APPLIED GEOLOGY FOR INVESTIGATION, DESIGN AND MITIGATION OF A LANDSLIDE IN NEWPORT, VERMONT

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Shortly after new embankment construction for Route 191 in Newport, Vermont in 1971, a slow-moving landslide developed, requiring the Vermont Agency of Transportation (VTrans) to periodically maintain the roadway with pavement shimming, guard rail repair, and culvert replacement. Initial investigations and mitigation in the 1970's included borings and drains, but slope movement was not reduced. Removal of 4 ft of pavement shim in 1986 indicated 3.2 in/yr of vertical movement from 1971-1986. VTrans installed piezometers and inclinometers in the 1980's to further delineate the landslide depth and extent, leading to installation of a stability berm near the suspected landslide toe to slow movement. After movement continued, additional inclinometers installed 2007-2008 further downslope indicated a much greater slide extent existed, and detected artesian groundwater pressures deep in the slide mass. The deep inclinometers relieving deep groundwater pressure, and movement slowed, indicating hydrogeology likely plays an important factor in landslide movement.

VTrans conducted a comprehensive geologic, hydrogeologic and geotechnical investigation in 2012-2013 to collect data and evaluate several mitigation approaches, with the goal of selecting a suitable remedy to slow or stop landslide movement. The investigation included field reconnaissance geologic mapping; an extensive subsurface investigation program, including sonic and conventionally drilled geotechnical borings; geotechnical sample analyses; well, piezometer and automated inclinometer instrumentation; and hydrogeologic testing. Field data were used to refine the site geologic and hydrogeologic 3-D models, develop a calibrated numerical groundwater model to support geotechnical stability analyses, remedial design development, and construction cost estimating.

Basal glacial sediments of the slide (alternating clayey silts, sandy silts and silty sands), which are key in evaluating remedial alternatives, exhibited high overconsolidation ratios, very stiff to hard, high plasticity silty clays, and folded varves. One geologic interpretation of the origin of these sediments is deposition by a pre-Pleistocene glacial advance, and subsequent burial by the last ice sheet. Sonic cores indicate several previous slip planes/zones exist, defined by slickensides and folded varves, indicating slumping or ice grounding deformed the sediments. The slip planes contributing to the current movement may occupy some of this historical failure planes. Pumping tests indicate hydrogeologic connectivity exists between the lowermost coarser sediments and overlying coarser sediments separated by clayey silts, suggesting the silty clay units are discontinuous, but act as semiconfining units. The applied geologic evaluations indicate that the landslide movement slowed after relieving artesian pressures, and also suggests one potential remedy to further slow and possibly stop landslide movement includes deep groundwater extraction wells installed at the toe of the slide.