Bedrock Structural Control in the Waterbury Dam Area

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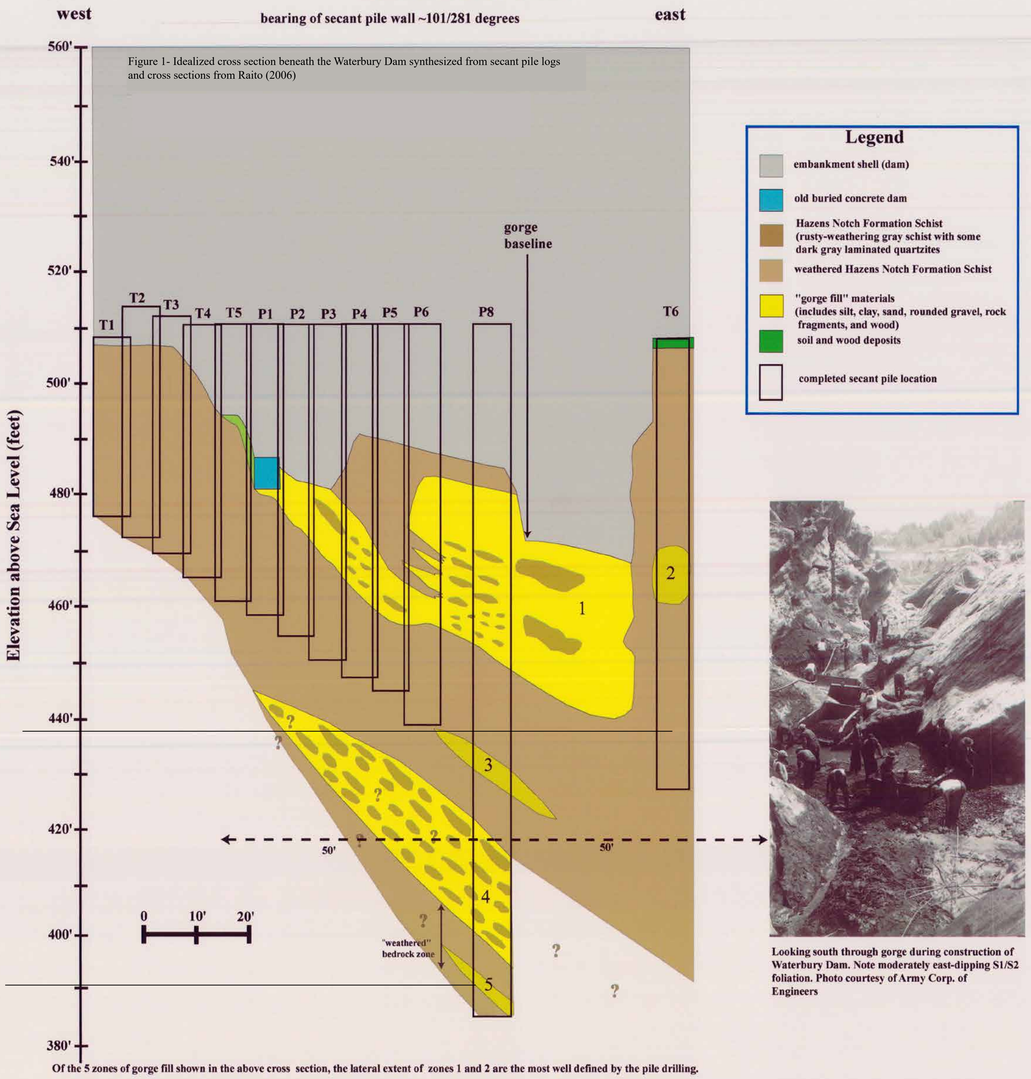


Legend

- embankment shell (dam)
- old buried concrete dam
- Hazens Notch Formation Schist (rusty-weathering gray schist with some dark gray laminated quartzites
- weathered Hazens Notch Formation Schist
- "gorge fill" materials (includes silt, clay, sand, rounded gravel, rock fragments, and wood)
- soil and wood deposits
- completed secant pile location

Looking south through gorge during construction of Waterbury Dam. Note moderately east-dipping S1/S2 foliation. Photo courtesy of Army Corp. of Engineers

Of the 5 zones of gorge fill shown in the above cross section, the lateral extent of zones 1 and 2 are the most well defined by the pile drilling.

Zone 1- the base of this zone has a dip of ~46 degrees which is close to the average dip of the S1/S2 foliation measured during the field investigation (48 degrees). The base of the bedrock body overlying the gorge fill on the western side of the gorge also has a similar dip to the average foliation. Prvious workers speculated that this rock body is a detached slab that slid down the dip of the S1/S2 foliation to the east. Based on the data from the "Design Documentation Report", it is unclear whether this bedrock body is attached to in situ bedrock to the north or south. If this body were actually contiguous with in situ bedrock, then it could not be considered a detached slab. The atitude of the west side of this body is consistent with north-northeast trending, west dipping fracture. The upper surface of this rock body has a dip of ~14 degrees which is significantly less than the dip of the average S1/S2 foliation; if this surface is parallel to the foliation, then the body must have undergone some counterclockwise rotation during transport. Alternatively, the upper surface may not be parallel to foliation at all. Although there are foliation parallel faults all over Vermont, the lack of lateral extent for this feature to the east argues against this.

Zone 2- Since this gorge fill does not daylight on the gorge wall, it must be assumed that this an isolated erosional feature such as a cavern or pothole that is connected to other such features in an upstream or downstream direction.

Zone 3- This thin seam of gorge fill could be filling a foliation parallel zone or be a a cavern or pothole that is connected to other such features in an upstream or downstream direction.

Zone 4- boulders, silt, sand, and rock fragments comprise the upper part of this zone whereas silty sand and clay adhering to rock faces occur at the bottom. Because other cores ~50' in a horizontal radius from this piling did not detect this zone (see dashed arrows for reference), it must be of limited extent. It could be a foliation parallel cavity and/or a cavity that connects to other erosional features in an upstream or downstream direction. The presence of clay and silt imply a connection to the varved clay deposits that line the perimeter and bottom of the Waterbury Reservoir.

Zone 5- sand, gravel, and small rock fragments and weathered rock fragments in a thin zone which could be foliation parallel or connected in an upstream direction to other erosional features deep in the bedrock.

Bedrock Structures

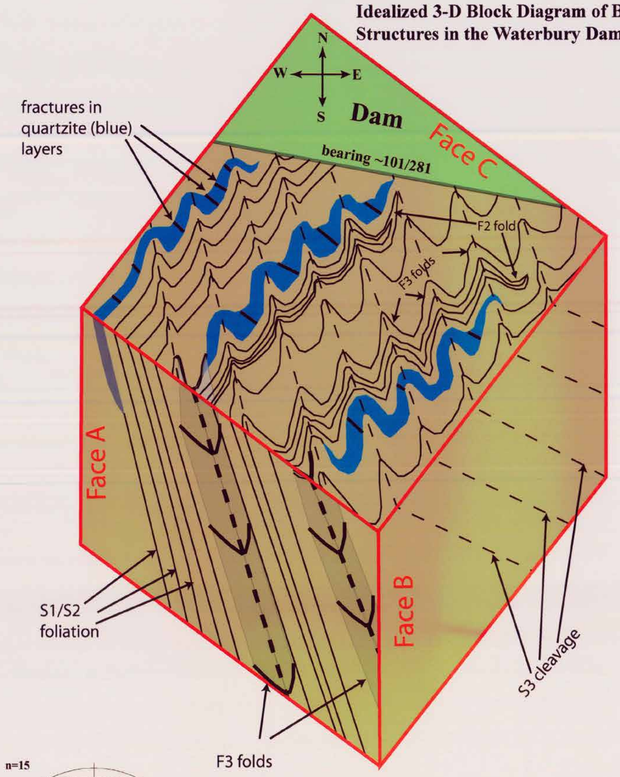
North-northeast striking, moderately east dipping S1/S2 foliation just west of dam spillway. Roughly equivalent perspective to looking at Face A on 3D block diagram. Quartzites shown in blue on 3D block diagram.

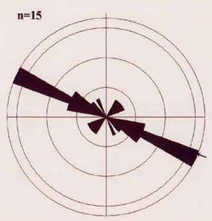
~10' thick gray quartzite layer in rusty-weathering Hazens Notch Formation schist. Note two sets of fractures in quartzite: north-northeast and west-northwest trending. Fractures are more abundant in the brittle quartzite.

F2 fold in gray quartzite. View in photo is looking at Face C in 3D block diagram.

F3 fold in Hazens Notch Formation schist.. View in photo is looking at Face C in 3D block diagram. Fold plunges into the ground and that perspective can be seen in Face A.

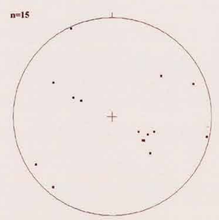
Idealized 3-D Block Diagram of Bedrock Structures in the Waterbury Dam Area





Sector angle = 10°
Scale: tick interval = 10% [1.5 data]
Maximum = 33.3% [5 data]
Mean Resultant dir'n = 112-292
[95% Confidence interval = ±29°]

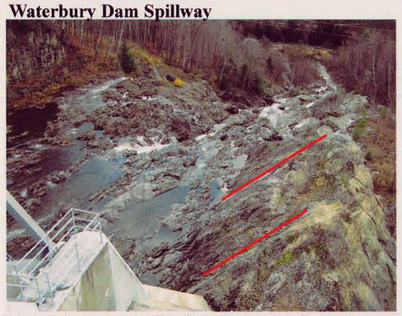
Frequency- Azimuth rose plot for fractures in the general vicinity of the Waterbury Dam. The dominant petal is west-northwest trending with subordinate petals to the north-northeast and northwest.



Mean Principal Orientation = 194/41
Mean Resultant dir'n = 290-12
Mean Resultant length = 0.57
(Variance = 0.43)
Calculated girdle: 093/81
Calculated beta axis: 003-9
Equal area net showing poles to fracture planes

Bedrock Control of Flow and Erosion Patterns

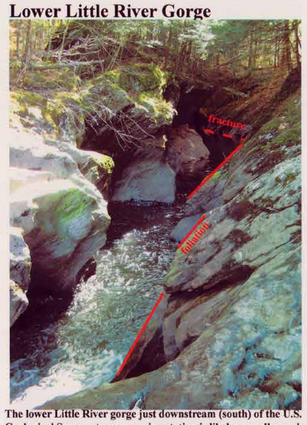
Waterbury Dam Spillway



This view looking south at the spillway for the Waterbury Dam shows that the present river flow is dominantly controlled by the north-northeast trending, moderately east dipping S1/S2 foliation (parallel to red line) in the Hazens Notch Formation schist.

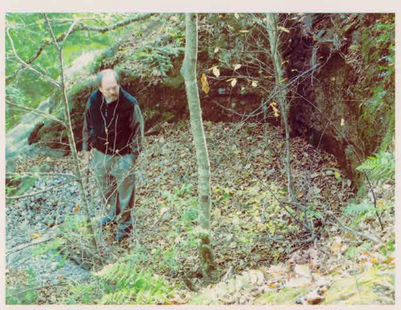
A closer view of the spillway looking to the north shows that water flows not only along the strike of the S1/S2 foliation, but also across this foliation along north-north east trending moderately west dipping fractures.

Lower Little River Gorge



The lower Little River gorge just downstream (south) of the U.S. Geological Survey stream gauging station is likely a smaller scale analogue for the gorge beneath the Waterbury Dam. The river dominantly flows along the S1/S2 foliation, but is offset by fractures that step the gorge to one side. The foliation is also deflected by F3 folds. Note half potholes on left (east) side of gorge

Three coalesced half potholes located along the foliation defined gorge. These potholes likely formed during glacial retreat as large volumes of meltwater carrying sand, silt, clay, and boulders eroded the bedrock surface. The S1/S2 foliation) provided a plane of weakness along which trains of potholes could form. As a pothole(s) enlarged, it eventually impinged on neighboring potholes and formed the coalescing scalloped shape. Some linear pothole zones would presumeably step downward along the foliation as they deepened. Some potholes are inclined with the foliation.



Stranded pothole west of and above existing water level in lower Little River gorge.

References:

Raito, 2006, Waterbury Dam, Seepage Control Modification, Design Documentation, Draft.

Citation:
Kim, Jonathan, J., 2007, Bedrock Structural Control in the Waterbury Dam Area, Vermont Geological Survey Technical Report VGTR 2007-2, 1 plate.