Oct 1st, 2017

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Recommended Citation

Daly, J., Eastler, T., and Locke, D., 2017, The Sandy River Re-visited in Johnson, B. and Eusden, J.D., ed., Guidebook for Field Trips in Western Maine and Northern New Hampshire: New England Intercollegiate Geological Conference, Bates College, p. 317-326. https://doi.org/10.26780/2017.001.0018

THE SANDY RIVER RE-VISITED

By

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INTRODUCTION

Investigating recent fluvial changes is exciting to geologists because of the opportunity to observe and better understand geologic processes on a human timescale. These changes also have significant consequences for the humans living and working near rivers and responding to shifting channel position, rates of erosion, and seasonal high-water events. Erosion resulting from meander migration poses a particular threat to farms, buildings, and roads adjacent to rivers. Extending from the Saddleback Mountain (Rangeley area) to the Kennebec River in Mercer (central Maine), the Sandy River watershed measures just over 500 square miles. In 2006, we led an NEIGC field trip visiting several large point bars on the river to look at changes in depositional patterns and channel migration recorded by detailed annual surveys from 2002-2006 (Daly and Eastler, 2006). In the decade since our 2006 trip, erosion at three locations prompted mitigation efforts at three of our trip stops. Each location features a different strategy for addressing erosion, prompting us to re-visit these sites and learn more about the benefits and costs of different treatments.

Figure 1. Changes in channel position at Voter Bar, Avon, Maine. The same view downstream (to the east) over an interval of a dozen years shows an example of the major channel migration at this location over time. Buildings at the Voter Vale farm are seen behind the trees in both photos. Channel migration has been a persistent issue at this location for two decades.

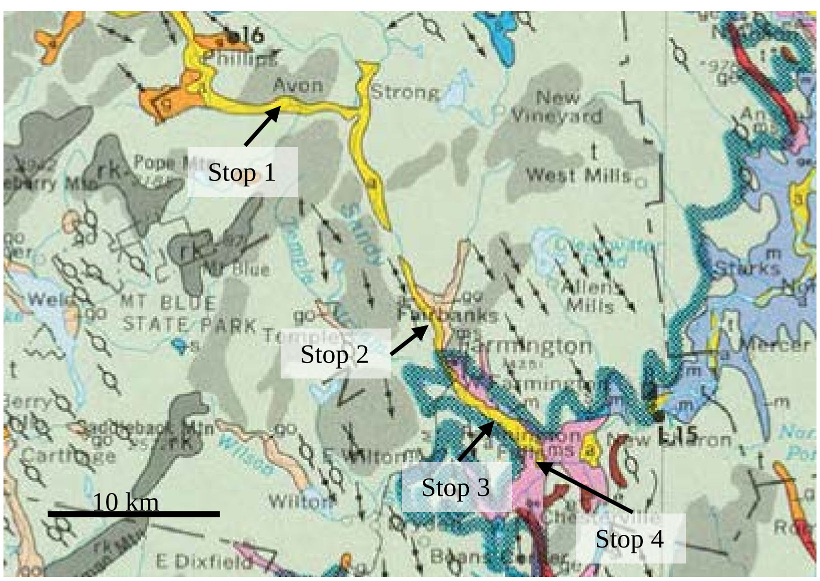

Figure 2. Excerpt of the state surficial geologic map, showing field trip stops (map from Thompson and Borns, 1985). Pale green indicates till, yellow is alluvium, and pink is nearshore marine. The stippled blue boundary indicates a generalized post-glacial marine limit.

Geologic Setting

This trip visits reaches in the middle of the Sandy River watershed, seeing point bars that reflect the transition from shallow, faster water in the upper part of the watershed to slower, deeper channels in the lower section. Figure 2 shows the generalized geologic context of the four field stops. At the upstream field site (stop 1), the channel sits in a relatively narrow valley bounded by till covered hills (Syverson and Greve, 2003). Cobbles, gravel, and sand derived from till and valley-parallel eskers yield abundant sediment. The upper limit of post-glacial marine inundation is likely somewhere between Strong and Phillips, ME. Small nearshore marine deposits (mostly sands and muds) are mapped along the margins of the floodplain from Farmington to Strong (Neil, 2007, and Weddle, 2003) and also contribute some sediment when they intersect an active channel. Downstream of Farmington, the gradient decreases and the floodplain broadens. In this section, the channel incises into the post-glacial marine mud and sand of the Presumpscot Formation overlain by post-glacial stream terrraces and floodplain deposits (Weddle, 2003).

Local channel morphology & dynamics

Figure 3. Examples of typical views across point bars on the Sandy River, looking downstream. A) View at Stop 1, typical of the mid-section reaches of the watershed with abundant rounded cobbles on the point bar surface and a relatively shallow channel. B) View at Stop 4, typical of a sandy point bar in the lower reaches of the river adjacent to a wider, deeper channel.

The point bars visited during the trip represent a range of morphologies and grain size that vary predictably moving from upstream to downstream reaches. Farther upstream, the channel is slightly narrower (<50m), shallower (<1m), and water velocities are faster. The surface of many upstream bars is an armor of rounded cobbles and gravel with some interstitial coarse sand. The cobbles are imbricated, and their diverse lithologies (granite, schist, slate, phyllite, chert) reflects their glacial material source. Moving downstream, more and more sand is present on the surface of the bar indicating lower velocities and gentler gradients even as the channel is wider (>50m) and deeper (>1-2m) to accommodate more discharge. The meanders are migrating predictably at each location, slowly increasing curvature and moving downstream simultaneously. When they reach their maximum length, the channel avulses and develops a shorter path. Evidence of old channel positions is found at numerous places along the Sandy River as oxbow ponds or simply abandoned channels beginning to re-vegetate. Our 2006 field guide used high-resolution topographic survey data collected over a period of five years to characterize volumetric change on the bars each year, and concluded that the bars were roughly in equilibrium (Daly and Eastler, 2006).

HISTORICAL BACKGROUND

Farmland and private property loss

Land loss as a result of cutbank erosion is a persistent and challenging issue along the Sandy River, bounded closely by roads and homes along its upstream reaches where the valley is relatively narrow and by agricultural fields downstream where the valley broadens significantly. Two of the three sites we will visit have decades of interventions to mitigate the impacts of erosion: Voter Bar (Avon) and Meader Bar (Farmington Falls).

The recent (twenty year) history of Voter Bar has been covered in a series of "Geologic Site of the Month" descriptions by Dan Locke (Locke 2001, 2006, and 2013). Beginning in 1998, property owners on either side of the channel have applied for a variety of permits to alleviate erosional pressure on cutbanks. As seen in Figure 4a, as the middle meander developed in the late 1990's it began to threaten the home located on Rt. 4 (indicated by the orange box). At the time, state agencies suggested enlarging an old channel (dotted arrow) to capture flow from the main channel. However, before that work started, the river began to naturally re-occupy the old channel. In this image from 2003, the majority of the discharge is still in the main channel, but a significant volume has started to use the shorter path.

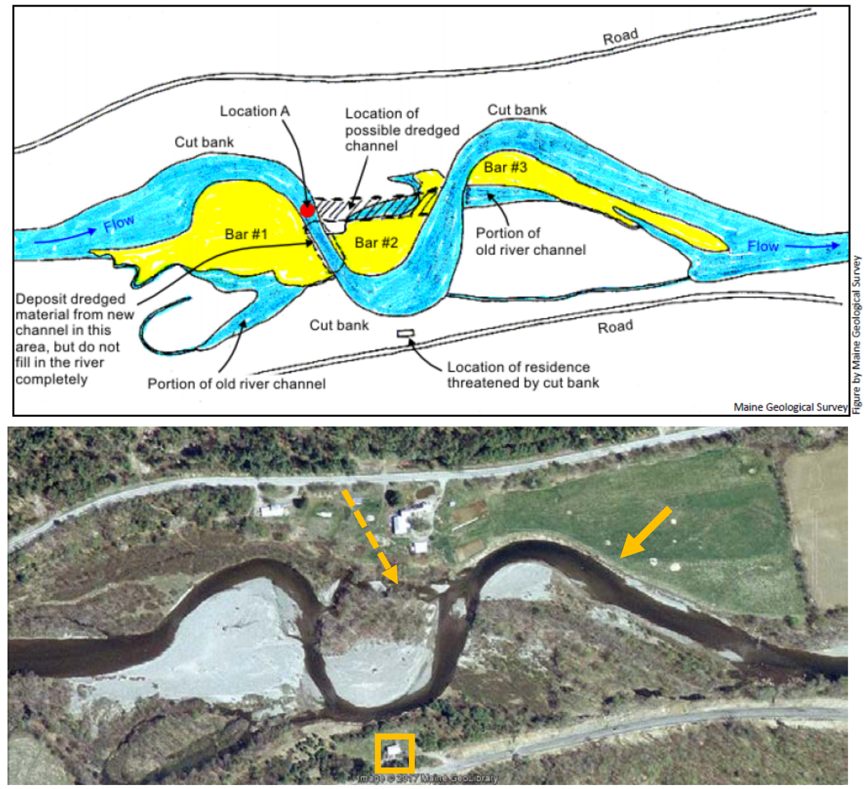

Figure 4a. Voter bar, Avon, ME in a rendering (top) from the Maine Geological Survey (Locke, 2001) and in 2003 (bottom, Google Earth, 2017). The house threatened by cutbank erosion in the late 1990's – early 2000's is indicated by the orange square. The dashed arrow points to the old channel that will be re-occupied and become the primary channel within three years. The solid arrow indicates the farm field that will experience significant erosion in the next decade, following the channel avulsion upstream (see Fig. 4).

Even fifteen and twenty years ago, erosion along the downstream meander was resulting in loss of agricultural land on the Voter Vale Farm, indicated by the solid arrow. As the avulsion progressed rapidly upstream, this cutbank has retreated even more significantly as seen in Figure 4b. In 2012, the farm owners applied and were granted a permit to remove sand and gravel from both active point bars at this location. The rationale cited in the permit was that lowering the points bars would relieve erosional pressure on the opposing cutbanks by allowing the river to occupy a larger cross-sectional area during high water events (Locke, 2013).

Figure 4b. Voter Bar in 2013 (Google Earth, 2017). The hatched orange area indicates field eroded in the previous decade as a result of meander migration.

Threats to public infrastructure

Downstream, a similar conflict has arisen between cutbank erosion and human infrastructure. For decades, the Sandy River has been threatening to undercut Rt. 156 and one end of Whittier Road in Farmington Falls. Over time, riprap emplaced along the cutbank has shunted erosion away from the road but has required extensions of the riprap as adjacent areas continue to erode. In the 2006 NEIGC field guide, we described the long-term evolution of the site from the 1950's to the present. Early cutbank erosion toward Rt. 156 prompted the placement of riprap at the apex of the meander where it was closest to the road. Over time, erosion persisted upstream and downstream of the riprap resulting in removal of a threatened house in the 1980's and application of several riprap extensions. As the riprap was extended, erosion migrated to either end of the hardened surface resulting in two active cutbanks separated by riprap. The upstream cutbank eroded toward Rt. 156 and a local road; following erosion during Hurricane Irene, the high cutbank came within 35' of the road, leading to traffic restrictions and some temporary closures (Hanstein, 2013).

The fundamental question underlying this trip is: given these problems associated with fluvial erosion, what are the actions to take to mitigate the damage? How can a geologic approach to these scenarios help inform decision-making?

EROSION MITIGATION

This trip will highlight examples of three mitigation strategies: 1) sand and gravel removal from the point bar, 2) riprap & hard berm emplacement, and 3) rootball revetment emplacement.

Sand and gravel removal

There is a long history of sand and gravel removal from the point bars along the Sandy River. However, between 2000 to 2012 no permits were issued for this activity and the point bars at our study sites (most of which had been skimmed in the past) accumulated sediment at faster rate. When we visited these sites in 2006, it had been less than a decade since this process ended. After over a decade without removal, permits were again issued starting in 2012 and sand and gravel have been removed from Voter Bar (Avon, stop 1) and Meader Bar (Farmington Falls, stop 4). An informational forum hosted by the county Soil & Water district in early 2012 drew over fifty people to learn about a new permitting process for gravel removal. In the intervening years, efforts to restore salmon to the Sandy River watershed were initiated and the new permitting process takes those into consideration (Hanstein, 2012).

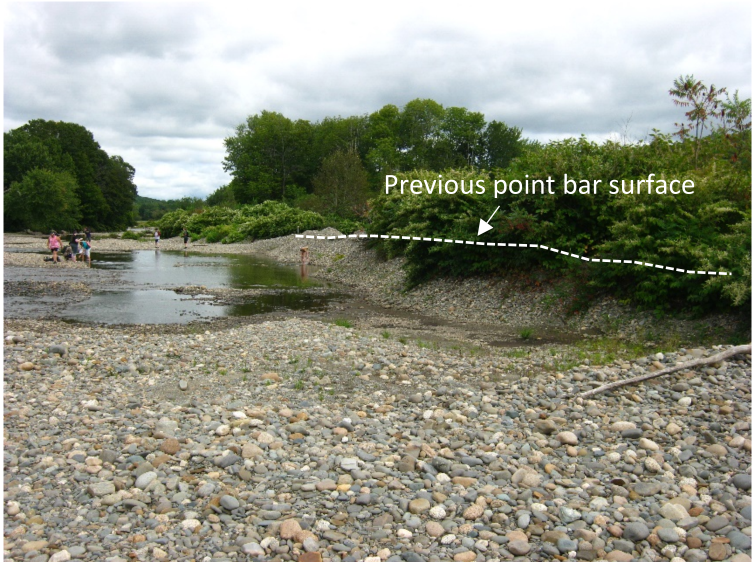

Figure 5. Gravel and cobble removal from a point bar in Avon. Students (~1.5 m height) at left for scale. Active channel is to the left of picture, view is downstream. Former height of point bar indicated by dashed line.

Riprap / hardened surfaces

Hardened structures, including riprap, are located sporadically along the Sandy River. Most riprap is installed along cutbanks or other unstable banks and has been effective in maintaining channel position at these locations. In mature riprap installations of rounded boulders, vegetation has taken root between some of the blocks or boulders and partially obscures the rocks. While the bank beneath the riprap has been stabilized, erosion continues at the margins of the riprap. The placement of riprap is controlled by Maine's Shoreland Zoning Act and is overseen by a permitting process.

Rootball revetment structures

“Soft” cutbank stabilization strategies include construction of a rootball (or rootwad) revetment. In this process, the slope is excavated and re-graded to be less steep, then tree trunks are buried in various orientations to slow water and improve slope stability. At the base, large trunks are anchored with their rootballs pointing upstream to help disperse energy during highwater events. These trunks are locked in place with buried boulders, and other tree trunks are partially buried in more vertical positions higher on the revetment. Vegetation is encourage to grow on the surface, further promoting stability.

Figure 6. Two views of the rootball revetment at Stop 4 in Farmington Falls, 2014 (left) and 2017 (right). Initially, it was easier to see the shorter trunks, but as vegetation has established itself (right), only the rootwads at water level are easily visible.

Table 1. Summary of erosion mitigation strategies

STRATEGY	**Pros**	**Cons**
Sand gravel removal	• Inexpensive/ yields some material with market value • Removal increases cross-sectional area of channel	• Needs to be repeated on an annual basis • Does not fix position of opposing cutbank
Riprap	• Maintains channel position • Long-term solution, may be low maintenance if properly designed and installed	• Cost • Diverts erosion to adjacent areas
Rootball revetment	• Diminishes erosion, doesn’t shunt fast water to other areas • Long-term solution if properly designed and installed	• Cost • Requires significant excavation/re-building, especially if bank is steep and tall

ACKNOWLEDGEMENTS

We gratefully thank the property owners for access: Darren and Angel Allen, Jim Meader, Kevin and Judy Vining, and Busse York. Significant early research on these bars was completed by Romany Shanti.

ROAD LOG

STOP 1. VOTER BAR, AVON, ME (19T 398033.40 m E 4961587.34 m N). This trip will begin at Voter Bar; please turn into the hayfield and park in the indicated area. We will be walking on a worn track across the hayfield. to access the bar.

Figure 7. Time series of Voter Bar, highlighting migration of the main channel since 2003 (Google Earth, 2017). After the middle point bar was abandoned, the upstream and downstream bars continued to accumulate sediment and migrate slowly downstream. Sand and gravel removal in 2015 from the upstream bar altered flow in the main channel.

Continued land loss on the north side of the river, especially due to migration of the downstream bar into the agricultural field, prompted property owners to approach Maine DEP for permits to mitigate erosion in the early 2000's. Initially approved to install rootball revetment on the downstream cutbank to protect their field, the owners couldn't afford the quarter-million dollar cost of construction (Hanstein, 2012). In 2012, the owners submitted an application to remove sand and gravel from both the upstream and downstream bar; the state approved this project as a two-phase plan (phase 1: upstream bar, phase II: downstream bar) (Locke, 2013).

Figure 8. The most recent Google Earth image of Voter Bar, acquired in 2016 (Google Earth, 2017). The main channel now follows only the dashed arrow. Prior to sand and gravel removal, the main channel was adjacent to the cutbank on the north side. A prominent chute, used during highwater flows, is shown by the dotted arrow. This path would have been the presumed new channel had the river migrated naturally.

Following sand and gravel removal, the upstream part of the channel re-located to the excavated area, abandoning the upstream cut bank and effectively slowing erosion along that surface. It is likely that the old channel will still be occupied during high water events, leading to some continued erosion in that area. Since 2003, the channel upstream of the third (downstream) bar has shortened significantly, potentially increasing the rate of erosion at this location.

Mileage

0.0 From the field, turn left onto Rt. 4 South and continue for 10.8 miles.

10.8 Turn right onto Town Farm Rd.

11.8 Turn left into E.L. Vining & Son Construction. Continue 0.3 miles down a dirt road to a large clearing at the south end of the property and park.

STOP 2. VINING BAR, FARMINGTON, ME (19T 407559.90 m E 4949215.74 m N)

Figure 9. The most recent Google Earth image of Vining Bar, acquired in spring 2016. The new berm structure, closing the breach created during highwater in 2009, is indicated. A detail of this structure is shown in the bottom left (Google Earth, 2017). River flow at this location is from north to south.

A well-established flooded borrow pit was breached during a highwater event in March, 2009. A small ice dam formed on a downstream point bar, backing up water locally. The narrow berm left at the north end of the point bar was breached, causing sediment to wash into the ponds and diverting flow from the main channel (Figure 10). The property owners value the wildlife habitat provided by the ponds, and constructed a large

Figure 10. Pre- and post-breach images of Vining bar. Note lower water levels and additional sediment in 2011 (Google Earth, 2017).

berm with a riprap surface to fill the gap eroded during the breach. Since construction, a modest amount of sand has accumulated in front of the berm, providing some buffer from erosion during high flows.

14.6 After returning to Town Farm Rd and turning left to continue south, turn left at the 4-way stop onto Bridge St.

14.8 At the stoplight turn left onto Rt.4, staying in the right-hand lane to cross the bridge over the Sandy River.

14.9 Follow signs and turn right onto Rt. 2 East / Rt. 27 South. Continue on Rt. 2.

** If you need to purchase gas/fast food/bathrooms, these are most readily accessible by continuing STRAIGHT through this light and using services at one of the establishments within the next quarter mile. **

17.8 Turn right into the Corn Maze, continue for 0.85 miles to a small clearing near the river and park.

18.8 STOP 3. LINDBERGH BAR, FARMINGTON, ME (19 T 412599.03 m E 4942557.17 m N)

Figure 11a. The most recent Google Earth image of Lindbergh Bar (indicated by red arrow), acquired in spring 2016. This relatively small point bar is associated with a cutbank that is actively eroding agricultural land on the opposite bank. The property owner is planning to submit an application for sand and gravel removal. Flow is from northwest to southeast (upper left to lower right).

The Lindbergh bar (Figure 11a) is an example of a point bar that has not recently been altered for erosion control. In contrast to the larger grain size seen on the surface of some of the upstream locations, this bar is located along a shallower gradient of the river with slower velocities, resulting in finer sediments on the

Figure 11b. View across the river at the Lindbergh bar. Note sand accumulated next to tree trunk in the foreground, and the thick section of floodplain sands and silts exposed in the cutbank. The river downstream of Farmington is incising the cohesive, clay-rich Presumpscot Fm.; this is exposed during low flows.

surface of the bar. The opposing cutbank (Figure 11b) shows a thick section of floodplain sands and muds overlying the clay-rich Presumpscot Formation that hosts the channel in the downstream reaches of the river.

18.8 Re-trace route to Rt. 2.

19.7 Turn right onto Rt. 141 and continue briefly through Farmington Falls and over the bridge.

20.2 Turn right onto Rt. 156 and continue.

20.6 Bear right to remain on Rt. 156 (also named Lucy Knowles Rd here), and cross a narrow bridge at 19.7 miles.

21.0 Turn right onto Whittier Road, continuing for 0.1 miles to a cleared area on the right side of the road. Please park as far to the right as possible, beware of poison ivy.

21.1 STOP 4. MEADER BAR, FARMINGTON FALLS, ME (19 T 413495.44 m E 4941010.66 m N)

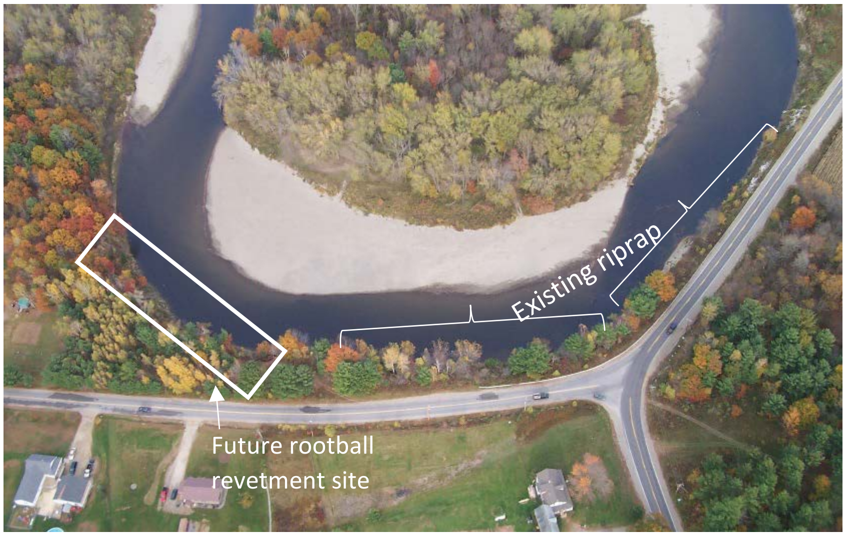

Figure 12. View of the Meader Bar in fall, 2011. Older riprap along Rt. 156 is indicated, and the extensive upstream point bar is in the center of the photo. River flow is from left to right. The future site of the rootball revetment constructed to protect Whittier Road is outlined.

Figure 13. View across the upstream bar to the eroding cutbank in March, 2012. Sand and gravel were removed during the low water period in fall 2011; a berm was left around the margins of the bar. During spring high water, the lower center of the bar is flooded and sediment is re-distributed from the berm.

As a result of rapid erosion during Hurricane Irene (August, 2011), the Sandy River threatened to undercut Whittier Road. A two-year permitting and construction process followed, resulting in the implementation of two mitigation strategies at this location (Hanstein, 2012, 2013, 2016). The first step was to remove sand from the opposite point bars for the first time in a decade (Figure 13). The town was permitted to remove 12,000 cubic yards of sand in 2012 (Hanstein, 2012b), leaving a low berm around the margin of point bar. Beginning in 2013, a large rootball revetment was constructed at a cost of over $450,000 (Hanstein, 2013). The final steps in stabilizing this bank were completed in subsequent years as vegetation grew over the surface of the revetment. Two rounds of plantings failed, but a recent invasive, Japanese knotweed, colonized the bank and provided the necessary cover. The rootball revetment has successfully survived three years with the major logs in place.

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