Harrington Beach State Park-South, Wisconsin

Located in the Town of Belgium, Harrington Beach State Park is a 715-acre unit within the Wisconsin State Park System. Annual visitation is estimated at 125,000, with the heaviest use occurring during the summer. In 2010, Harrington Beach was converted from a day-use only park to an overnight facility, with the construction of a 69-unit campground. Overall, the park has 1.1 miles of beach shoreline, which is divided into north and south sections (Harrington Beach-North and Harrington Beach-South, respectively) by a peninsula near the midpoint. There are no lifeguards and the beaches are not regularly groomed.

Figure 1. *Harrington Beach State Park "South" and "Cedar Road Beach".*

Figure 1 shows the portion of Harrington Beach State Park from the southern boundary at Cedar Road to the mid-point peninsula (approximately 3,300 ft; Harrington Beach-South). The Ozaukee County Public Health Department monitors water quality and collects samples at two fixed stations four days per week (Thursday through Sunday). Officially, the U.S. EPA recognizes the shoreline associated with each of the two stations as separate beaches. The southernmost stretch is known as "Cedar Road Beach". In 2008 through 2009, samples collected from the two stations were composited before being transported to the Port Washington drinking water utility lab for *E. coli* testing using the standard 18-hour, colilert analysis. From a management standpoint, they constituted a single beach. Beginning in 2010, the county resumed its earlier procedure of maintaining and testing separate samples for the two sites.

Harrington Beach-South has seen an increase in advisories and closures in recent years, both in absolute terms, and since the resumption of single sample testing, in comparison to Cedar Road Beach. In 2010, there were 23 posted advisories and four closures at Harrington Beach-South (compared with nine advisories and four closures at Cedar Road). In 2011, there were 20 posted advisories and one closure at Harrington Beach-South (compared with eight advisories and one closure at Cedar Road). Although an intensive sanitary survey has never been conducted at Harrington Beach, the disparity in advisories suggests that there is considerable spatial variation in the sources and pathways of *E. coli* contamination. Routine observation and reporting of beach conditions suggests that water quality is heavily influenced by wave height, wave direction, and the level of Cladophora algae (large fields of which are visible offshore in Figure 1) on the beach and in the water column.

Nowcast Model

The 2012 beach season was the first with a nowcast model at Harrington Beach–South. For most of the season, however, the nowcast was operated in test-mode only as it proved difficult to predict numerous dry weather exceedances. We could not account for these difficulties, but they appeared to be related to high levels of Cladophera, extreme high water temperatures, and observed mass die-offs of mussels, possibly related to the unusually warm water. Eventually, the model was rebuilt to increase its sensitivity to these unusual conditions. Both versions of the model were built by the Wisconsin DNR using *Virtual Beach 2.2*. Beach monitoring staff at the Ozaukee County Public Health Department provided expert guidance and suggestions based on their long-term observations. The finished models were provided as *Virtual Beach* model (.VBMX) files for local operation using the software. The full process of data assembly, model set-up, and model-building, as well as mid-season evaluation and rebuilding, is described in detail in the report *Building Operational "Nowcast" Models for Predicting Water Quality at Five Lake Michigan Beaches*[1].

The 2012 Harrington Beach–South nowcast model was specified as:

LOG10(*Ecoli*) = -1.027 + 0.531*(POLY(*RRAIN120*,1.4356084,-0.011799177,0.00042613486)) + 0.02823*(*RRAIN24*) + 0.487*(SUM(*Turbid_y1_0*,*Opaque_y1_0*)) + 0.2756*(SUM(*AlgBch_mod1_0*,*AlgBch_high1_0*)) + 0.7276*(POLY(*WaveA_comp*(WVHT,WVDIR,15.45),1.3582417,0.11702918,1.917174)) + 0.001636*(SQUARE(*WTEMP*))

Where:

Ecoli = *E. coli* (MPN/ 100mL) — Measured by the Racine Health Dept.
AlgBch_high1_0 = Algae on beach "high"? (y=1/ n=0) — Ozaukee Co. Pub. Health
AlgBch_mod1_0 = Algae on beach "moderate"? (y=1/ n=0) — Ozaukee Co. Pub. Health
Opaque_y1_0 = Water "opaque"? (y=1/ n=0) — Ozaukee Co. Pub. Health
RRAIN24 = Rainfall, 48 hours (mm) — Radar Est. from the North Central River Forecasting Center, NOAA
RRAIN120 = Rainfall, 5 days (mm) — Radar Estimate…. NOAA
Turbid_y1_0 = Water "turbid"? (y=1/ n=0) — Ozaukee Co. Pub. Health
WTEMP = Water Temperature (degrees C) — GLCFS, NOAA

[1] Mednick, A.C. 2012. *Building Operational "Nowcast" Models for Predicting Water Quality at Five Lake Michigan Beaches.* PUB-SS-1098. Bureau of Science Services, Wisconsin Department of Natural Resources, Madison.

WaveA_comp = Alongshore Wind (meters/sec) — Derived from:
Significant Wave Height (meters) — GLCFS, NOAA
Wave Direction (from 0-360 deg.) — GLCFS, NOAA

And where:
LOG10 = logarithm, base 10
INVERSE = $1/X$
POLY = polynomial transformation ($a + bX + cX^2$)
POWER = $X^{1/3}$
PROD = $X1 * X2$
QUADROOT = $X^{1/4}$
SQUARE = X^2
SQUAREROOT = $X^{1/2}$

Nowcast Operation

The Harrington–South nowcast was run alternatively by beach monitoring staff at the Ozaukee County Health Department and staff at the Wisconsin DNR using daily data uploaded to the *Wisconsin Beach Health* website. The process of running the nowcast took the operator five minutes or less, on top of routine beach monitoring and public notification activities. Nowcast model runs were conducted after monitoring personnel returned to the health department office from collecting water samples and taking routine sanitary survey measurements at the beach (Figure 2). Routine sampling and sanitary surveys took place around 06:00 a.m.

Figure 2. *Beach conditions entered on a routine sanitary survey form.*

The nearshore water at Harrington Beach-South was classified subjectively as “clear,” “somewhat turbid,” “turbid,” or “opaque,” following the routine sanitary survey protocol. On most days, however, beach monitoring personnel also used a turbidity tube (Figure 3) to derive a simple quantitative measure of water clarity (i.e. centimeters of visibility). This measure will likely be used in place of the subjective categories in future nowcasts.

Figure 3. *Using a turbidity tube to measure water clarity.*

The procedure for running the model was for the operator to first access and download "automated" data inputs via the U.S. Geological Survey's *Environmental Data Discovery and Transformation* (ENDDAT) system [2] using a custom ENDDAT web URL developed by Wisconsin DNR staff. Launching the URL downloads a one-row table of the most recent values of several model inputs, including: *WTEMP* (water temperature in degrees C), *RRAIN24*, and *RRAIN120* (millimeters of rain estimated by radar over the past 24 and 120 hours), *Significant Wave Height* (meters), and *Direction* (0-360 degrees). Next, the operator opened the *Virtual Beach* model (.VBMX) file and imported the daily ENDDAT table into the MLR Prediction tab, leaving the operator to manually-enter *AlgBch_high1_0* (algae on beach "high" [1] or not [0]), *AlgBch_moderate1_0* (algae on beach "moderate" [1] or not [0]), *Turnbid_y1_0* (water "turbid" [1] or not [0]), and *Opaque_y1_0* (water "opaque" [1] or not [0]). Once all of the input values were entered, the operator executed the model to make a prediction (Figure 4).

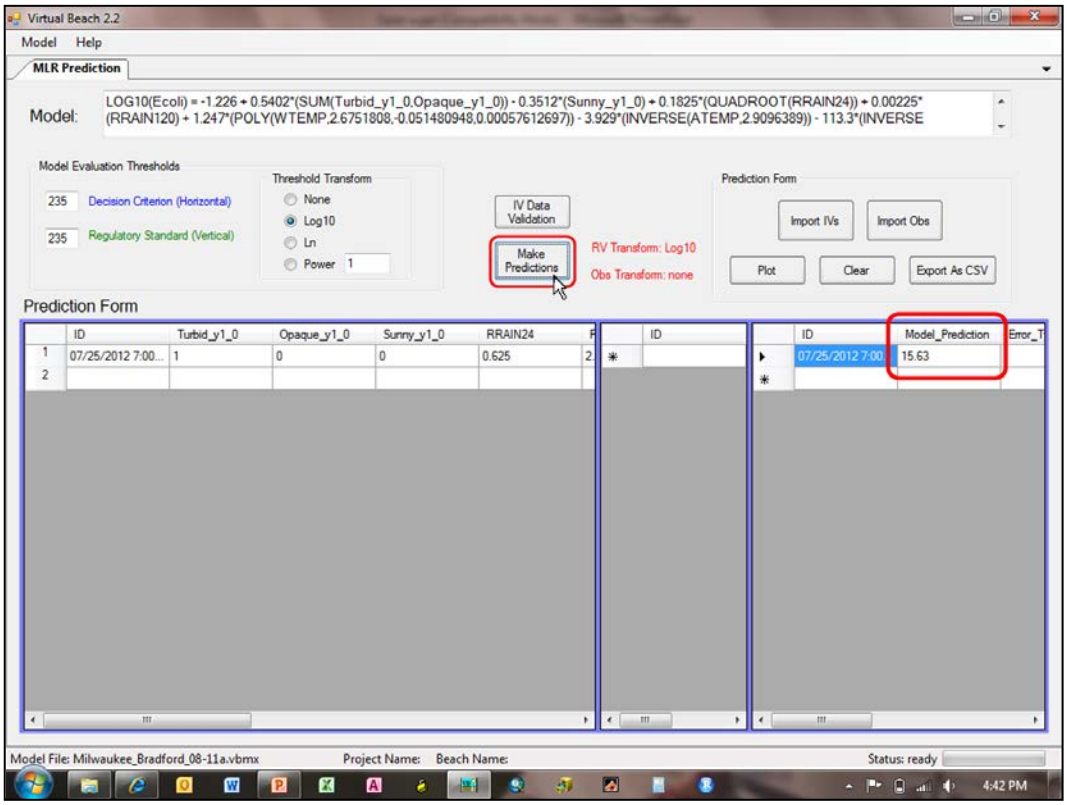

Figure D4. Virtual Beach – Making a Prediction

Outputs of the nowcast model included both the estimated concentration of *E. coli* and the statistical probability of exceeding the 235 CFU/100 mL water-quality standard. As discussed above, the revised nowcast model for Harrington Beach-South did not become operational until the final week of the 2012 beach season. Applied retroactively over the full season, the model proved to be 76% accurate in predicting water-quality exceedances and non-exceedances, compared to 72% for the "persistence method" (i.e. the previous day's lab results).

[2] http://cida.usgs.gov/enddat/

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Bureau of Science Services
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707-7921

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Author: Adam C. Mednick
Editor: Dreux J. Watermolen

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