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Lonnie G. Harper & Associates, Inc.
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Attention: Chris Wheat

Subject: Report Addendum #1
BA-195 Barataria Bay Rim Marsh Creation and Nourishment
Jefferson and Plaquemines Parishes, Louisiana
File No. 10883-022-00

GeoEngineers Inc. (GeoEngineers) has prepared this addendum for Lonnie G. Harper & Associates, Inc. (LGH) to our February 14, 2018 Geotechnical Services Report to provide additional recommendations regarding cut to fill ratios as they relate to fill height and suggestions regarding how to contractually specify construction.

INTRODUCTION

Implementation of marsh creation design seems straightforward at first glance. For the parties responsible for monitoring construction, verifying completion of fill placement is difficult. We understand fine grained (clay) hydraulic fill for marsh creation projects has typically been placed to a specified fill height based on, among other factors, fill surface settlement vs. time curves typically provided in a geotechnical report. Due to difficulty surveying the top of freshly-placed marsh fill, judgement and rules of thumb have been used to assess when dredged material placement is complete. Ambiguities for determining when enough fill has been placed include assessments of when fill is "substantially dewatered" and assessing how to interpret survey rod equivalents when the low-pressure shoe at the base of the rod sinks over a foot into the fill slurry.

We propose a different, simpler way to think about specifying fine-grained hydraulic fill placement and completing construction-period measurements to verify and monitor placement. This proposed methodology is based on post-construction field monitoring for the Freshwater Bayou marsh creation project, calculation of void ratio versus time for several marsh creation projects, and our experience with soft soils.

PROPOSED METHODOLOGY

The underlying position of this methodology is hydraulic fill dredged from borrow areas with very soft to soft consistency fine-grained soil (clay and silt) will achieve a long-term density similar to its in-place density prior to dredging. Given this belief, the cut-to-fill ratio to achieve a desired long-term marsh elevation is simplified to the sum of:

1. The volume of fill (long-term consolidated state) from the existing mudline/marsh in the fill area to the desired long-term target elevation;
2. The volume of fill required to overcome subgrade consolidation under the fill load; and
3. Losses during dredging.

Component 1 is easily evaluated based on a survey of the existing mudline/marsh elevation and the long-term target marsh elevation. Component 2 can be estimated based on consolidation theory and a geotechnical study of the fill area. Component 3 is a function of the fill area size, dredging equipment, containment design and integrity, and probably several other factors.

Instead of specifying a target elevation for newly placed unconsolidated hydraulic fill that is difficult to define and measure, we recommend specifying a cut volume of fill at a ratio of 1 unit volume of in-place pre-dredge borrow to 1 unit volume of the sum of items 1 through 3. For example, per square foot of area, for a fill area with a pre-fill mudline elevation of -1 foot (El. -1 ft.), a target long-term fill elevation of El. +0.5 ft., a long-term subgrade settlement of 0.1 ft., and a 20% allowance for dredging losses, the in-place cut volume would be calculated as (1.5 + 0.1)*1.2 = 1.92 cubic feet per square foot. The cut-to-fill ratio based on the difference between the pre-fill marsh elevation and final long-term target elevation would be 1.92/1.5 = 1.28.

ADDITIONAL EVALUATIONS

Fill Volume and Rate

Use the cut-to-fill ratio determined above to specify the volume of fill to be placed (based on in-place cut volume) either by unit area, or by individual fill area.

Required containment heights can be initially estimated using fill bulking based on the rate of fill, settling column test results and the method described in Appendix C of U.S. Army Corps of Engineers Engineering Manual EM 1110-2-5027. Bulking may also be estimated by extrapolating the zero-stress void ratio from low-stress consolidation test results as initial placed void ratio. The table below provides bulking coefficients for a given long-term volume of fill placed in the BA-195 marsh creation areas for a range of fill construction periods based on EM 1110-5-5027 and settling column test results.

INITIAL FILL BULKING – BA-195 COMPOSITE BORROW MATERIAL PROPERTIES

Construction Duration, days	Estimated Bulking Coefficient	Approximate Initial Fill El. (Long Term Fill El. = 0.48 ft, Initial Mudline El. = -1 ft, & 1.1 Subgrade Settlement Factor)
15	2.43	+3.0 ft
30	2.20	+2.6 ft
60	2.00	+2.3 ft
120	1.81	+1.9 ft

The bulking factor will be consistent for a given construction duration for a given fill material, but initial fill elevation will change depending on mudline elevation and foundation soil settlement. Bulking calculations assume soil is in a state of "compression settlement", meaning enough material has fallen out of the water column for the soil to behave as a solid mass. Based on settling column testing results, this state is likely to be achieved within a few days of fill placement.

As indicated in the table, initial fill elevations (freshly placed) can be approximated based on construction duration, design long-term fill elevation, and borrow material properties.

Fill Elevation vs. Time Curves

With this revised approach, a question that may be asked is why go through the effort of developing the fill elevation vs. time charts that have typically been the emphasis of many geotechnical evaluations. These complex evaluations are typically completed using the Primary consolidation, Secondary compression and Desiccation of Dredged Fill (PSDDF) model and inputting fill rates and properties. These evaluations still have value, as described below:

- Once a stable containment dike geometry has been determined, PSDDF can be used to check the initial fill bulking calculations and containment adequacy. This is a critical evaluation that warrants a check by two methods. Another way to envision this is if fill is placed very quickly, its bulked fill volume may be more than the containment capacity. While we understand there is a reluctance to specify methods, this approach would allow agencies to gauge whether an over-sized dredge may need to be cycled over a longer period (i.e. place fill in lifts), or whether an under-sized dredge can use lower containment berms because of fill consolidation during placement.
- GeoEngineers uses PSDDF to evaluate fill consolidation/submergence over time, which also affects subgrade soil consolidation; typically reducing subgrade consolidation.
- PSDDF provides fill density with respect to time, which can be used to verify that the long-term fill density is consistent with the in-place borrow area soil density prior to dredging.

BA-195 RECOMMENDATIONS

Given this approach is acceptable to LGH and the Natural Resources Conservation Service (NRCS), our recommendations for BA-195 are:

Cut to Fill Ratio

- The long-term target fill elevation is Elevation 0.48 foot (El. 0.48 ft.), as we understand the design.
- Calculate the fill thickness between El. 0.48 ft. and the average existing mud/marsh line elevation. We understand that the average mud/marsh line is approximately El. -1 ft. Therefore, the long-term average fill thickness is 1.48 foot.
- Based on our evaluations add 0.1 foot to the fill thickness to account for subgrade consolidation.
- Per unit area, calculate the cut to fill ratio as (1.48 + 0.1)/1.48, or 1.1 not including dredging losses.
- Add an appropriate additional percentage to account for dredging losses.

Previously provided fill elevation vs. time curves and cut to fill ratios match results from this evaluation methodology. Using this method, determining a target time and elevation to measure fill at the end of dredging becomes unnecessary. Verification is achieved by surveying the cut volume and confirming the correct volume has been placed in a specified fill area. If some type of placement area verification is desired, a rough visual check may be achieved by using the bulked fill elevations at the time hydraulic fill placement is complete.

LIMITATIONS

This addendum should be considered part of our February 14, 2018 Geotechnical Services Report, and the limitations presented in that report are applicable.

CONCLUSION/CLOSING

Many construction-period variables impair the use of settlement curves as a construction acceptance criterion. In this addendum, GeoEngineers submits a more practical approach to planning and monitoring construction based on long-term cut-to-fill ratios and volumes, containment capacity and bulking properties for a given construction duration.

GeoEngineers appreciates the opportunity to work with LGH and NRCS on this project. If there are questions about this addendum, please contact us at 225.293.2460.

Sincerely,
GeoEngineers, Inc.

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Principal

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