Surface Roughening Pilot Study on the Salton Sea Playa

Background

The Imperial Irrigation District (IID) Water Conservation and Transfer Project (Water Transfer Project) includes a long-term transfer of up to 303,000 acre-feet of water annually from IID to the San Diego County Water Authority and Coachella Valley Water District. The Water Transfer Project, along with other factors affecting Salton Sea inflows and water balance, will result in accelerated exposure of the Salton Sea floor. As the Sea continues to recede, there is potential for windblown dust emissions from the exposed dry lakebed (the playa). A significant portion of this windblown dust is PM_{10} (particulate matter with an aerodynamic diameter of 10 micrometers or less). PM_{10} are approximately 1/7th the thickness of a human hair, are small enough to be inhaled, and represent a potential human health risk.

The primary source of PM_{10} emissions from exposed Salton Sea playa will likely be from saltation of sand and sand-sized soil particles. Saltation is the bouncing or leaping of sand and soil particles across the playa surface. As particles saltate, they abrade surfaces and dislodge smaller particles, generating dust (Figure 1). Windblown erosion can also expose underlying, sometimes more erodible soil layers. Dust control measures (DCMs) on the Salton Sea playa will be designed to reduce PM_{10} emissions by reducing the availability and/or kinetic energy of saltating particles.

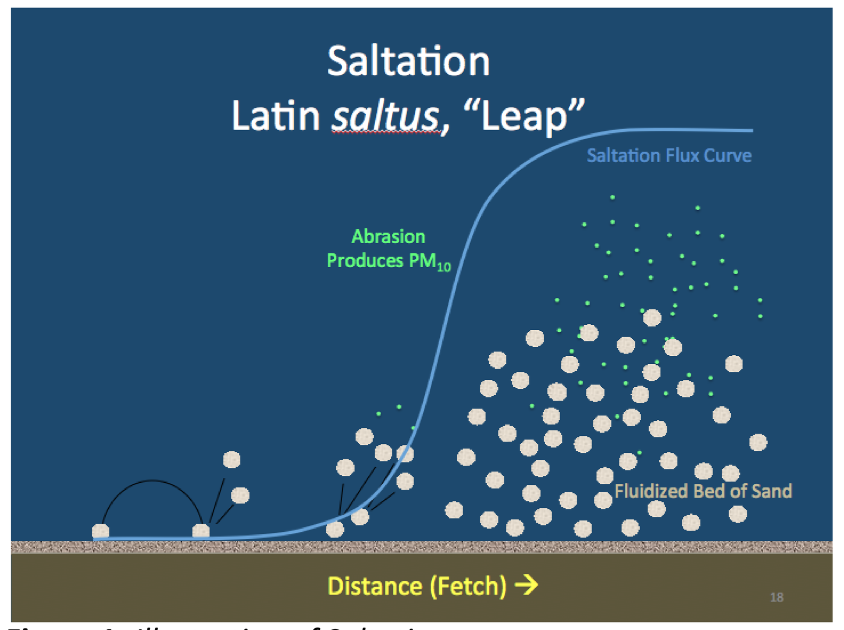

Figure 1. *Illustration of Saltation*

Surface Roughening as a Dust Control Measure

Surface Roughening is recognized in the United States and around the world as an effective DCM on bare, unprotected surfaces in arid climates. Surface Roughening is also expected to provide quick, waterless, and effective control on soil types at the Salton Sea playa. Surface Roughening provides dust control in two ways: (a) by modifying the airflow and decreasing the wind velocity at the surface, and (b) by physically trapping soil particles that enter the roughened area from upwind sources (Figure 2).

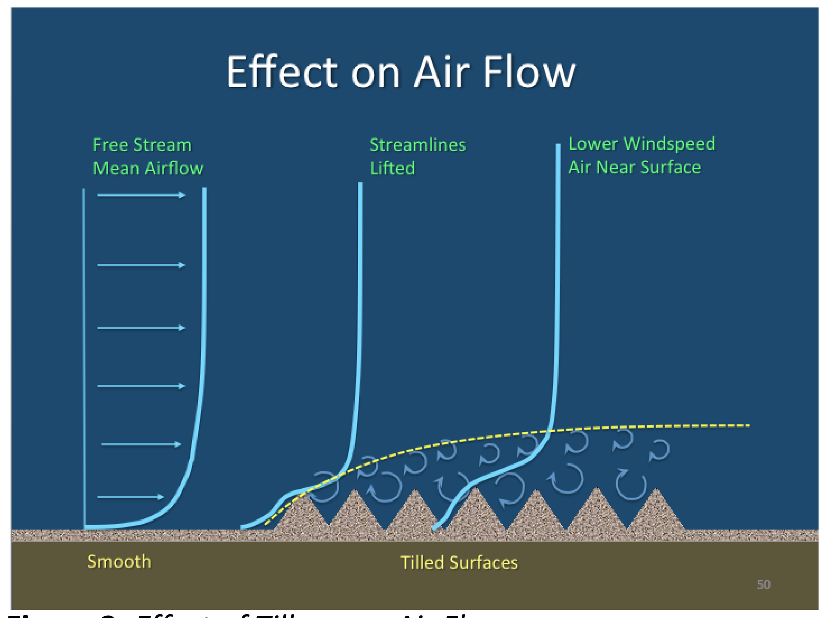

Figure 2. *Effect of Tillage on Air Flow*

Surface Roughening is typically created by a tractor-drawn tillage implement, such as a disk, plow, or rotary hoe (Figure 3). It also may be achieved with tilted dozer blades or excavators. After installation, roughness levels are monitored and areas are periodically re-tilled to restore roughness that has eroded over time. When necessary, water may be applied to restore soil structure so that re-tilling is more effective.

Figure 3. *Photograph of a Bull Plow (left) and Switch Plow*

Dust control effectiveness is dependent on the geometric characteristics created by the tillage implement. Furrow depth, ridge height, and ridge spacing are functions of the implement. Interrow spacing is the spacing required between implement passes to achieve effective dust control. Figure 4 displays a conceptual schematic of the geometric parameters for a bull plow and a switch plow.

Purpose of Pilot Study

The purpose of this pilot study is to perform an operational field test to support approval of Surface Roughening as a Best Available Control Measure in the updated Imperial Valley PM_{10} State Implementation Plan. The pilot study will evaluate the durability and longevity of surface roughening on different soil types tilled with various types of implements. Results will be used to understand which soils and equipment confer the greatest, most sustainable degree of roughness. Results also will inform development of a soil roughening suitability map based on soil types, surface roughness monitoring results, and the experience of operating various equipment and implements on the playa.

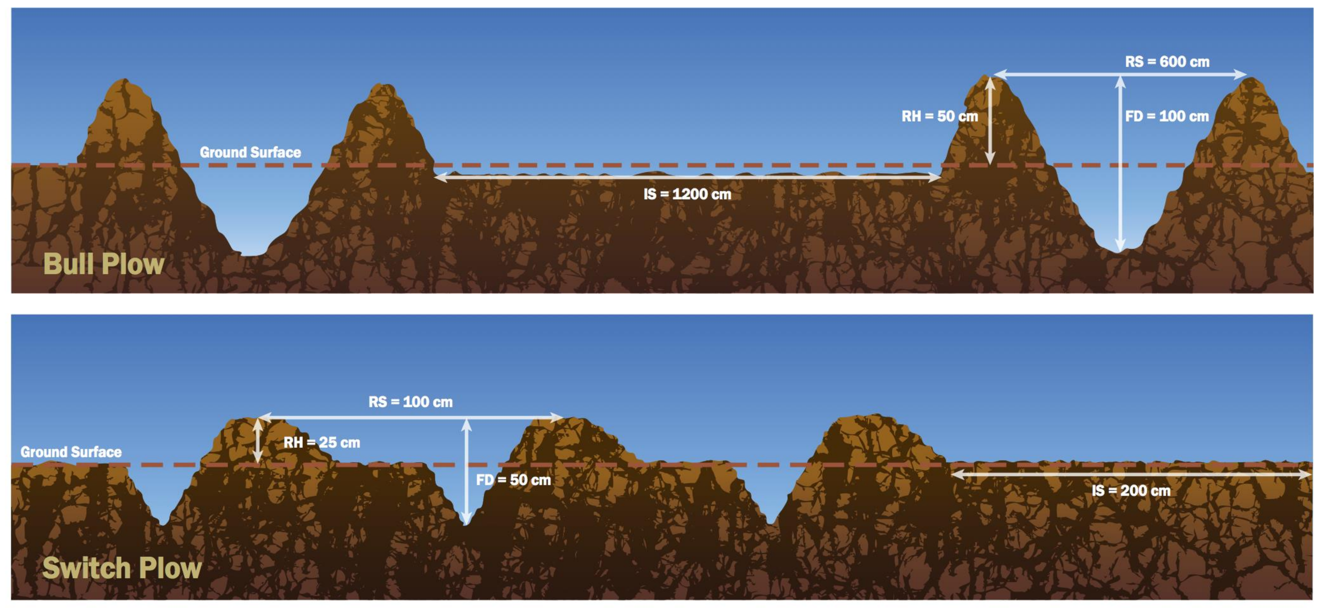

Figure 4. *Conceptual Schematic of the Ridge Height (RH), Ridge Spacing (RS), Furrow Depth (FD), and Interrow Spacing (IS) for a Bull Plow and a Switch Plow (Not to Scale).*

Site Selection

Twenty five potential study sites were prioritized based on land ownership, access, soil conditions, and the areal extent of available land. The selected study area is located near the Alamo River delta and includes six study sites (Figure 5). The soils are sandy-loam, and represent the range of soil types that will be exposed as the Sea recedes.

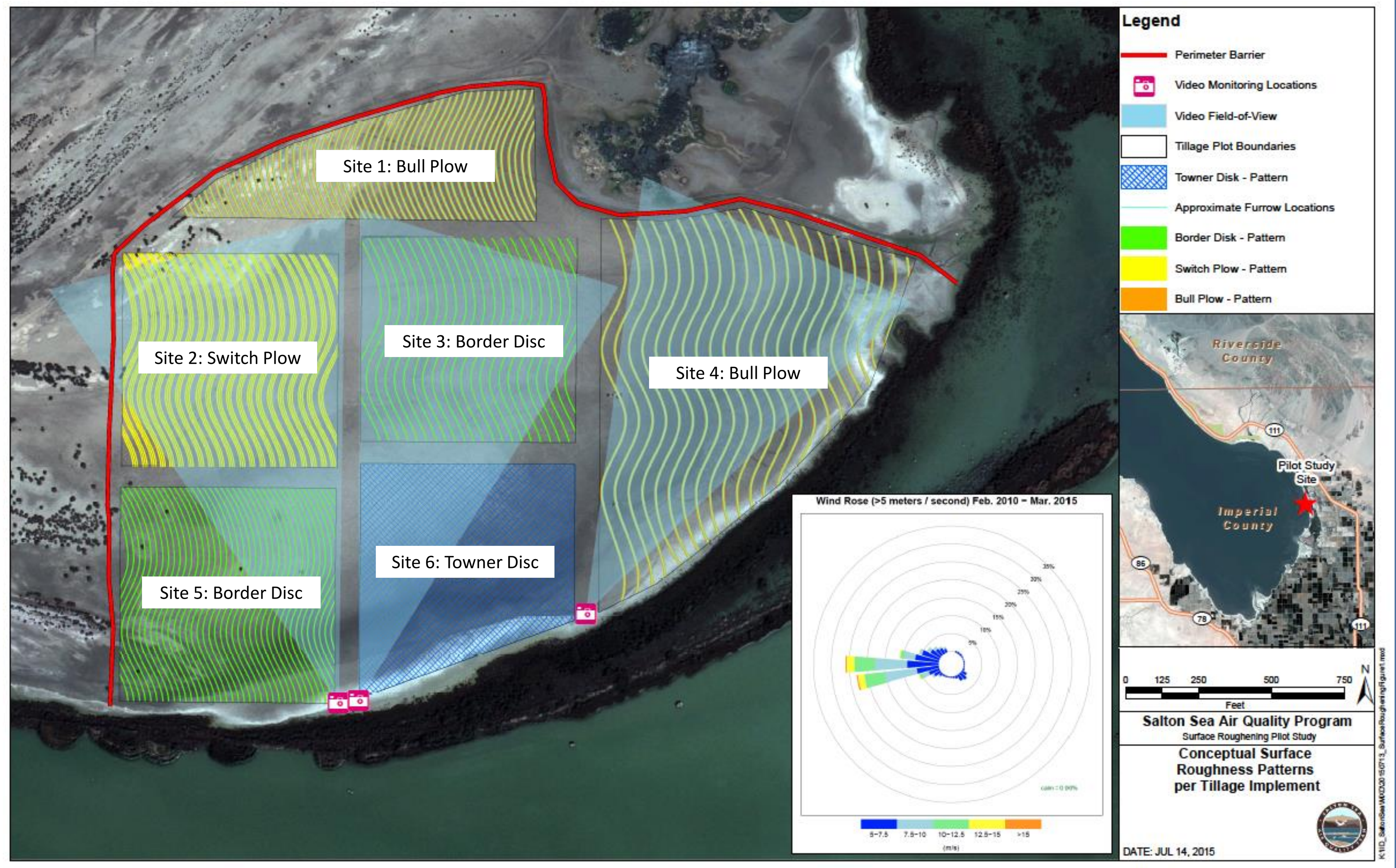

Figure 5. *Surface Roughening Study Area and Wind Rose Showing the Primary Wind Direction*

Design

Based on the methods of Hagen and Armbrust (1992), Surface Roughening is expected to provide greater than 99 percent dust control effectiveness as long as the average ridge height (RH) within tilled areas is greater than the threshold RH required to arrest soil particle motion. The threshold RH is a function of average ridge spacing (RS) and the design wind speed. The design wind speed chosen for this pilot study is 14 m/s, which is the maximum sustained (four-hour rolling average) wind speed measured at 10 meters above ground.

The ridges will be tilled perpendicular to the predominant wind direction but in a sinusoidal pattern to reduce saltation when the wind direction varies from perpendicular. Figure 6 shows a conceptual schematic of a sinusoidal curve.

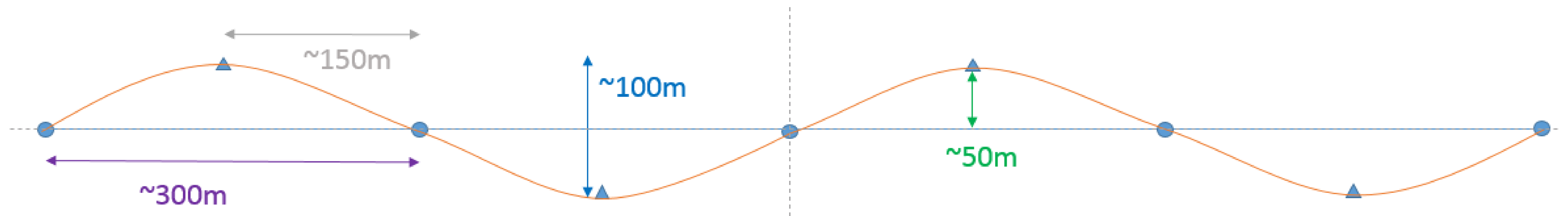

Figure 6. *Conceptual Schematic of a Field Pass in a Sinusoidal Curve (Plan View).*

Each study site is designed to achieve the geometric characteristics necessary for effective dust control. Table 1 displays the preliminary design parameters for each site. The spacing between each site is 2500 cm (984 in) to ensure sufficient wind run so that roughening in one site does not influence another site.

Table 1. *Preliminary Design Parameters for Each Study Site*

	Implement and Dimensions (cm, in)					
Parameter	Site 1 Bull Plow 1	Site 2 Switch Plow	Site 3 Border Disc 1	Site 4 Bull Plow 2	Site 5 Border Disc 2	Site 6 Towner Disc
Ridge Spacing	325 (10.7)	100 (3.3)	500 (16.4)	325 (10.7)	800 (26.2)	Continuous roughening
Furrow Depth	100 (3.3)	50 (1.6)	Not applicable	100 (3.3)	Not applicable	Not applicable
Interrow Spacing	675 (22.1)	100 (3.3)	500 (16.4)	1,275 (41.8)	800 (26.2)	Continuous roughening
Ridge Height	50 (1.6)	25 (0.8)	50 (1.6)	50 (1.6)	50 (1.6)	Not applicable[1]

[1] Dust control provided by continuous random roughness rather than directional ridges

Implementation

Implementation of the pilot study will include:

- Obtaining and mobilizing equipment.
- Field marking each study site with stakes and/or flags.
- Surface roughening based on a GPS course to ensure proper orientation with the wind.
- Installing a physical barrier and safety signage to prevent ATV access to the study area.
- Monitoring of surface roughness for one year.

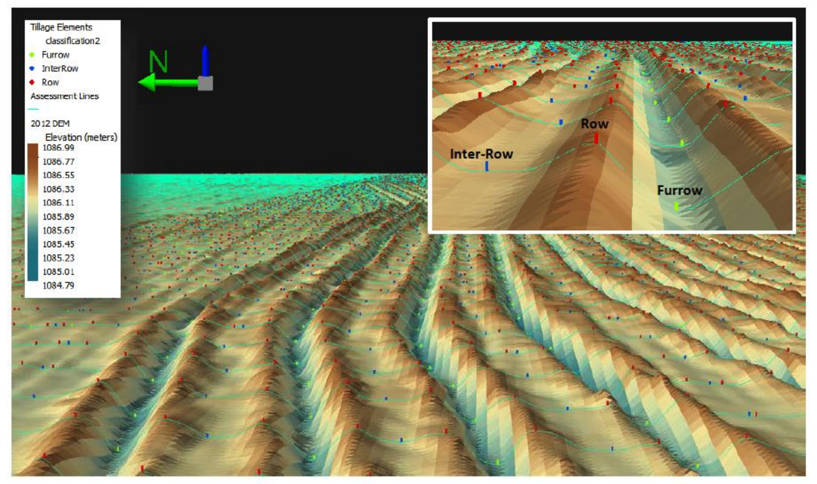

Figure 7. *Example High Resolution Digital Elevation Model (DEM) with Geometric Elements Identified*

Monitoring the durability and longevity of roughness over time is essential to understanding which soils and equipment confer the greatest, most sustainable degree of roughness. Geometric elements will be monitored with remote sensing techniques (Figure 7). Video monitoring also will be used to identify periods when other sources (e.g., unauthorized ATV traffic, nearby vehicle traffic, off-area windblown dust) are impacting the study area (see Figure 5).

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1. Hagen, L. J. and D. V. Armbrust. 1992. Aerodynamic Roughness and Saltation Trapping Efficiency of Tillage Ridges. Transactions of the American Society of Agricultural Engineers 35(4): 1179-1184. July-August 1992.
2. Imperial County Air Pollution Control District. 2005. Rule 806, Conservation Management Practices. November 8.
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