ASBPA WHITE PAPER:

Beach nourishment profile equilibration: What to expect after sand is placed on a beach

By

Kenneth Willson, Gordon Thomson, Tiffany Roberts Briggs, Nicole Elko, and Jon Miller

ASBPA Science & Technology Committee

March 2017

Beach nourishment is a commonly implemented solution to mitigate long-term erosion, provide habitat, and reduce storm-damage to coastal communities. During a beach nourishment project, large volumes of sand (with similar properties as the native sand) are added to the beach from upland, offshore, or nearby inlet sources to establish a designed level of protection and/or restore sand that has eroded.

During the construction of a beach nourishment project, sand is brought to the beach by dredges or truck hauling to widen the beach. Bulldozers are then used to grade the sand into a pre-determined construction template. Nourishment projects are designed and constructed to take advantage of the natural forces, such as waves and currents, to move sand offshore. This process results in a natural sloping beach within the littoral zone, and is referred to as **profile equilibration** (or profile adjustment).

The process of profile equilibration, which typically occurs within 12 months following sand placement (depending on storms), dramatically decreases the width of dry beach from the very wide beach observed immediately after nourishment. This decrease in beach width (profile equilibration) is often misunderstood by some of the public as the failure of the beach nourishment project because they perceive "all the sand washed away." The objective of this paper is to explain the process of profile equilibration in a non-technical way to inform coastal communities and increase public understanding of how beach nourishment works.

BEACH BASICS

One of the first steps in understanding how beach nourishment works is to define "the beach profile." For purposes of this discussion, the **beach** (Figure 1) refers to the typically dry area between the (high) water level and **dune**/upland region. Seaward of the beach is the **surf zone**, extending beyond the region where waves break. The dune, beach, and surf zone comprise the **beach profile** (Figure 1). The seaward boundary of the beach profile, just beyond where the largest waves break, is the closure depth. The closure depth depends on the local wave climate and the size of the sand, and represents the seaward-most point at which noticeable changes in the beach profile occur. Sand placed on the dry beach during nourishment is expected to be redistributed across the entire beach profile by the waves and currents, filling in the underwater portion of the beach profile as far offshore as the closure depth.

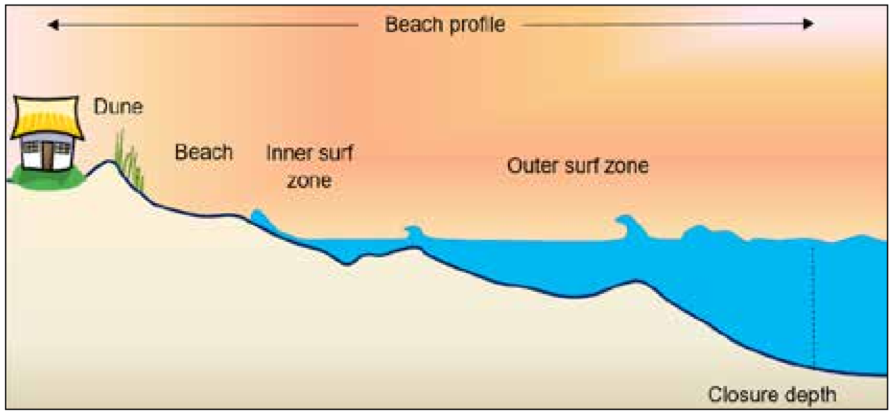

Figure 1. Diagram showing the basic features of a beach profile typical of many U.S. beaches.

Beach nourishment involves placement of sand along the upper (dry) portion of the beach profile either by dump truck or dredge. Once the sand is placed, bulldozers redistribute the sand across the dry portion of the beach. Conventional construction equipment cannot physically place sand to a designed configuration 15-25 feet under water, which is the common range of the closure depth. It is for this reason that beach nourishment projects are *designed* to take advantage of the natural processes by including a volume of sand intended to be transported offshore (Figure 2).

The constructed beach nourishment project includes a total volume of sand, "**constructed fill,**" which consists of several components each with different functions. When engineers design a beach nourishment project, they determine how much sand is needed to meet the stated design goal. A typical goal may be to prevent waves overtopping the dune during a storm event. Since this is the basis of the design, it's called the "**design fill**" (Figure 2).

The anticipated storm event, and basis for determining the design fill, may occur several years after construction. In the time between construction and the major storm event, the beach will lose sand due to average waves and smaller storm events at a fairly predictable rate (long-term erosion rate). The design must account for this expected sand loss. To ensure that the design fill is always present and available to protect the upland infrastructure, additional sand is included in the construction fill called the "**advanced fill**." The advanced fill erodes at the long-term rate (e.g. x ft/yr). Ideally,

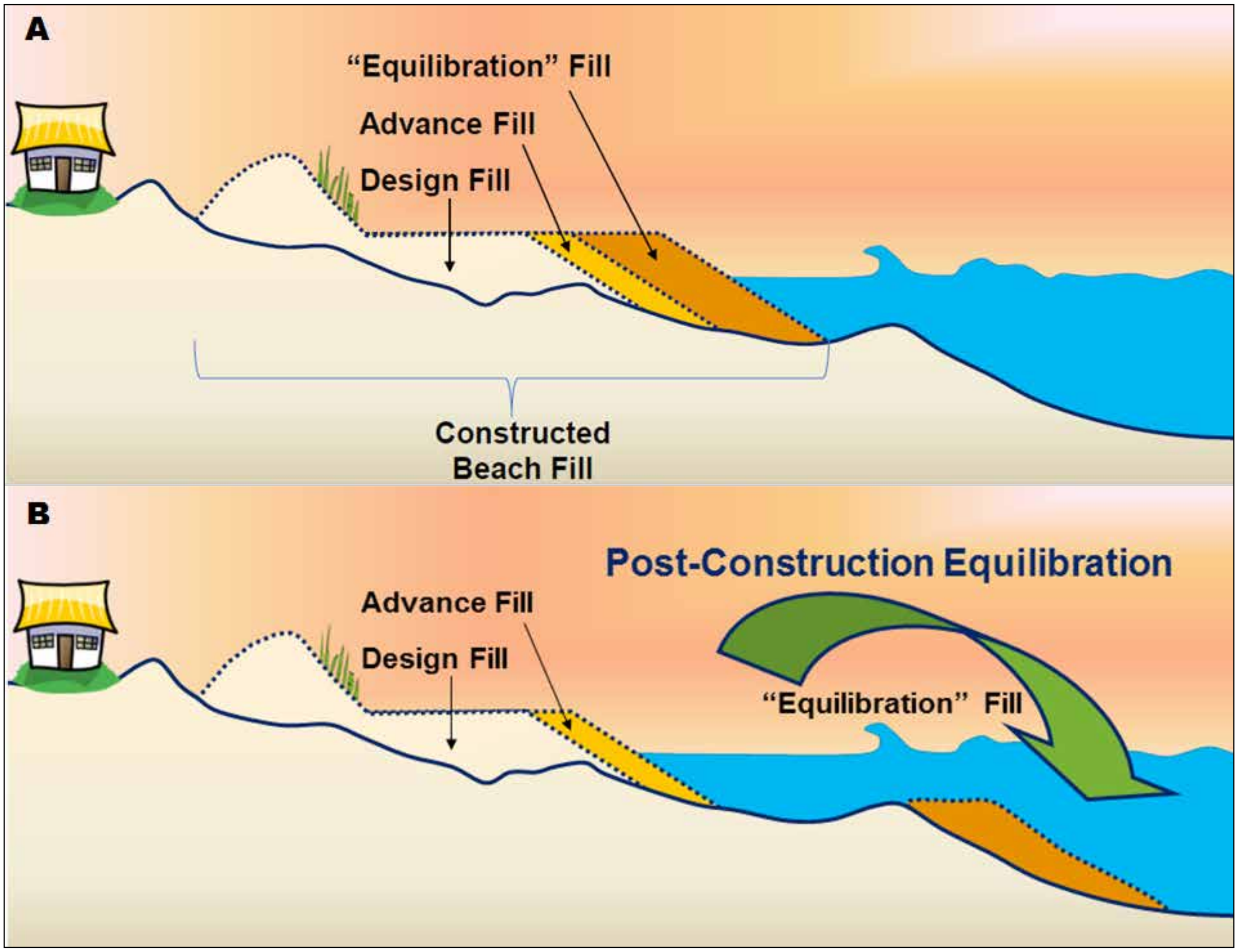

Figure 2. Beach nourishment projects are designed to allow sand movement across the profile, while maintaining a certain dry-beach width

once the advanced fill has dispersed and the design fill is beginning to erode, the next project (called a renourishment) will begin. The goal is to ensure that when a major storm occurs, at a minimum the design fill is present to reduce damage to the community.

A less intuitive volume of sediment included in beach nourishment design and construction is called the "**equilibration fill**." The equilibration fill is actually part of the advanced fill and design fill. During construction, the dredging contractor places sand at a slope steeper than the natural beach slope because it's cost prohibitive to shape the beach profile beyond the area where the waves are breaking. After construction, the waves and currents naturally soften the slope and move the sand offshore to fill the deeper parts of the beach profile. During this process, no sand has been lost from the beach profile; it has rather been redistributed to create a more stable beach shape, which is more effective in breaking larger waves further offshore. The movement of the sand from the steep construction slope to this flatter, more stable shape typically occurs within 12 months after construction, depending on how many storms impact the area.

Although profile equilibration is factored into the design of beach nourishment projects, the public may negatively perceive this process. The immediate, rapid loss of newly placed (and often quite expensive) sand may discourage project stakeholders if the process of profile equilibration is not explained. It is critical that stakeholders understand that this loss of sand does not represent a failure. In fact, the offshore transport of equilibration fill (Figure 2) is part of the engineering design. Most often the beach profile hasn't lost any sand, the sand has just moved offshore as intended where it is performing an important role dissipating wave energy. After this initial equilibration process during which the shoreline retreats rapidly, the shoreline retreat rate slows down as the profile approaches equilibrium.

REAL-WORLD EXAMPLE

The 2015 North Topsail Beach (NC) post-nourishment profile (constructed fill) and equilibration profile (equilibrated fill) provides a real-world example illustrating the equilibration process (Figure 3). The constructed fill (Figure 3A) equilibrated over a period of seven months transporting sediment to the surf zone (Figure 3B) and adjusting the overall beach profile (slope). As shown in the example beach profile, the equilibration fill is often deposited as a sandbar, which helps to trip the waves, and further reduce the amount of wave energy reaching the beach.

ENVIRONMENTAL CONSIDERATIONS

Understanding sediment transport pathways of the constructed fill is com-

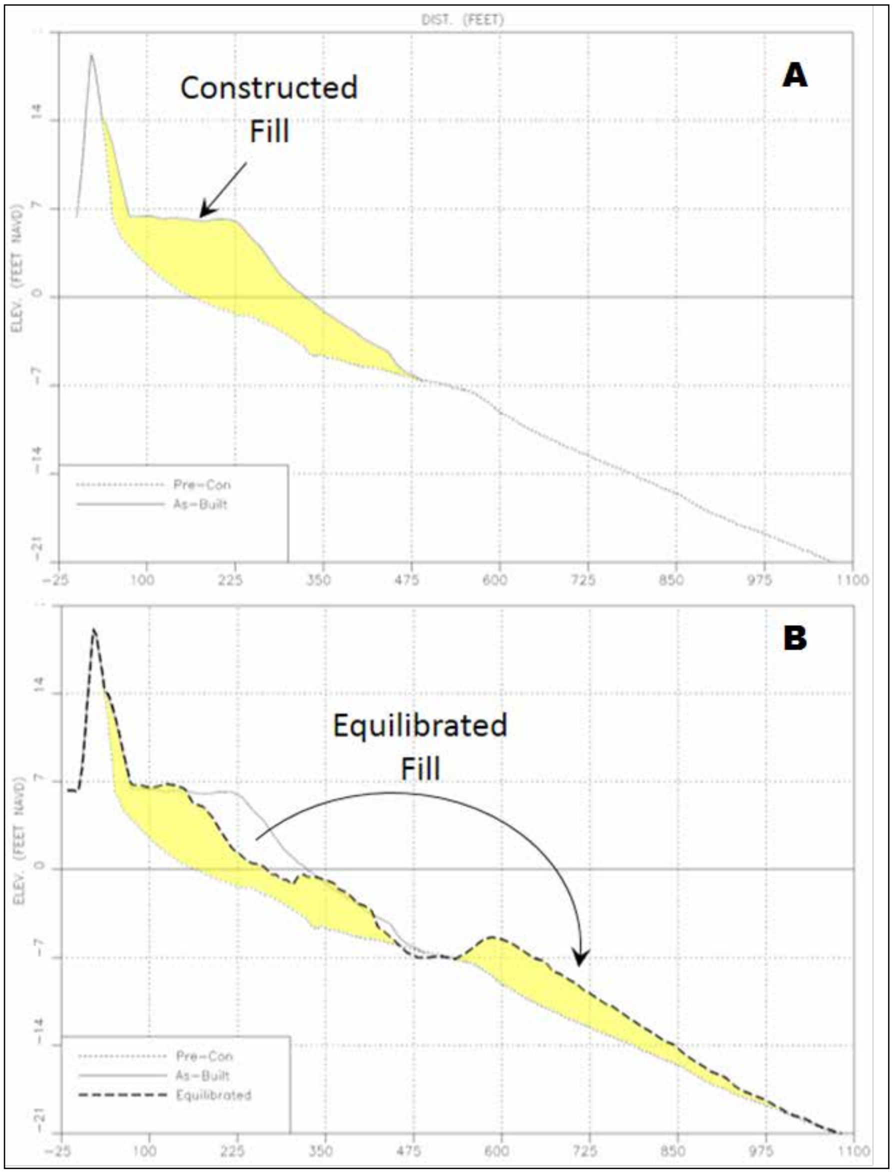

Figure 3. The North Topsail Beach (NC) beach profile immediately following nourishment construction (A), and seven months later once the profile equilibrated (B).

plex and is dependent on a number of factors. Therefore, when designing a beach nourishment project, careful consideration must be given to potential impacts of the equilibrating beach profile on adjacent resources. The movement of sand (equilibrated fill) from the constructed template seaward into the surf zone typically occurs over a period of months. Mobile benthic organisms are resilient in this highly dynamic setting and can adapt to frequent changes in the elevation of the seafloor. On the other hand, sessile organisms (that cannot move) may be more susceptible to impacts associated with sand transported offshore.

SUMMARY

The objective of this paper is to explain the process of profile equilibration to inform coastal communities and increase the public's understanding of beach nourishment. During beach nourishment projects, conventional construction equipment cannot physically place sand within the surf zone, and therefore projects are *designed* to include a volume of sand that the waves and currents will transport offshore to fill in the lower parts of the beach profile. During this process, the dry beach appears as though it has eroded, however this sand has moved offshore by design, where it is more effective at dampening the effects of the waves. ASBPA encourages coastal communities to share this white paper with coastal stakeholders before beach nourishment project construction begins.