Tully Valley Mudboils

Onondaga Creek Fact Sheet

INTRODUCTION

Tully Valley mudboils are "muddy springs" composed of water, liquefied sediments, and dissolved mineral salts which are discharged through surface vents via subsidence fractures caused by persistent artesian groundwater pressure (see Figures 3 & 4). Associated land subsidence (sinking) results from erosion underneath the land surface, as water removes deeply buried glacial-lake deposits.

Basic Facts about Tully Valley Mudboils

Occurrences have been documented from 1899 to the present day. Activity may predate the 20th century, but phenomena have been continuous since 1987. Mudboil flow occurs year round due to persistent artesian ground water pressure with "head" in the valley walls that is higher than the valley floor.

Location is near Onondaga Creek, south of Otisco Rd., Lafayette, NY. The area of concentrated mudboils where land subsidence has occurred is known as the Mudboil Depression Area (MDA) (see Figures 1 & 2).

Number of surface vents varies. From the 1980s to present, typically 3 to 7 mud boils discharge at any given time in the MDA, with one or more in a 'rogue' area.

Duration A vent cone can form within few days and then stop, while others discharge for years. One has been monitored for a decade. New vents are more likely to develop near recently active mudboils, due to the subsurface fracturing.

Flow intensity fluctuates with groundwater level, which is typically highest in Spring, with a secondary peak in late Fall-early Winter.

Rare Phenomenon. Other recorded mudboils occur under contrasting conditions (earthquake, freeze/thaw conditions, or tectonic weight on sediments). Most were temporary phenomena that formed in response to earthquakes in California and Alaska. In general, sand springs are more common than mudboils.

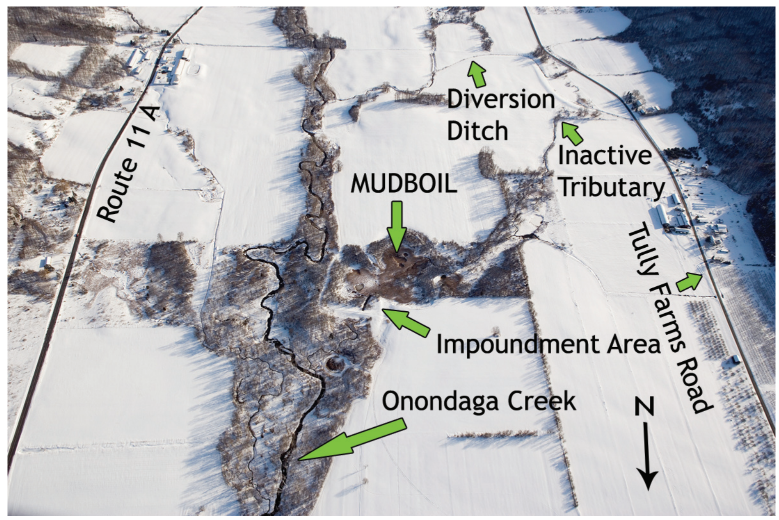

Figure 1. Aerial view from the north of the Tully Valley Mudboils. Photography by William S. Hecht, 2005.

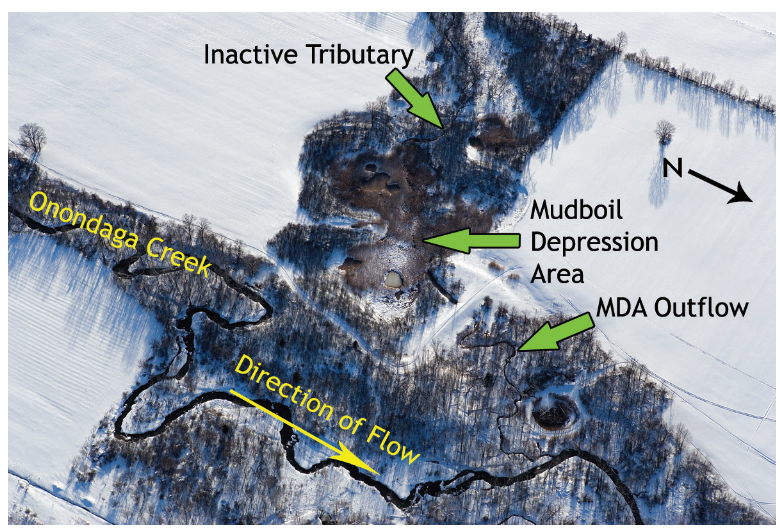

Figure 2. Aerial view from above mudboil area, south-southwest is left, west is at top. Photography by William S. Hecht, 2005

onondaga creek
CONCEPTUAL REVITALIZATION PLAN

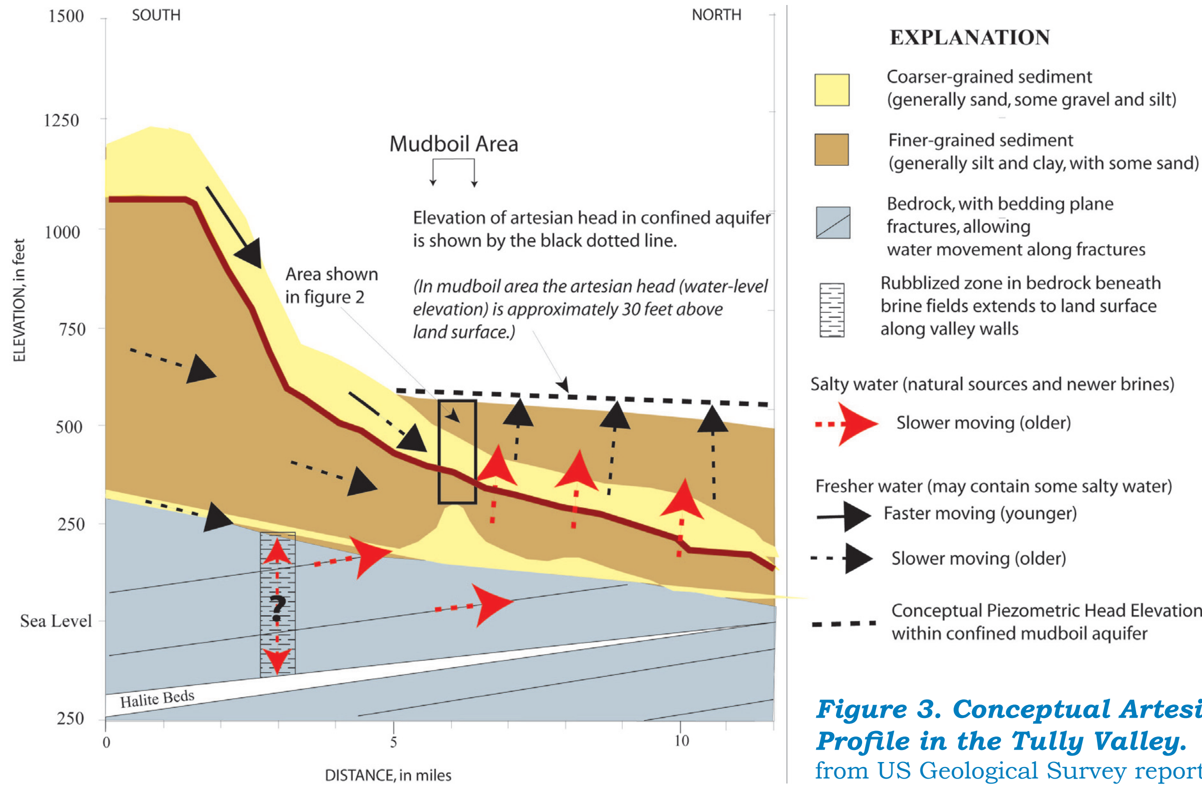

Figure 3. Conceptual Artesian Head Profile in the Tully Valley. Adapted from US Geological Survey reports.

Sediments discharge from vents in a range of particle sizes:

- Fine sand accumulates to form a 'volcano' cone around each mudboil vent.
- Silt-size particles settle behind a dam (see remedial measures).
- Finer silt and clay-sized particles flow to Onondaga Creek, turning it a turbid (cloudy) brown color.

Dissolved ions discharge from deep aquifer zones through the mudboils, contributing salty or brackish water to Onondaga Creek.

- Fresh water mudboils, once common in 1977, are harder to find today.
  - High suspended solids (turbid, brown water).
  - Low dissolved solids, not salty.
- Brackish to saline mudboils are the most common type occurring today.
  - High suspended solids (turbid, muddy water).
  - Higher dissolved solids: Brackish/ slightly saline to very saline (sea-water quality.
  - Typical dissolved ions: Sodium, Magnesium, Calcium, Chloride, Sulfate

Three kinds of aquifers provide artesian pressure which erodes and discharges unconsolidated subsurface material to the land surface. Figure 3 shows groundwater directional flow along the south to the north cross-section of the Onondaga Valley (Kappel 2000).

- *Brackish water* aquifer deep under the valley floor at 250 to 400 ft. depth. Source waters originate in:
  - Deep regional bedrock flow.
  - Interconnected bedrock aquifers in the solution-mining collapse areas.
  - Tully Moraine - southern end of the Tully Valley.
- *Fresher water* aquifer located under the valley floor at an approximate 60 to 120 ft. depth.
- *Fresh water,* near-surface recharge from alluvial fans of tributaries from the side walls of the Tully Valley.

Remedial measures were implemented and are maintained to date by the U.S. Geological Survey to reduce mudboil sediment discharges from the MDA to Onondaga Creek.

- *Depressurizing wells* were installed in the early to mid 1990s to lower artesian pressure.
- *A diversion channel* was installed in June 1992 to reroute an unnamed tributary away from the MDA.
- *A dam* was constructed in July 1993 creating a settling impoundment where detained water also maintains hydraulic pressure over the mudboils.

Mudboil loading (as measured in outflow) is now largely driven by the artesian pressure in the aquifers (Kappel, Sherwood *et al*. 1996).

- In early 1992 prior to tributary diversion, the annual mean daily discharge (outflow) from the MDA was 2.2 cubic feet per second (cfs), combining surface water with mudboil "spring" water.
- After 1993 improvements, the average annual

mean daily discharge dropped to 1.02 cfs (Kappel *et al*., p42)

- Since 1993, average annual mean daily discharge ranged from 0.71 cfs to 1.04 cfs outflow from the MDA, which reflects the continuing dominant role of aquifer discharge.

Sediment reduction from the MDA.

- Before remediation: 29.7 tons per day (measured 1992 water year, Oct. 1991 –Sept. 1992).
- After remediation: 0.7 tons per day (measured 2005 water year, Oct. 2004- Sept. 2005).
- Landslides in two creek tributaries contribute sediment to the creek downstream of the mudboils
    - Rainbow Creek (2004)
    - Rattlesnake Gulf (2005)

Land subsidence deforms the surface terrain.

- MDA is approximately 5 acres in extent in 2006.
- Maximum subsidence depth is approximately 15 ft. in 2006.

If the remedial measures cannot be maintained, site restoration (closure) must be conducted. Without funding for continuous maintenance of the wells, impoundment dam, and diversion ditch, the property would have to be restored as much as possible to the condition before the measures were implemented.

- The depressurizing wells would be closed down.
- The impoundment border would be graded to remove the dam.
- The diversion ditch would not be maintained, thus permitting the tributary to resume passing through mudboils.

Property ownership

- Honeywell International owns the surface in which mudboils are active, including the locations of the impoundment dam and depressurizing wells; the Onondaga County tax assessor lists Allied Chemical Corp. as owner. Allied Chemical is the corporate name prior to a merger with Honeywell.
- The diversion ditch passes though the property of John Snavlin and Richard Snavlin.
- Onondaga County holds an easement for the ditch.

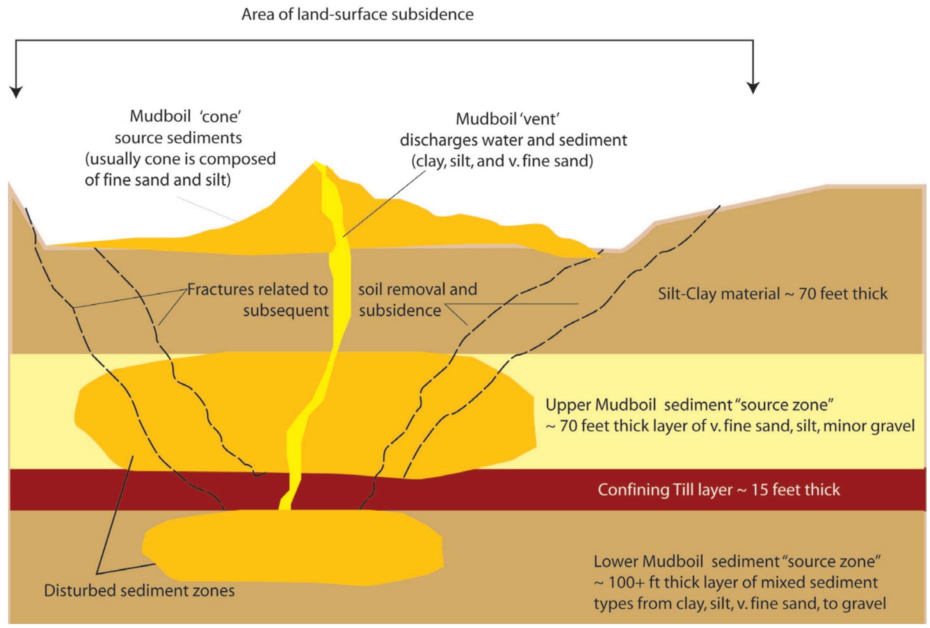

Figure 4. Typical mudboil layers, adapted from US Geological Survey data. Not to scale.

Anthropogenic influence

Solution mining in the Tully Valley led to increased artesian groundwater pressure in deep aquifers (over pre-existing natural conditions.) Rain and snow melt in the porous Tully brine field can penetrate fractured rock and disturbed sediment layers, thereby increasing the volume and depth of groundwater.

During mine operation, brine was continuously withdrawn from deep in the hydraulic system. This withdrawal generally lowered groundwater table and reduced artesian pressure in the brine field. When brine mining ceased, the groundwater level rose and artesian pressure increased, thereby exacerbating mudboil conditions.

The added groundwater recharges two aquifers in the valley floor that affect the mudboils. Under pre-mining conditions, ground water flow was more likely retained in shallow aquifers or surface water, without recharging deeper aquifers.

FINDINGS

- The flow of artesian-pressured water causes mudboils.
- Hydraulic pressure exceeds the capacity of wells to prevent further mudboil eruptions (Hayes 1998)
- Depressurizing wells bring fresh to mostly brackish water to the surface from the deeper aquifer.
- Subterranean solid material is exceptionally vulnerable to erosion and will continue to be brought to the surface.
    - Fractures in unconsolidated sediment layers connect aquifers to the land surface.

- ◦ Water erodes unconsolidated material as very fine sand, silt, and clay, discharged at land surface.
- Location and timing of new mudboils is not predictable.
- Land subsidence is expected to continue, although at a reduced rate from that measured in the early 1990's.
- Should new mudboil discharges be eliminated, currently existing mudboil sediment deposits on the creek bottom will continue to impact water quality for several decades.
- The brine-mining subsidence area in the southern part of the Tully Valley allows formerly separate bedrock aquifers to interconnect and thereby provide greater artesian pressure and greater volumes of brackish water that discharge from the mudboils.
- Dissolved halite (sodium chloride) from the Tully Valley brine field probably moves northward to the mudboils.
- Most of the dissolved ions in the mudboils are from the deep brackish water aquifer.
- Clay and fine silt from mudboils can remain suspended as turbid water in Onondaga Creek and affect water quality.
- Dissolved ions (salts) from mudboils continue to affect water quality in Onondaga Creek.

IMPLICATIONS

Mudboil management will require intermittent maintenance activities:

- Reshape the impoundment area where subsidence has occurred or where a new mudboil has formed.
- Maintain tributary diversion channel.
- Redevelop depressurizing wells and (or) replace with new wells as older wells lose their ability to discharge water due to sediment fouling within the mudboil aquifer

Mudboil management has persistent regular activities:

- Dredge sediments from the impoundment area before it fills.
- Monitor water quality and detect new eruptions.

Mudboil conditions could limit water quality improvements.

- Suspended sediments of clay and silt intermittently cloud the creek.
- Brackish water reaches the creek from mudboils and landslide areas further to the north.
- Multiple aquifer sources limit options to reduce mudboil activity.
- Management practices are not presently financially self-sustaining.

Land uses in the area are at risk.

- Subsidence and loss of land occurs in adjacent agricultural fields.
- New mudboil eruptions are not predictable in time or location but will probably occur within and near the historic mudboil 'corridor' upstream of Otisco Road and on the main mudboil tributary channel leading to the MDA.
- Channel instability (landslides) occurs in nearby tributaries (Rattlesnake Gulf and Rainbow Creek).
- Mudboil material
  - Is a quicksand that is not safe for walking.
  - Has highly astringent properties, removes soil, leaving skin dry upon contact, similar to a 'facial.'

SUMMARY

Mudboils are a persistent natural phenomenon that appears to have been exacerbated by solution-mining activities south of the mudboil area. Dynamic and unpredictable mudboil activity will require regular monitoring and innovative management solutions. Brackish water and suspended fine sediment will continue to reach Onondaga Creek, even with careful and continuous management.

REFERENCES

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The Onondaga Lake Partnership (OLP) sponsors the Onondaga Creek Revitalization Plan project with funds from the U.S. Environmental Protection Agency. Visit www.onlakepartners.org for more information about the OLP.

This fact sheet and additional information about the Onondaga Creek Revitalization Plan project can be found on the World Wide Web at www.esf.edu/onondagacreek/.