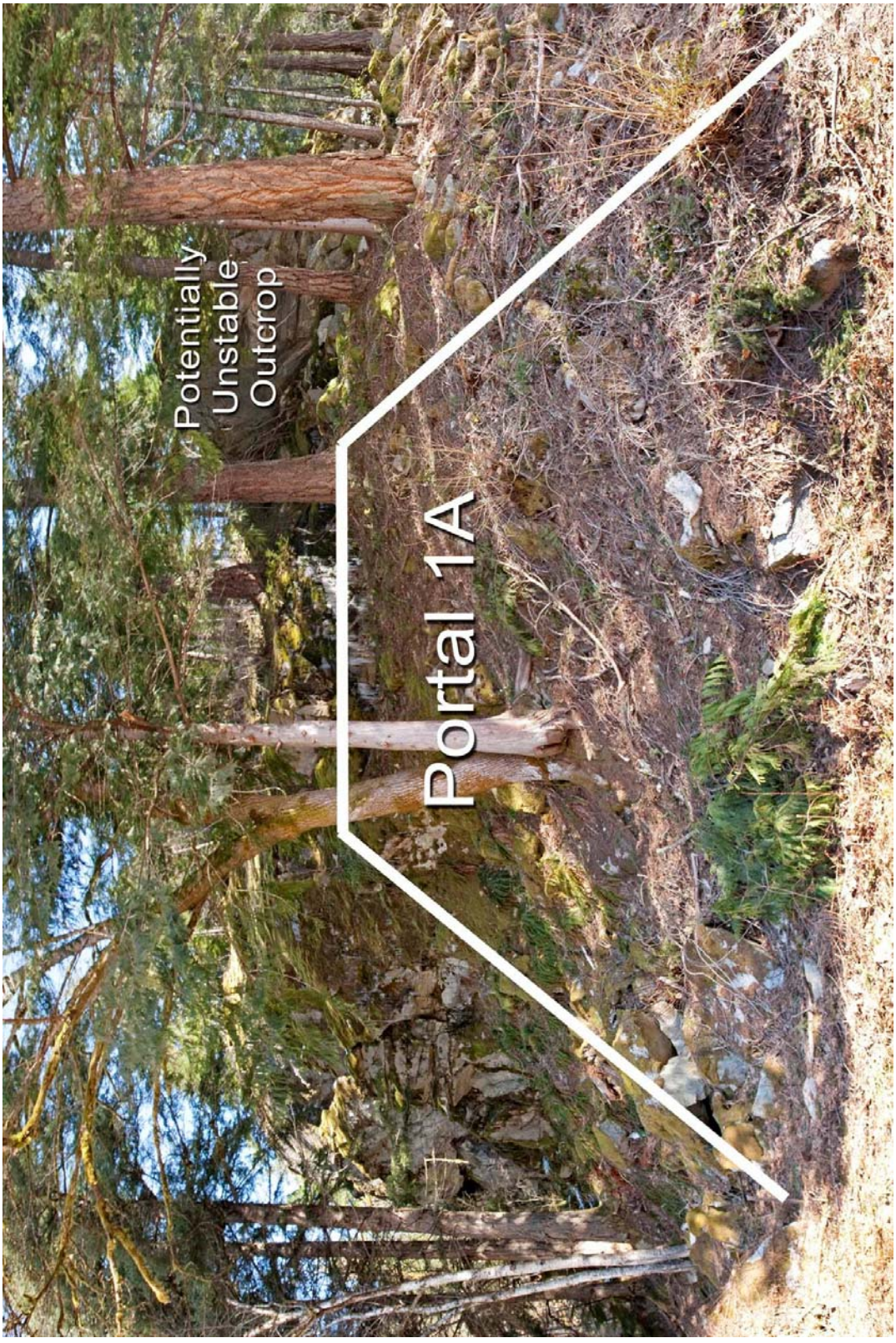

Figure 5. Portal 1A location

Figure 6. Portal 2 location

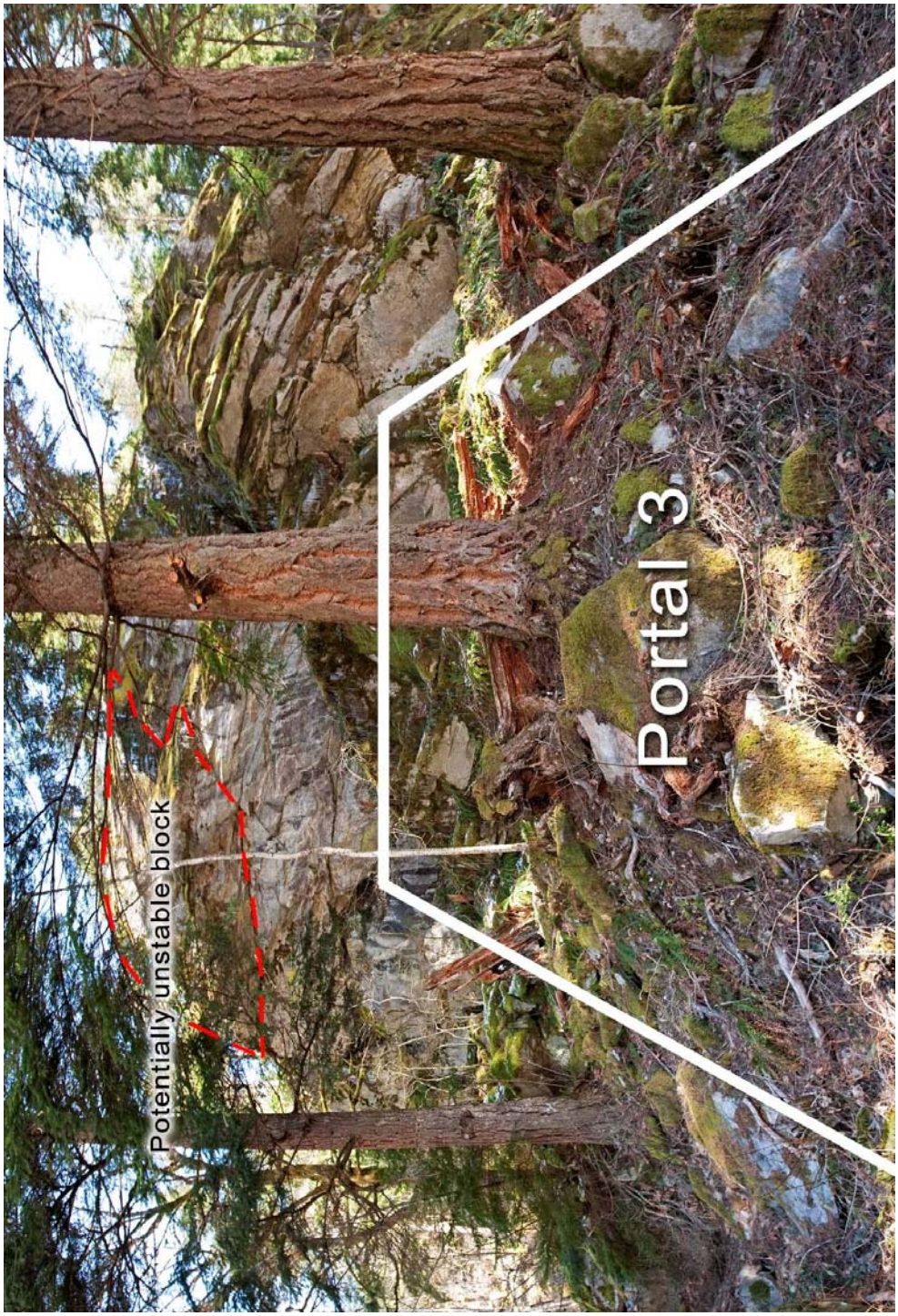

Figure 7. Portal 3 location

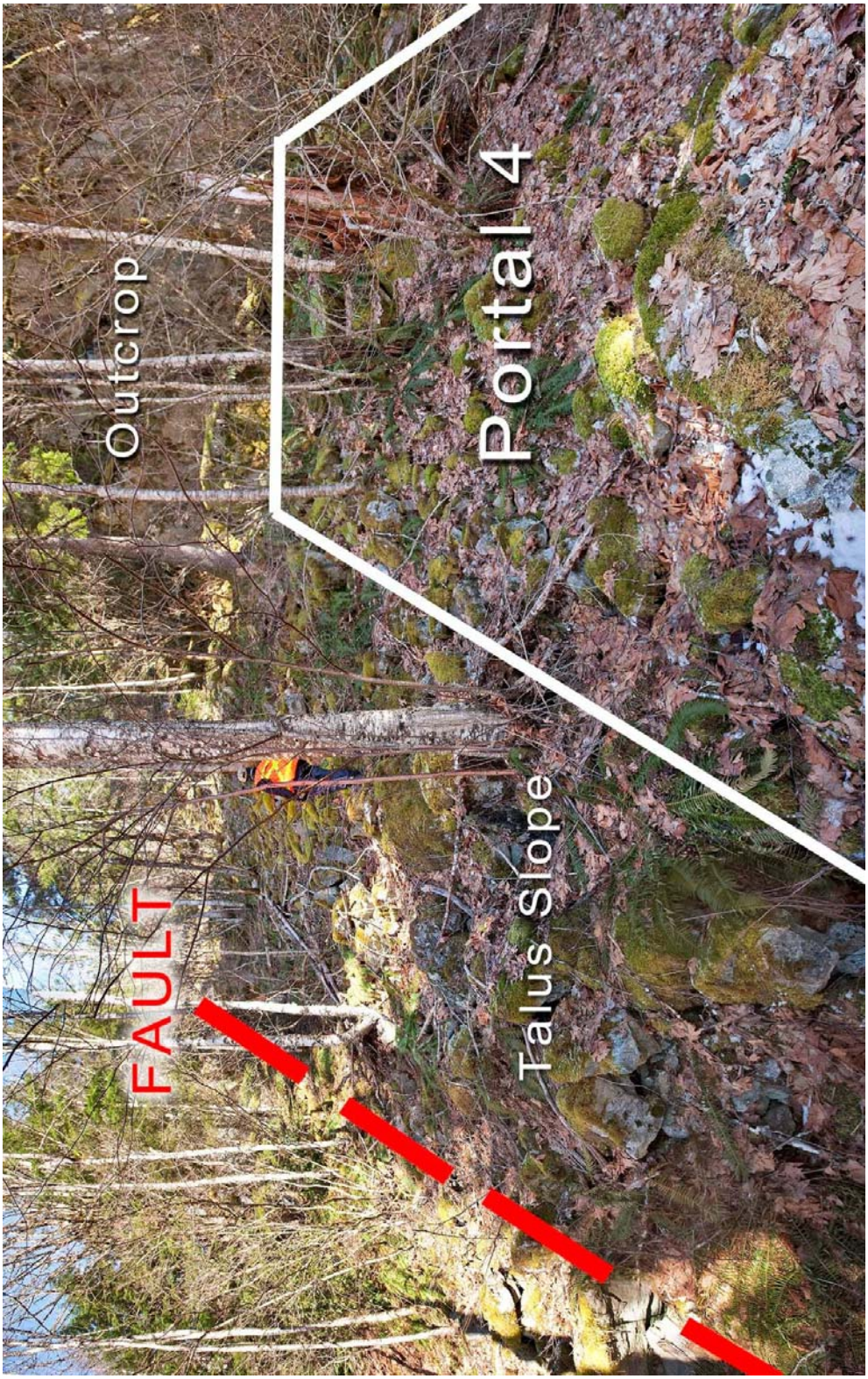

Figure 8. Portal 4 location

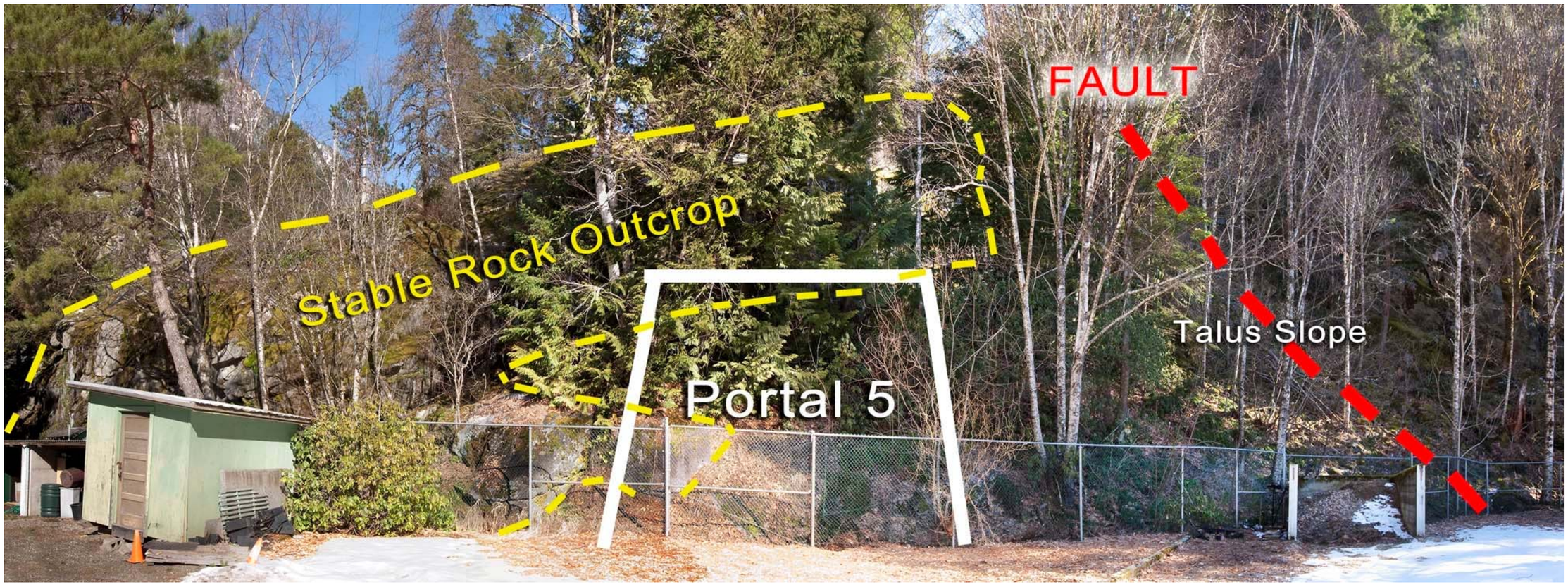

Figure 9. Portal 5 location