USGS science for a changing world

Landslide Hazards in Glacial Lake Clays - Tully Valley, New York

Introduction

At approximately midday on April 27, 1993, a large landslide occurred along the foot of Bare Mountain in LaFayette, Onondaga County, New York, about 12 miles south of Syracuse (figs. 1, 2). The slide moved rapidly east toward the middle of the Tully Valley and impacted approximately 50 acres of land, destroyed three homes, and resulted in the evacuation of four other homes. Debris from the slide, consisting mostly of remolded clay, covered Tully Farms Road with up to 15 feet of earth for a length of some 1,200 feet. Springs that developed near the top of the slide discharged either freshwater or brackish water, which contained concentrations of dissolved evaporites (salt and gypsum) and other minerals. The total volume of earth moved by the slide is estimated to be about 1.3 million cubic yards. According to the New York State Geological Survey, this slide is the largest to have occurred in the State in more than 75 years. Most residents were away from their homes at the time of the slide, and so there were no fatalities or serious injuries caused by the slide.

Figure 1. Oblique aerial view of the Tully Valley landslide taken April 30, 1993, 3 days after the slide. Debris moved toward the viewer, in the process covering Tully Farms Road (dashed line) up to 15 feet deep with reddish remolded clay.

Three people were rescued by helicopter behind the white house (lower left) from the rapidly advancing landslide. Springs located between red arrows.

Physical Setting

Tully Valley is located in the Finger Lakes region of New York State. Like the Finger Lakes, Tully Valley is a glacially carved valley into which lake sediments were deposited. Tully Valley is approximately 6 miles long and on average about 1 mile wide along the valley floor. Onondaga Creek flows north through the valley and eventually drains to Lake Ontario. The valley walls generally consist of colluvium (weathered bedrock) and glacial till (dense soils) over bedrock. The valley floor consists of more than 400 feet of glacial lake deposits (gravel and sand grading upward to silt and clay at land surface). The valley floor terrain slopes gently (generally less than 10°) from the valley walls toward the center of the valley. Land use in Tully Valley is mostly agricultural and low-density residential. Brine mining (solution mining of salt) took place from 1889 to 1986 at the southern end of the valley.

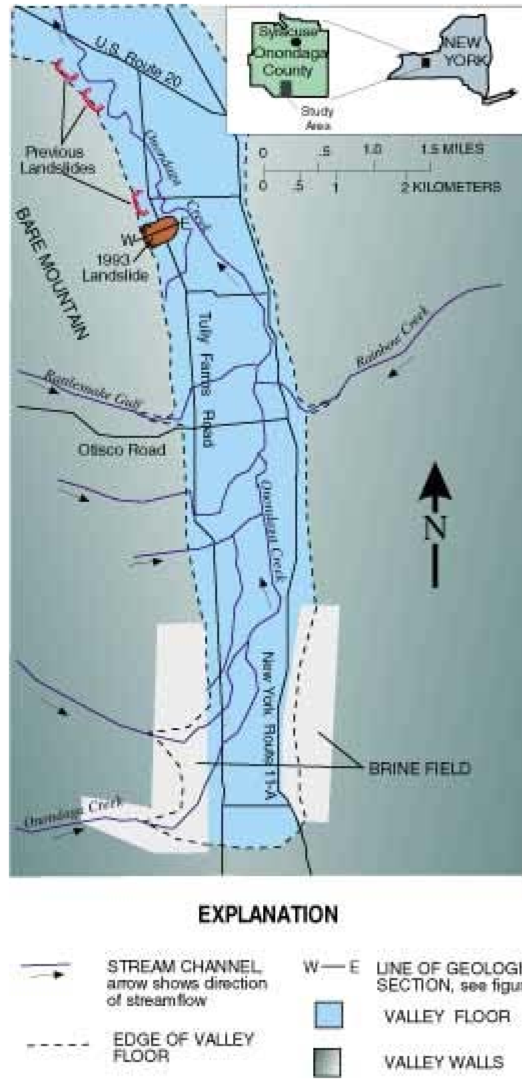

Figure 2. Major physical features in Tully Valley, including the 1993 landslide, previous landslides, and the brine-mining area at the southern end of the valley.

Along the west side of the valley, several older landslide areas have been identified (fig. 2). However, none of the previous landslides were known to local residents or were reported in newspapers or historical records dating back to about 1780. Therefore, the frequency of landslide events in Tully Valley has not been established reliably. As the 1993 landslide has shown, though, the potential damage from such an event can be catastrophic.

Hydrogeology of the Tully Valley

Profiles of soil stratigraphy before and after the 1993 landslide are shown in figure 3. A massive, red, soft to firm lacustrine silty clay deposit interfingers with coarse sandy soils and a varved clay sequence (fig. 4) that lies against the steeply dipping weathered shale bedrock. The upper thin cover of stiff silty clay traps artesian-pressured ground water in the coarse sand interfingers. Below the massive red clay and the coarse interfingers, a dense till confines and separates brackish water from the overlying freshwater in the coarse interfingers. A few local wells derive domestic water supply from this lower aquifer; however, the water quality has gradually degraded to a point where some wells were abandoned in the late 1980's.

During a normal year, highest ground-water pressures develop in the coarse interfingers during spring -- following snowmelt runoff and spring rains and preceding the development of foliage on the forested hillside. Once the trees leaf out, ground-water pressures decline rapidly. Review of winter 1992-93 weather records indicates that heavy winter snowfall was followed by a large snowstorm (the blizzard of March 1993) and above-normal rainfall in April. Melting winter snow increased the saturation of near-surface soil strata. A rapid melting of the blizzard's snow and nearly constant rainfall in April contributed to greater than normal surface and subsurface flow toward the slide area from the adjacent Bare Mountain.

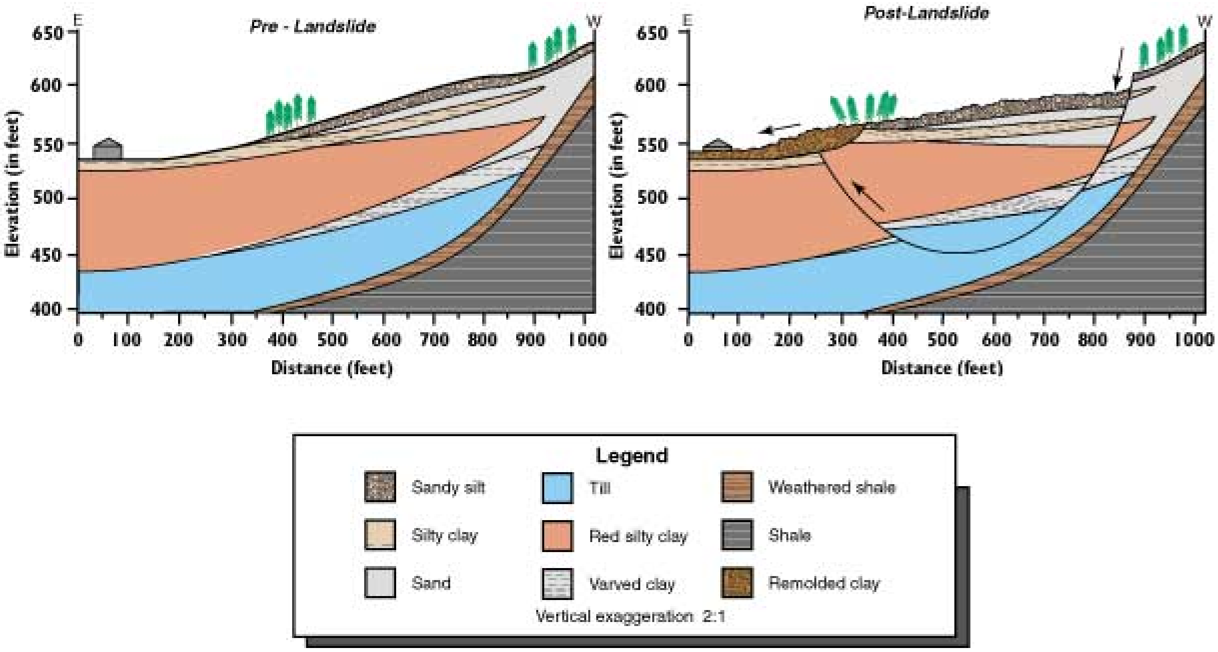

Figure 3. Soil stratigraphy before and after the 1993 landslide.

Review of available data from the New York State Department of Environmental Conservation (NYS-DEC) and statements by local residents indicate that there were signs of developing instability months to years prior to the 1993 landslide. As early as 1990, evidence of ground cracks, bulging, and slumping was noted by the NYS-DEC near what would be the southwest corner of the slide. The foundation of one house was slowly being pushed into the cellar space and had to be repaired in 1992, and the surface of a wetland in what would become the southern extent of the landslide area rose and fell. Even if these features had been reported to local officials, they probably would not have been sufficient for accurate prediction of the landslide location or timing.

Figure 4. USGS and Syracuse University scientists using a vane shear device to measure undrained shear strength of an exposed stratum of glacial lake clay at the top of the 1993 Tully Valley landslide.

Landslide Susceptibility Mapping

Large parts of New York State are covered with glacial lake sediments (including the Finger Lakes region and the Hudson and Mohawk River Valleys) and are subject to landsliding. In the aftermath of the 1993 Tully Valley landslide, residents and public officials were concerned about the potential landslide hazards in settings similar to the Tully Valley. In response, the U.S. Geological Survey prepared a map of 160 square miles of southern Onondaga County showing the susceptibility to landsliding categorized as low, moderate, or high (Jäger and Wieczorek, 1994). The landslide susceptibility was quantitatively modeled by using statistical analyses of the relationship between an inventory of landslides and the areal distribution of lake clay deposits, limits of glacial lakes, and categories of slope steepness. The map, at a scale of 1:50,000, is being used by the towns of Tully and LaFayette, as well as agencies of Onondaga County, for land-use planning and for zoning decisions within the 160-square-mile area. Landslide susceptibility maps would be useful for other areas with glacial lake clay deposits where landsliding is possible.

What You Can Do

To mitigate slide hazards, vigilant observation and reaction to changing conditions are important.

- **Become familiar with the land surface and ground-water conditions around you.**
- **Observe and record occurrences and changes in land surface features such as cracks, bulging, and slumping.**

- **Note changes in water quality (color, taste, smell), other than normal seasonal changes.**
- **Note development of new springs and changes in the clarity of spring discharge (muddiness, color change).**
- **Inform local authorities of changes and new developments that you observe.**
- **Support and collaborate with local authorities and research groups engaged in subsurface investigations and data collection.**

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Sources of Technical Information

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