SMITHGROUP

MEMORANDUM
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PROJECT	Illinois Beach State Park Shoreline Stabilization	DATE	4/22/2021
PROJECT NO.	12324		
PROJECT LOCATION	Zion, IL		
SUBJECT	Littoral Drift Analysis and Prefill Recommendation		
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Littoral Drift Study

General Methodology

SmithGroup gathered historical information of the site and a series of numerical models were used to determine the sediment transport rates along the park's coastline. The following methodology was carried out:

1. Acquisition of an overall bathymetric survey for the park, compiled from various sources, including NOAA's nearshore bathymetry from LiDAR 2012 for the offshore bathymetry and a survey performed by JSD Professional Services, Inc. from March 20 to May 22, 2020.
2. Performance of a wave climate analysis to determine the conditions at the park using 35 years of historic information. Te wave data for this step was taken from an offshore data point maintained by the U.S. Army Corps of Engineers (USACE) Wave Information Studies (WIS).
3. Digital propagation of these waves from the offshore to the nearshore using the MIKE21 SW spectral wave model. This model propagates the offshore waves allowing to naturally bend, heighten, and even break over the shallow bathymetry as they enter the nearshore area of the model.
4. Calculation the longshore sediment transport or littoral drift along the coastline using the nearshore bathymetry and annual average wave climate.
5. Calibration and verification of the model's results.

6. Computation of the transport rates along the park's shoreline and the altered rates once coastal structures are implemented.

All numerical modeling was completed using DHI's MIKE21 and LITPACK software packages capable of simulating physical nearshore processes. The software package is a modular product that includes simulation engies for different applications, including wave modeling, hydordynamics, and sediment transport dynamics.

Littoral Drift Calculation

The first step for the analysis was the calculation of the net longshore sediment transport or littoral drift along the coastline. The modeling of littoral transport consists of two parts: a hydrodynamic model to calculate the wave propagation towards the coast and resultant wave driven currents, and a sediment transport model to calculate the longshore transport.

The main input parameters for the hydraulic computations are the wave properties: wave height, angle, and period for a given depth in the profile. From this position, the model will shoal and refract the waves across the profile into the coast and calculate the resulting longshore current across the profile.

To calculate the annual net sediment transport, a representative wave climate was created using the 35 years of historical wave data. The representative nearshore wave climate, shown in Figure 1, consists of a number of events, each described by its frequency of occurrence, propagation direction, and nearshore wave height. The summation of the occurrence of the individual events totals one year and therefore this wave climate is representative of an average year of lake events.

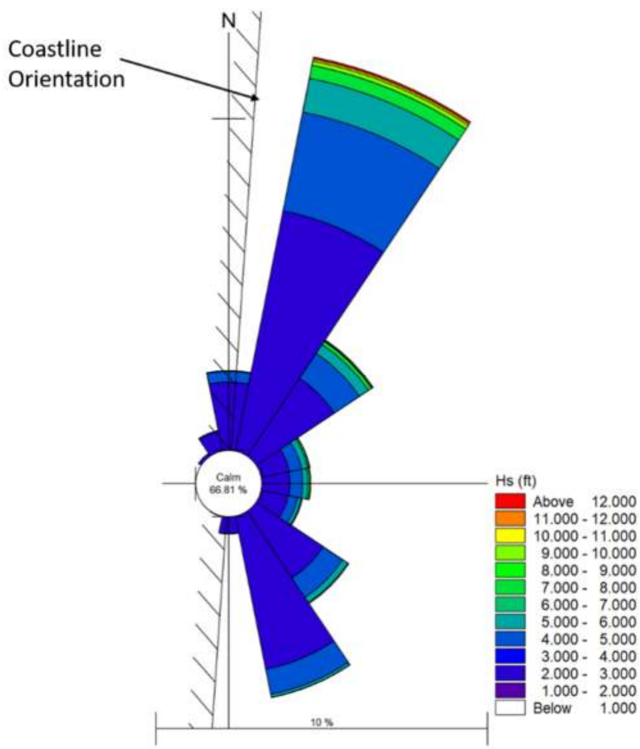

Figure 1: Offshore wave rose of the representative wave climate and its relation to the shoreline.

Three representative profiles were extracted from the bathymetry, located at the three areas of concern (Figure 2). Longshore sediment transport potential was simulated by integrating the calculated sediment transport for every grid point across the profile, defined by local hydrodynamics and sedimentological conditions.

The selected profiles were extended to a depth of 82 ft, where wave-driven longshore currents generally become insignificant. Because transport rates depend on the steepness of the cross-shore profile, the three profiles were conversely extended inland so that the last couple of grid points are always dry and therefore not affected by longshore currents.

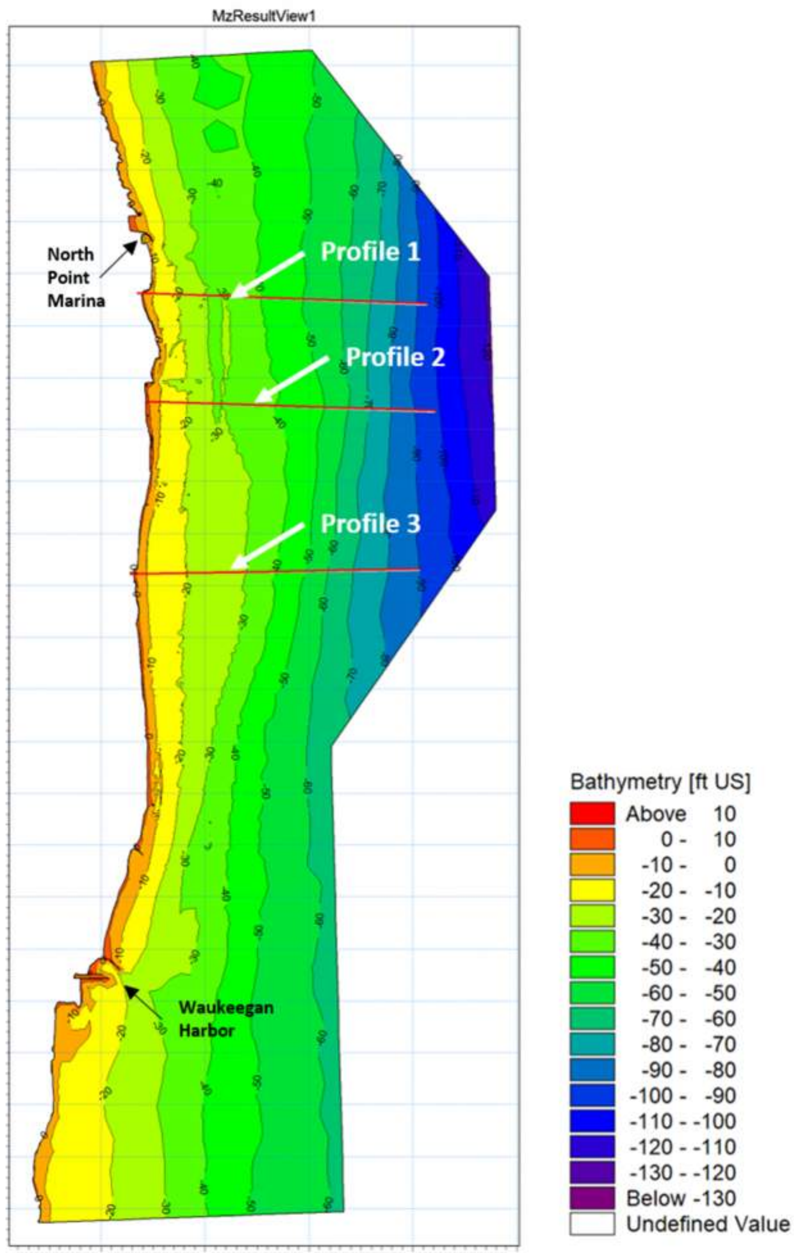

Figure 2: Location of the three representative profiles along the coast

The annual sediment transport rate was calculated for each profile using the representative offshore wave climate and evaluated to determine how closely the model corresponded to the expected rates. Because a representative yearly wave climate was used, it was necessary to perform a sensitivity analysis of the influence of different water levels. After calculating the net annual transport rates, transport tables for the coastal evolution simulations were created. These tables summarize numerous littoral transport rates associated with a range of hydrodynamic conditions, providing representative littoral transport rates associated with various wave events.

Results

Area 1 – North Beach

Historical documents show that North Beach was actively eroding prior to construction of the North Point Marina. The addition of the revetment and the offshore submerged breakwater following marina construction created a hard diffraction point that bends incoming waves around it. Another of the main reasons for this to be an accelerated area of erosion is that there is not enough sediment coming from up coast as marinas and breakwaters built to the north along the Lake Michigan shoreline act as sediment sinks preventing the natural flow of sediment to the south.

To stabilize the shoreline in this area, the project proposes to utilize a design of ten structures and sand nourishment.

Figure 3: Area 1 proposed design.

The potential littoral drift rates before and after the placement of the structures and the nourishment are shown in **Figure 4**. This graphic shows that the structures in place are slowing down the transport south by approximately 12,000 CY/year.

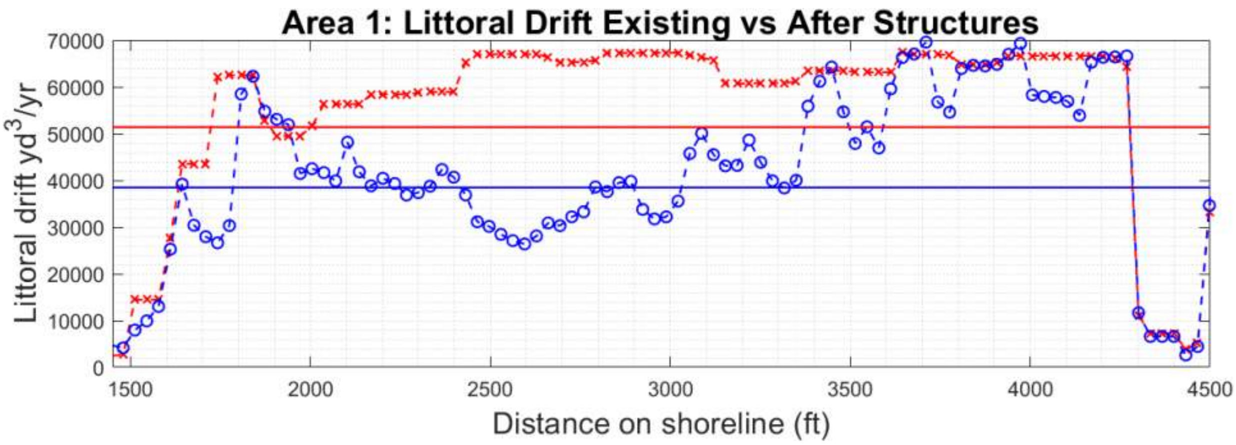

Figure 4: Littoral drift potential of the existing shoreline before and after the installation of structures, Area 1

Area 2 – Camp Logan

Several shoreline protective measures have been used to control erosion northward of the Lake County Public Water District that include revetments, sheetpiles, and concrete cubes. While the LCPWD intake station is protected and stabilized by a rubble revetment, the area to the south, which contains recreational trails, a nature preserve and RAMSAR wetlands, is threatened by the rapid erosion. The proposed design to mitigate the erosion in this area, consists of seven structures south of the LCPWD intake station as well as sand nourishment.

Figure 5: Area 2 proposed design.

The potential littoral drift rates before and after the placement of the structures and the nourishment are shown in **Figure 6**. This graphic shows that the structures in place are slowing down the transport south by approximately 11,000 CY/year.

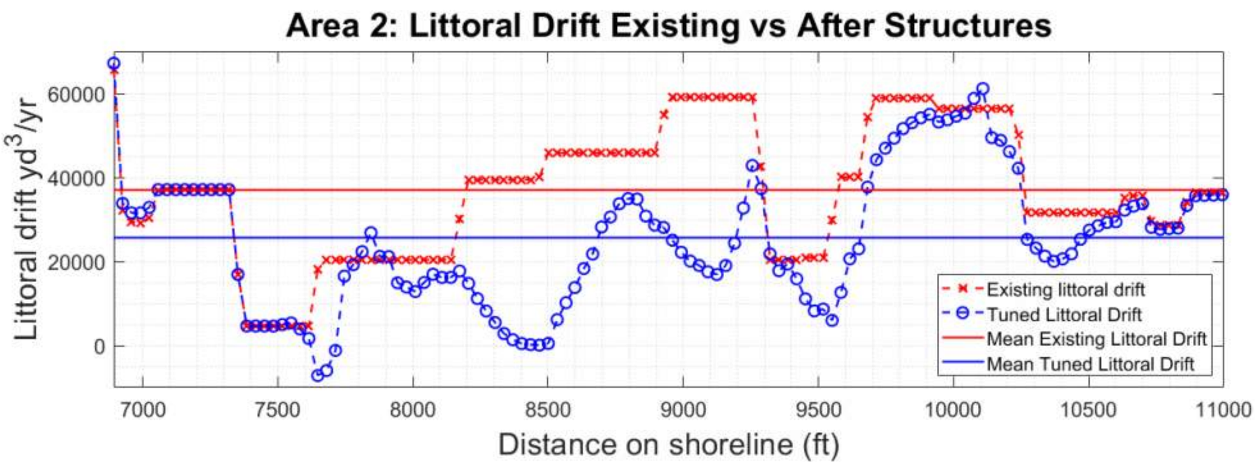

Figure 6: Littoral drift potential of the existing shoreline before and after the installation of structures, Area 2

Area 3 – Swimming Beach

Erosion of this shoreline has required the installation of a riprap revetment north of the recreational beaches to protect the beach walkway. Additionally, beach nourishment has periodically been placed at the swimming beach to protect the parking lot and provide a wider recreational space for visitors. The design for this area consists in 5 offshore breakwaters and a sand nourishment.

Figure 7: Area 3 Proposed Design

The potential littoral drift rates before and after the placement of the structures and the nourishment are shown in **Figure 6**. This graphic shows that the structures in place are slowing down the transport south by approximately 7,000 CY/year.

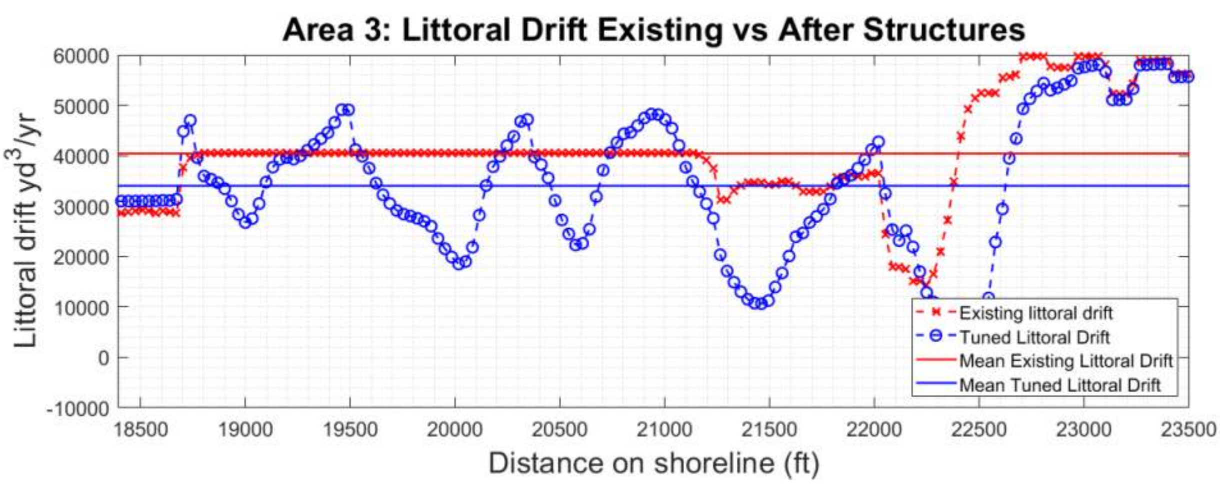

Figure 8: Littoral drift potential of the existing shoreline before and after the installation of structures, Area 3

It's important to note in Figures 4, 6 and 8 that the potential transport rate at the end of the graphic goes back to match the existing littoral drift as the influence of the structures placed does not extend south of the project areas.

Minimization and Compensation

Results show that the structures in place will slow down the overall littoral drift an average of 10,500 CY/year. SmithGroup suggest that this amount be spread out over three years to minimize any effects downdrift.