CENTER OF EXCELLENCE FOR GREAT LAKES AND HUMAN HEALTH

# Fifth Annual Water Quality Forum
# Ottawa County Michigan November 1, 2010


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Michigan Dept. of Natural Resources and the Environment

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Wisconsin Dept. of Natural Resources


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Sea Grant Michigan

Michigan DNRE

WISCONSIN DEPT. OF NATURAL RESOURCES

# Ottawa County Beach Forecasting Model Talk Outline

1. Status of Beach Water Quality Forecasting
2. Need for Statistical Models
3. Deterministic Models
4. Combined Forecast Models
5. Future Plans Beach Water Quality Forecasting

# •Federal Collaboration on
# •Beach Health in the Great Lakes


**Remediation, Decision Support, & Environmental Research**

**•BEACH HEALTH INTERAGENCY**
**•COORDINATION TEAM**

**•Beach Water Quality**
**•Forecasting**
**•Coordinator**


**Operational Forecasting & Research**


**Monitoring & Modeling Research**

# NOAA'S Oceans and Human Health Initiative's Goal

- **Lead the development of early warning systems**
- **Forecast threats**
- **Predict long-term risks to human health throughout U.S. coastal and Great Lakes waters.**

# *USGS* Ocean Research Priority Plan

- **Science-based information**
- **Methods for beach water closure  advisory decisions**
- **Source tracking**
- **Understanding physical processes affecting beach contaminants**
- **Mitigate bacterial contamination restoring beach water quality to protect the public.**

# USEPA's Great Lakes Healthy Communities and Ecosystems Goal 4.3.3

**Protect, sustain, or restore the health of people, communities, and ecosystems using integrated comprehensive approaches and partnerships.**

- Decision Support Systems for Beach Water Quality Management
- Being Applied in Many Geographical Areas
- Using USEPA GLRI Funding


- **Red Flags NOAA** **Blue Push Pins NOAA-NWS – CEGLHH/CILER**
- **Green Flags USGS** **Orange Push Pins NOAA-GLERL – CEGLHH/CILER**
- **Yellow Light Bulbs USEPA**
- **Yellow Pins WDNR Nowcast Models Using EPA's Virtual Beach Software**

# Forecast Decision Support Systems

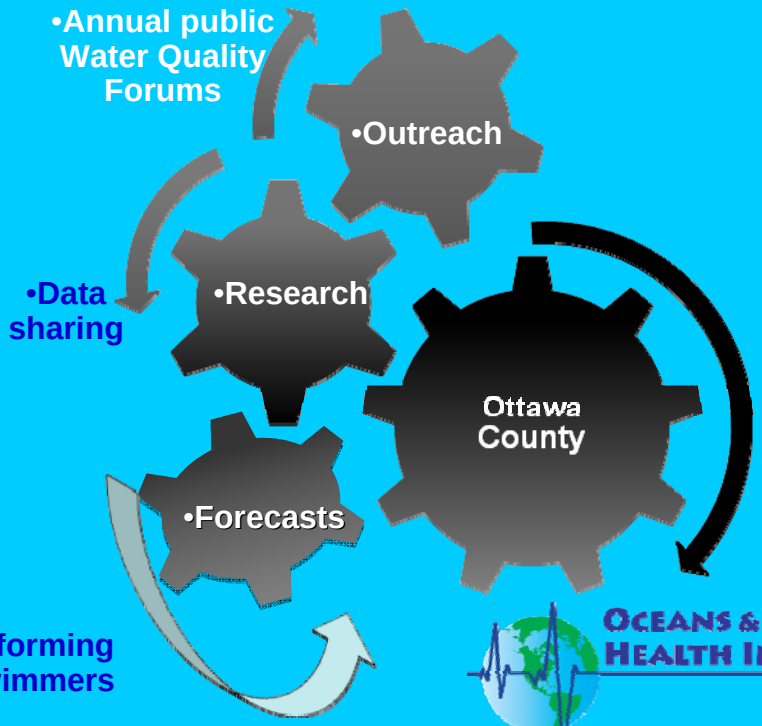
## Grand Haven Beach Forecast Development Partnership

CEGLHH
NOAA Center of Excellence for Great Lakes and Human Health

•Ottawa County Health Department

Great Lakes Beach Association

Coastal Western Michigan

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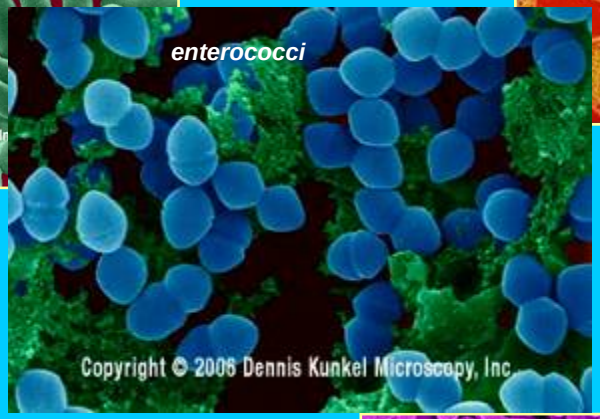
NATIONAL WEATHER SERVICE

CEGLHH
NOAA Center of Excellence for Great Lakes and Human Health

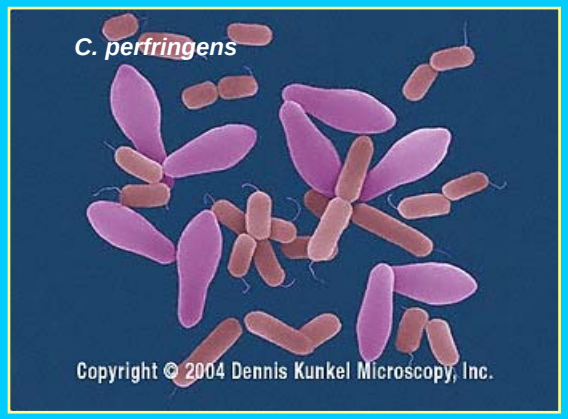
# Recreational Water Illness

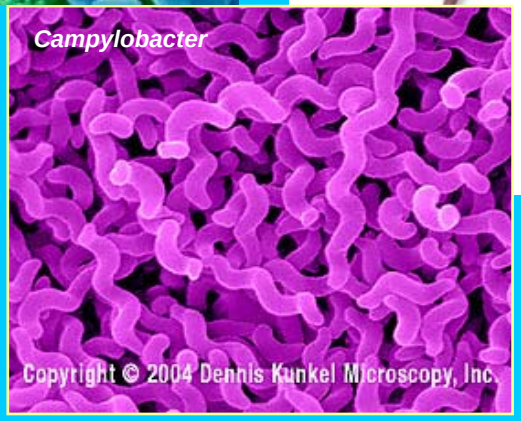







Michigan DNRE Department of NATURAL RESOURCES and ENVIRONMENT




The National Park Service


WARNING
•WATER WAS BAD YESTERDAY
•DON'T KNOW ABOUT TODAY
•COME BACK TOMORROW


•THE NEXT DAY
•IF YOU SWAM YESTERDAY,
•YOU'RE OKAY, WATER WAS FINE!
•TODAY "PROBABLY" OKAY TOO
•BUT - WE WON'T SAMPLE AGAIN
•UNTIL NEXT WEEK

# ‘Persistence’ Model

- Standard monitoring approach
  - Collect/ transport water quality samples
  - 18-24 hour lab analysis
- Often not reflective of current conditions
  - Type I Errors (false exceedance)
  - Type II (false non-exceedance)

**Quanti-tray enumeration**

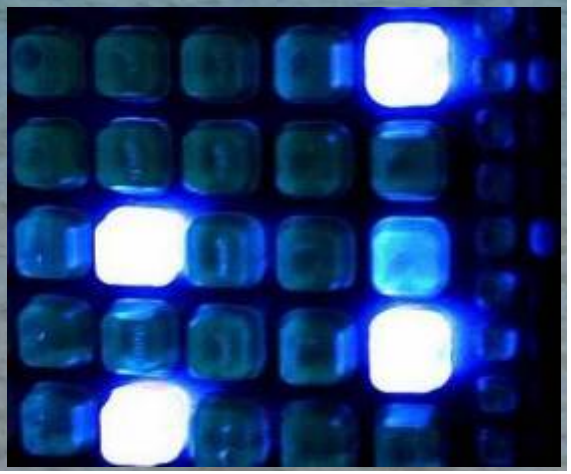
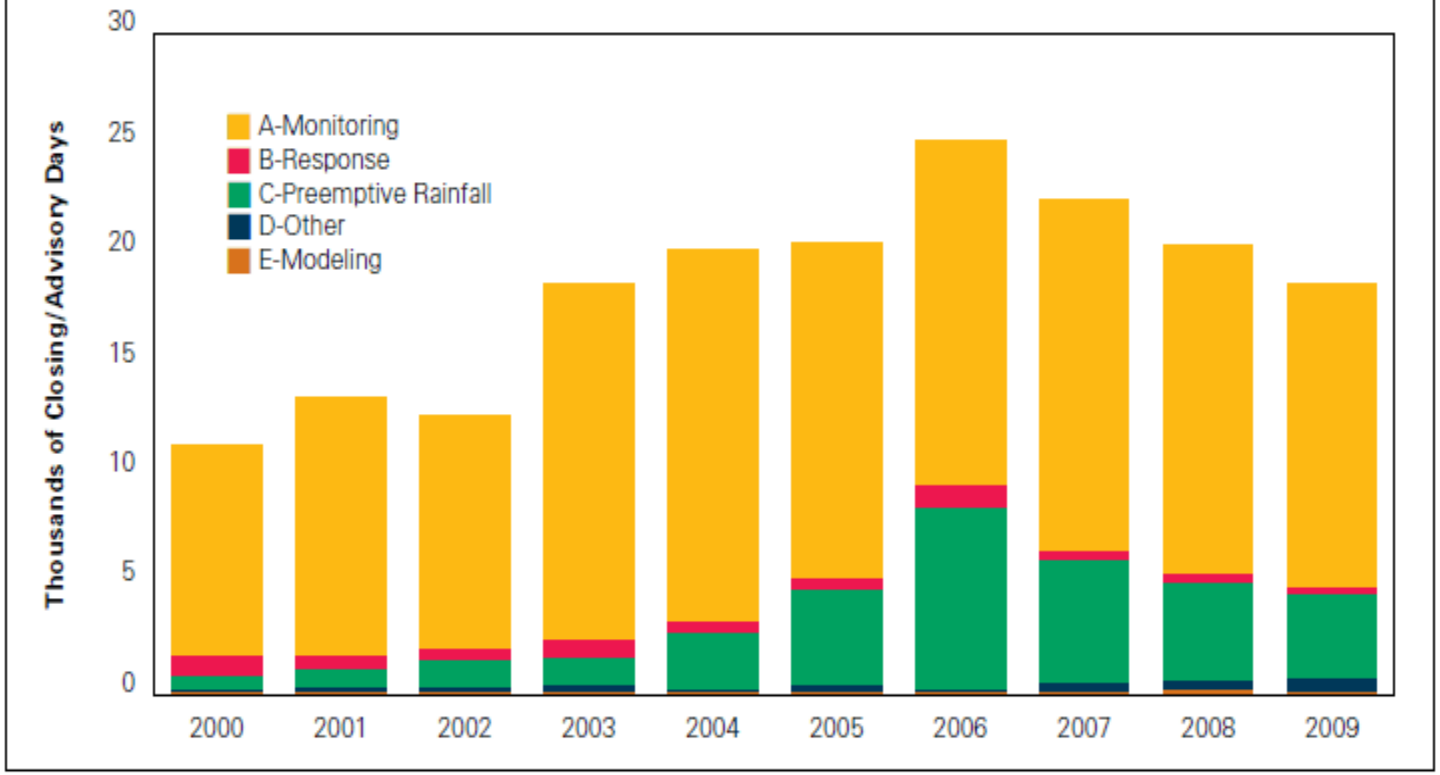


**Figure N-5. Reported Reasons for Closings/Advisories, 2000–2009**




**Key:** (A) Based on monitoring that detected bacteria levels exceeding standards. (B) In response to known pollution event without relying on monitoring. (C) Preemptive due to rain known to carry pollution to swimming waters. (D) Other reason. (E) Real-time, predictive computer modeling.

# Rainfall Models

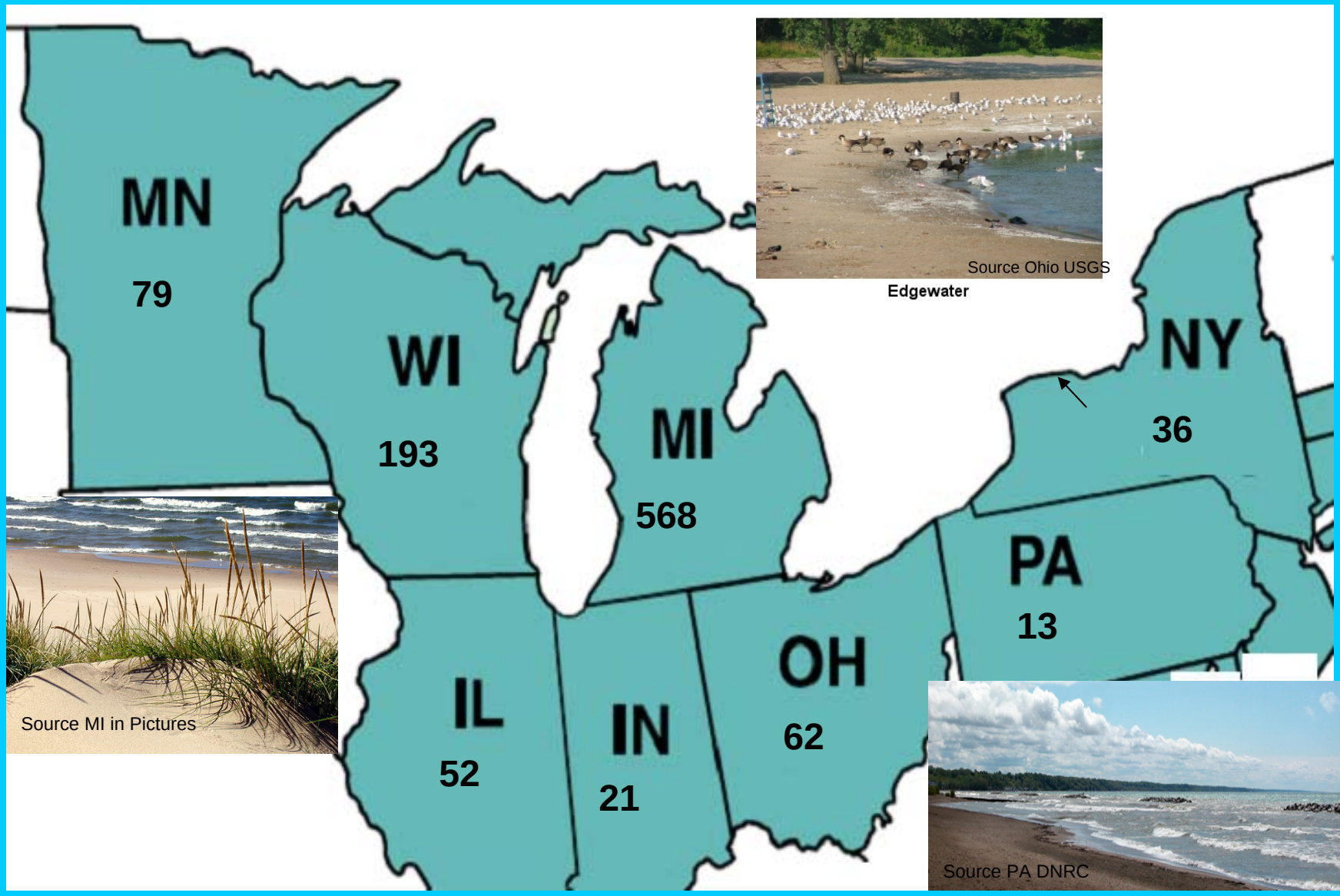
- Advisories posted after significant- or threshold rainfall events
  - Often not reflective of *E. coli* concentrations
  - Sampson, R.W., et al. 2006. "The effects of rainfall on *Escherichia coli* and total coliform levels at 15 Lake Superior recreational beaches." *Water Resources Management* 20: 151-159.

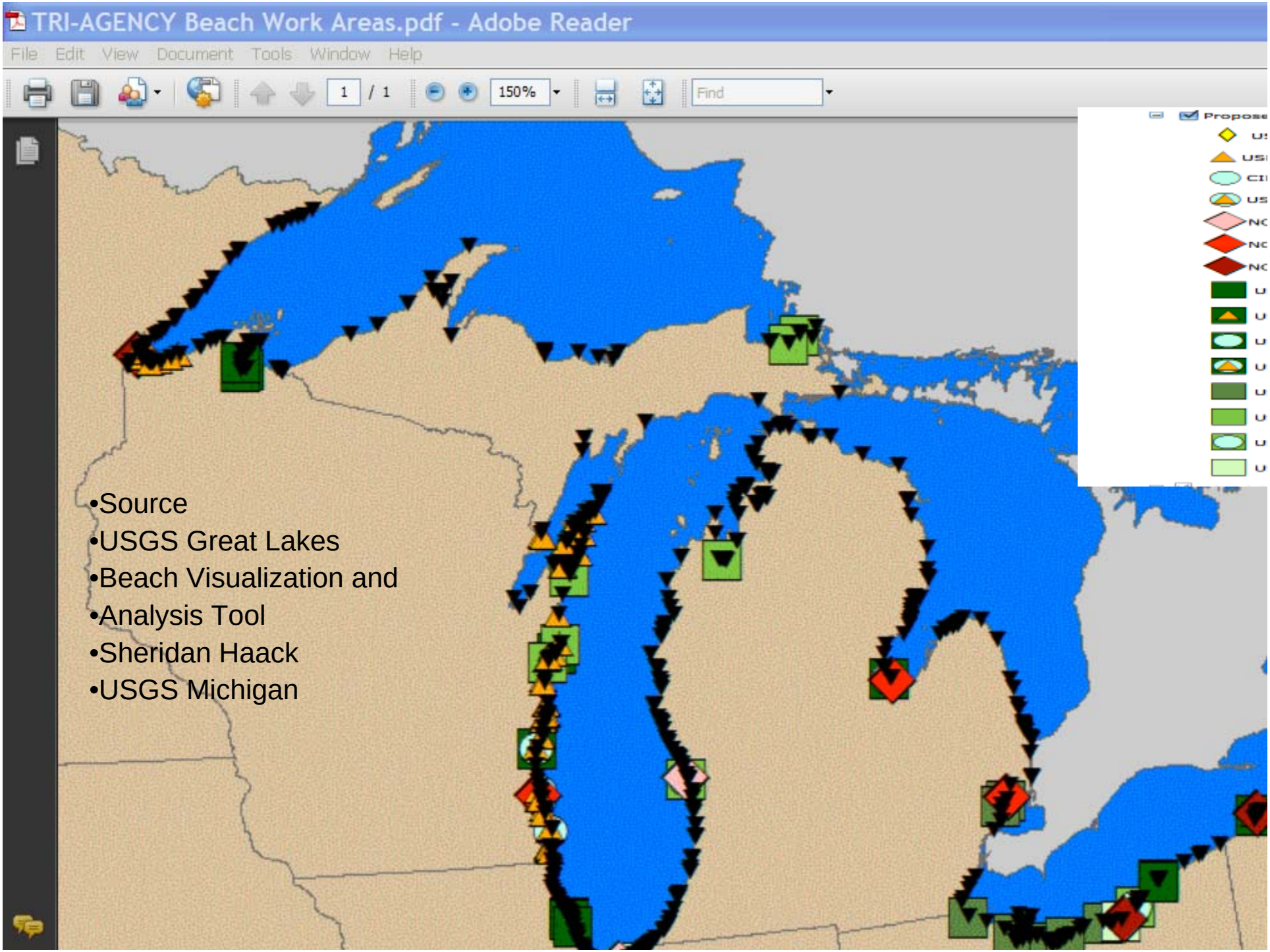
# The Public Demands Action!

Michigan DNRE Department of NATURAL RESOURCES and ENVIRONMENT

# Protect Swimmer Health

# Great Lakes Beach Act  Beaches




TRI-AGENCY Beach Work Areas.pdf - Adobe Reader
File Edit View Document Tools Window Help
1 / 1
150%
Find
•Source
•USGS Great Lakes
•Beach Visualization and
•Analysis Tool
•Sheridan Haack
•USGS Michigan

www.deq.state.mi.us/beach/

Yahoo! Search

rites Tools Help

beach guard

ystem - Home

Page Safet

rtment of Environmental Quality

Michigan.gov

Home | Michigan.gov Home | Search | RSS | About | Log In

BeachGuard System. Select a county from the map below to see beach information for that county.
the search box in the navigation bar to find by beach or waterbody by name.

visories are displayed above

## Michigan Beaches

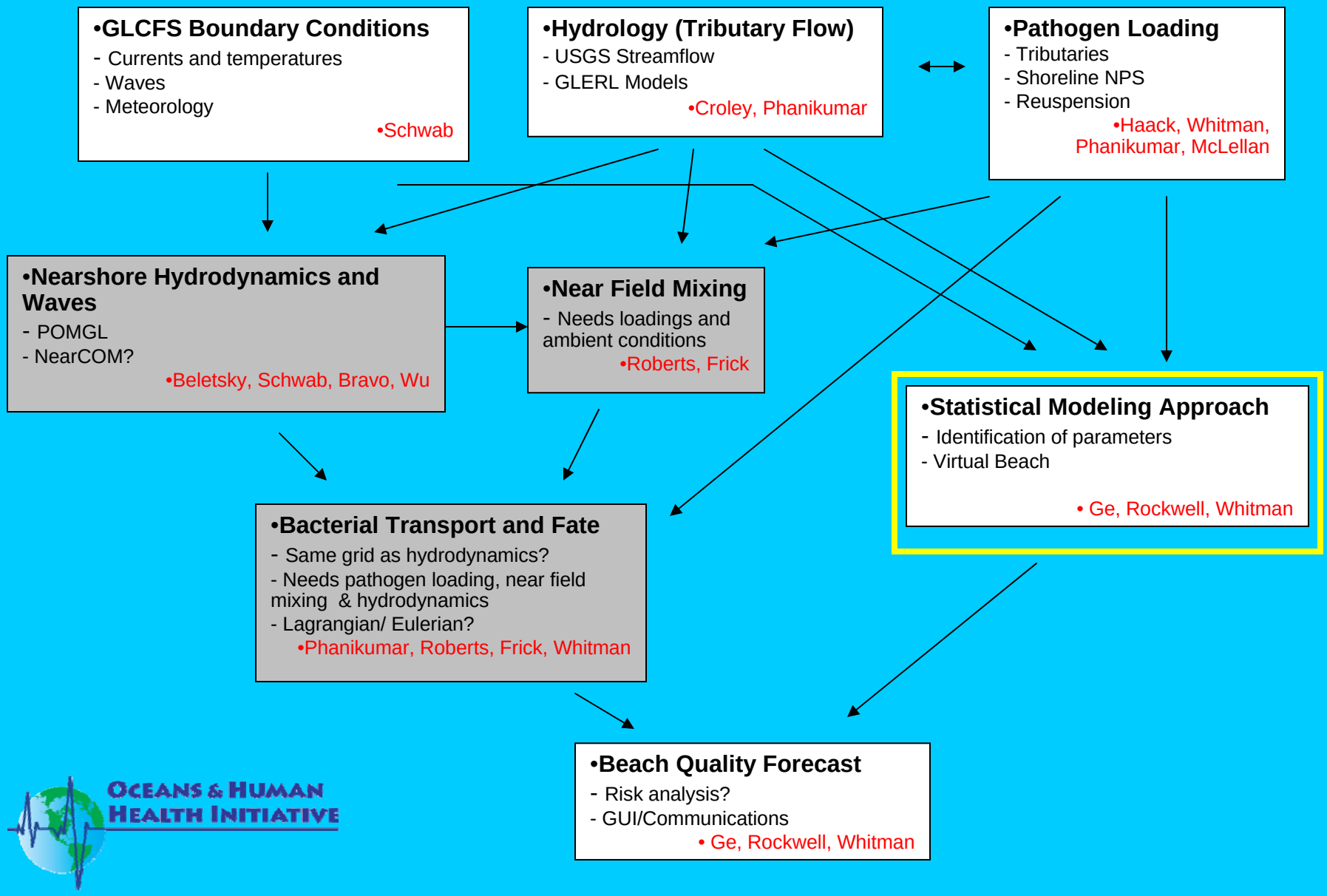
1197 Public Beaches

473 Private Beaches

2 Closures and Advisories

| Waterbody and Location Name | County |
|---|---|
| St. Mary's River - Sugar Island Township Park | Chippewa |
| Lake Huron - Cheboygan State Park Duncan Bay | Cheboygan |

# •Statistical Beach Quality Modeling Approach

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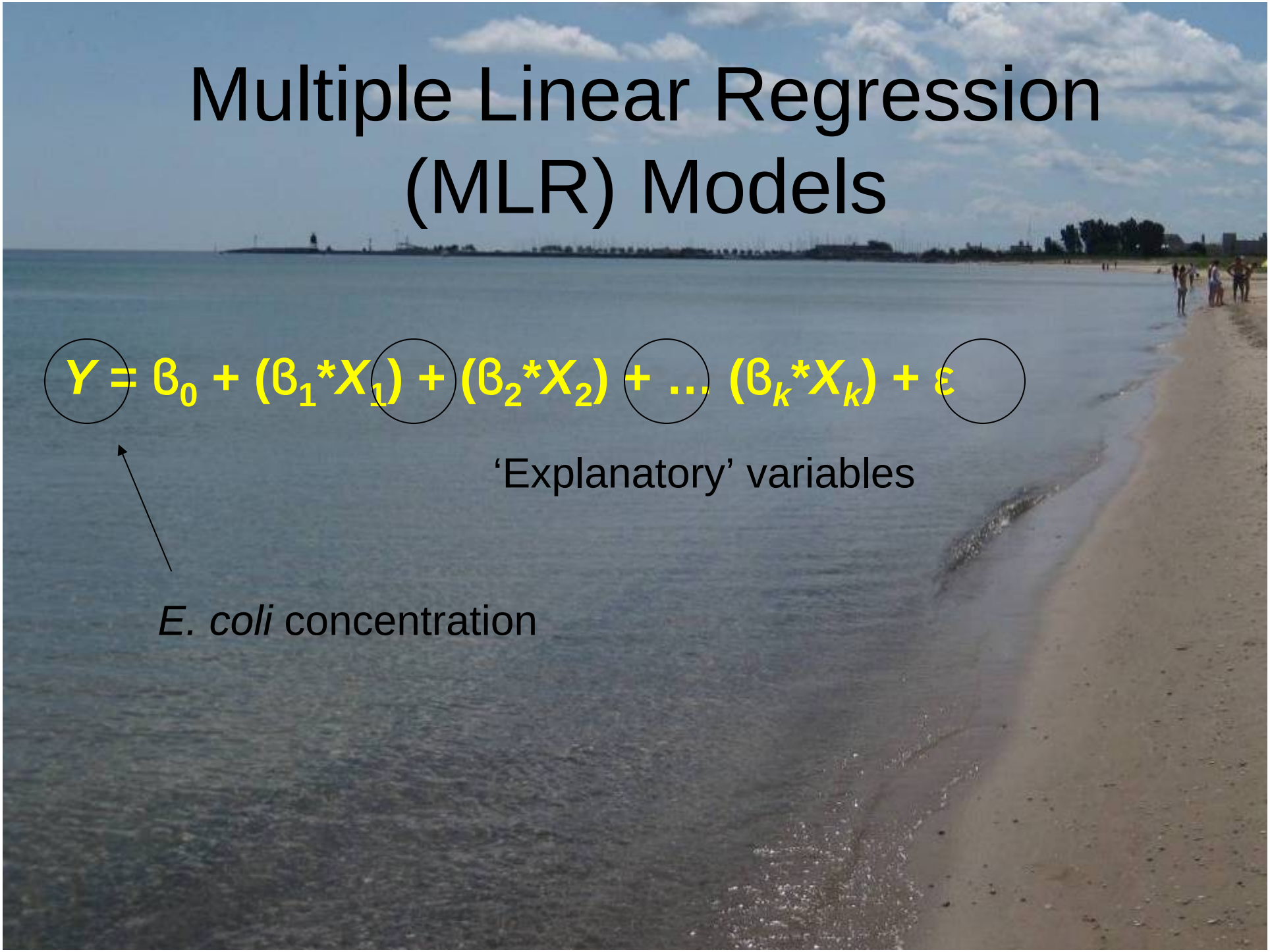
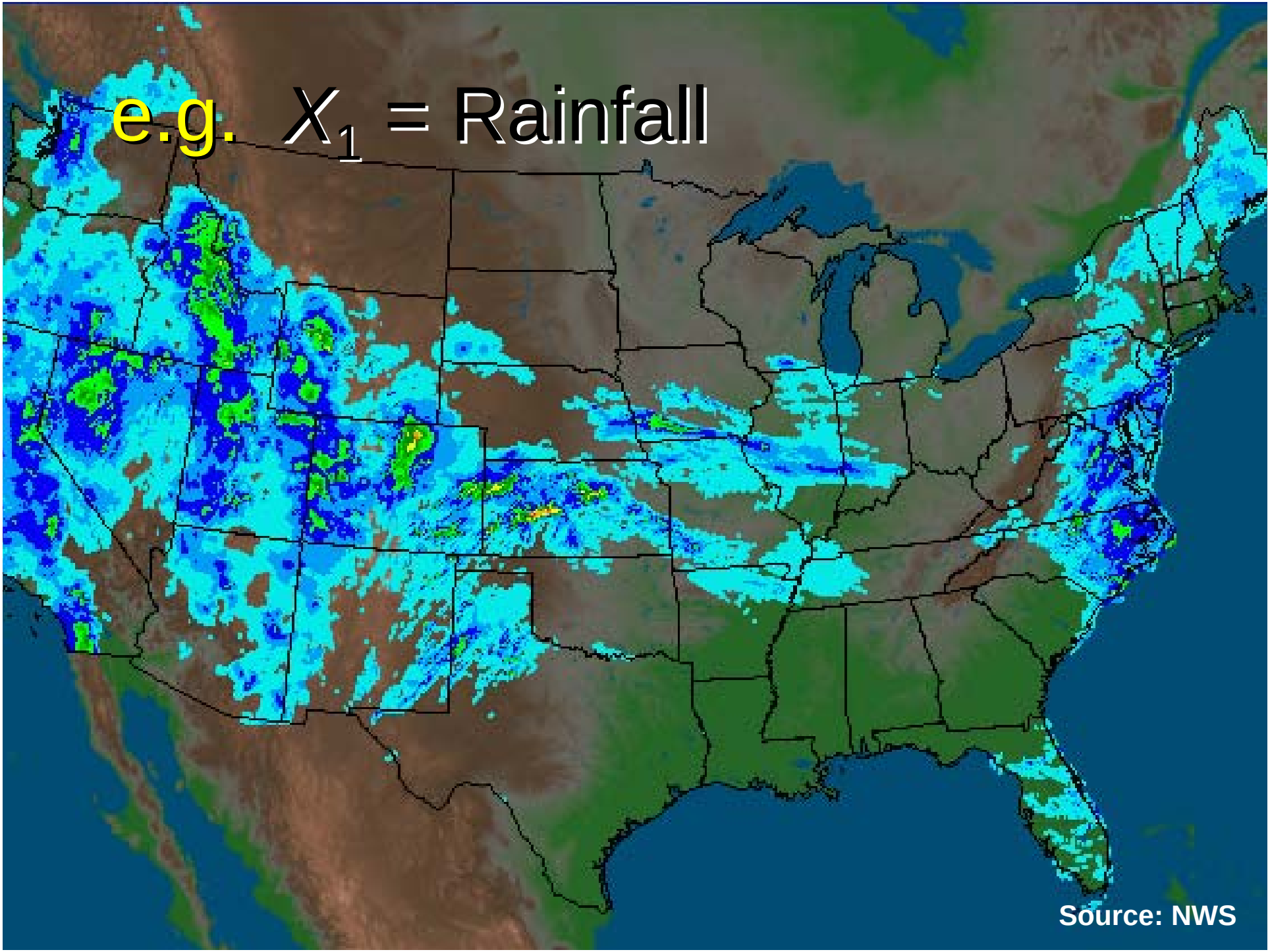
# Multiple Linear Regression (MLR) Models



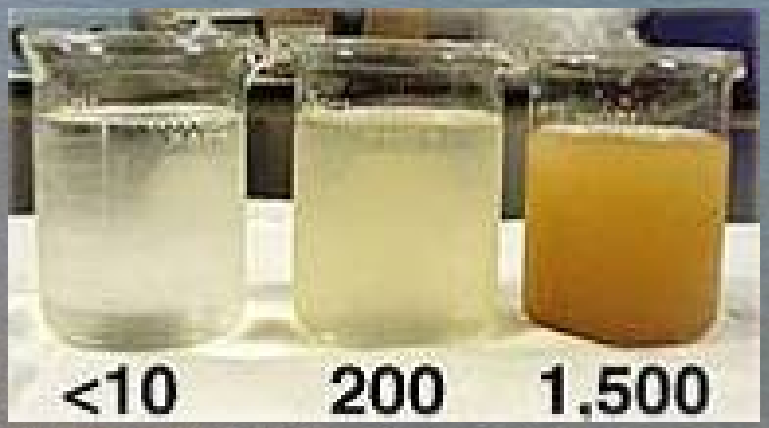
$$Y = \beta_0 + (\beta_1 * X_1) + (\beta_2 * X_2) + \ldots (\beta_k * X_k) + \varepsilon$$

'Explanatory' variables

*E. coli* concentration


e.g. $X_1$ = Rainfall
Source: NWS

# $X_2$ = Turbidity (NTU)

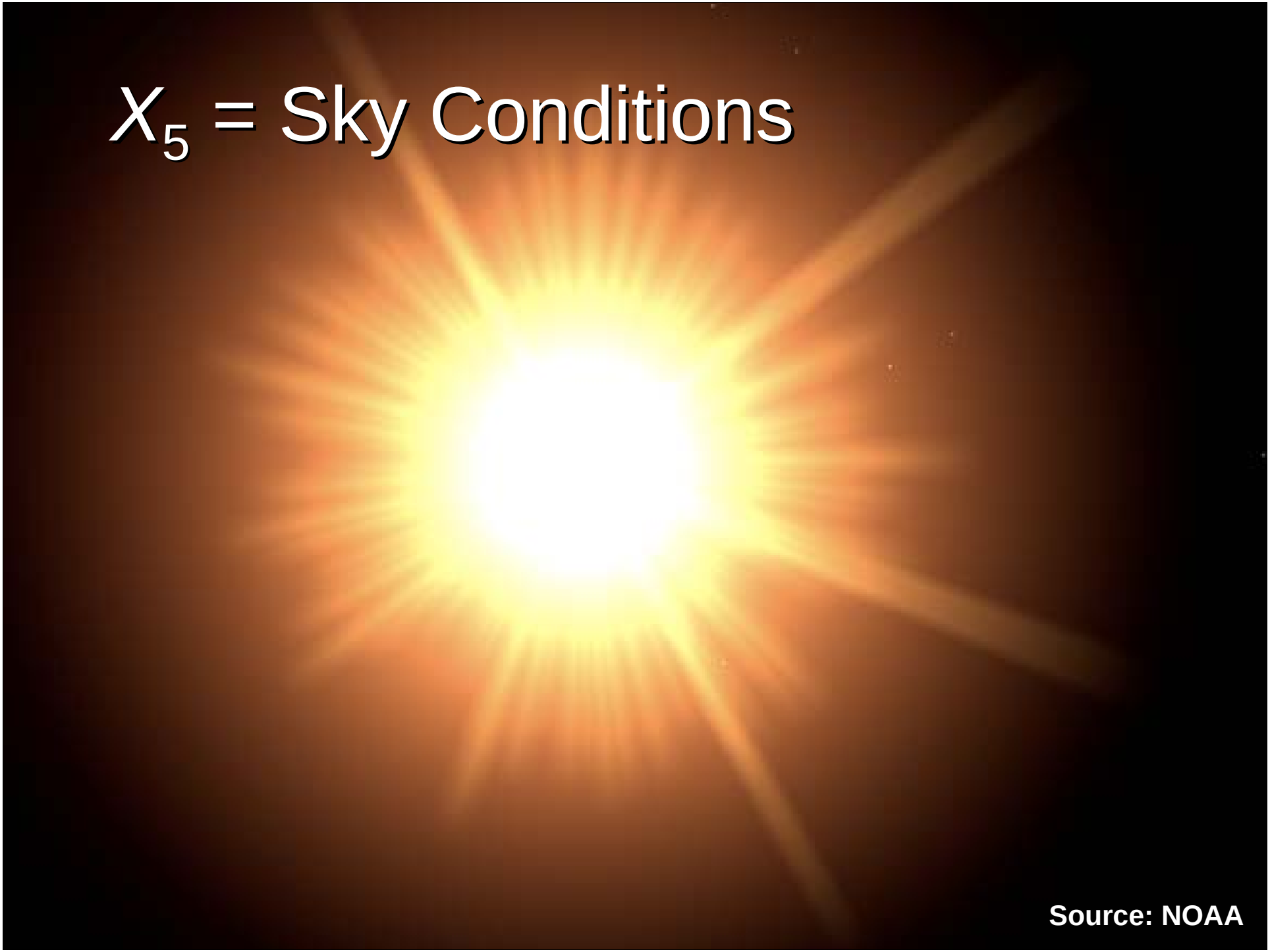


# $X_3$ = Wave Height

Source: USGS Ohio Water Science Center


$X_4$ = Stream Flow

# $X_5$ = Sky Conditions



Source: NOAA

# $X_6$ = Wind Speed*Direction

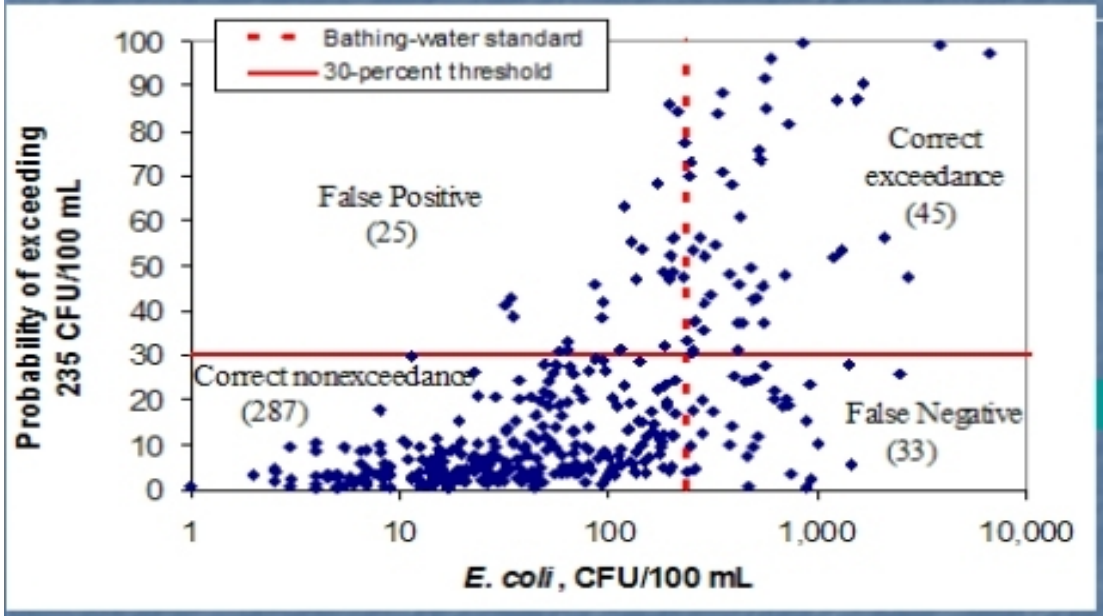
Source: NOAA

# Where are MLR models used?

- Research Sites
  - MLR models have been developed for R&D and Sanitary Survey purposes at a number of sites around the Great Lakes
- **Operational** Nowcasts
  - Only **9 beaches** have used MLR models as the basis for swim advisories --


The nowcast at Edgewater, Cleveland, OH.


The nowcast at Huntington, Bay Village, OH.




| Probability | Total correct | False + | False - |
|---|---|---|---|
| 37 | 332 | 20 | 38 |
| 36 | 332 | 20 | 38 |
| 35 | 333 | 20 | 37 |
| 34 | 333 | 20 | 37 |
| 33 | 334 | 20 | 36 |
| 32 | 333 | 21 | 36 |
| 31 | 332 | 24 | 34 |
| **30** | 332 | 25 | 33 |
| 29 | 330 | 27 | 33 |
| 28 | 327 | 30 | 32 |
| 27 | 327 | 32 | 31 |
| 26 | 323 | 35 | 31 |
| 25 | 324 | 37 | 29 |

30-percent threshold

Determining the threshold probability as 30%, Huntington model 2000–06. Thresholds are determined as part of determining model output variables.

# Predictive Modeling

- Refine and evaluate procedures for building water quality models used for notification and advisories/closures
- Virtual Beach Software for Statistical Modeling

- **Model Builder** for developing multiple linear regression models for indicator prediction and
- **Beach Advisor for** providing user friendly beach advisory decision support for non technical users

Virtual Beach Model Builder 10:23 14:22 YOUR-A9279112E3 Administrator ScreenHunter

General | Empirical Model

# Virtual Beach

***Disclaimer:***

This software has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

build

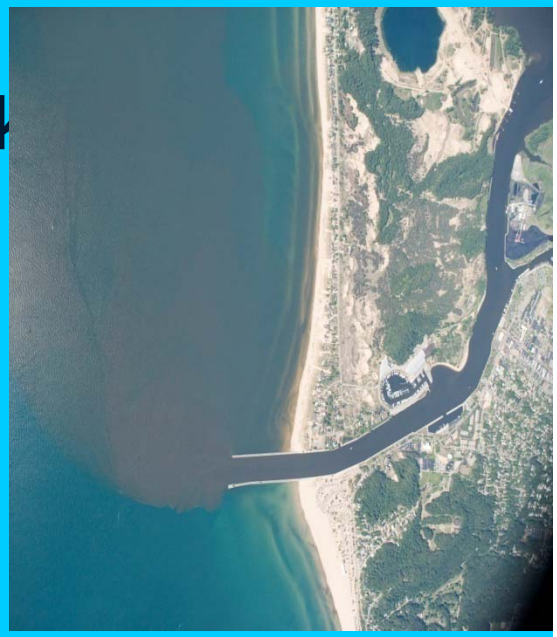
# NOAA Center of Excellence for Great Lakes and Human Health

- Develop sustainable forecasting tools to minimize risk to human health in coastal environments.
- Identify sources and causes

- Water Quality
- Beach closures
- Harmful Algal Blooms

# Beach Forecasting Research

- Influence of winds and waves on fate and transport of pollutants
- Grand River: largest tributary of LK Michigan
  - Study Location- Grand Haven area, Michigan
- Agricultural and urban loadings
- Recreational river
- Beaches along shoreline



Grand River

# NOAA develops Great Lakes algal bloom forecasts

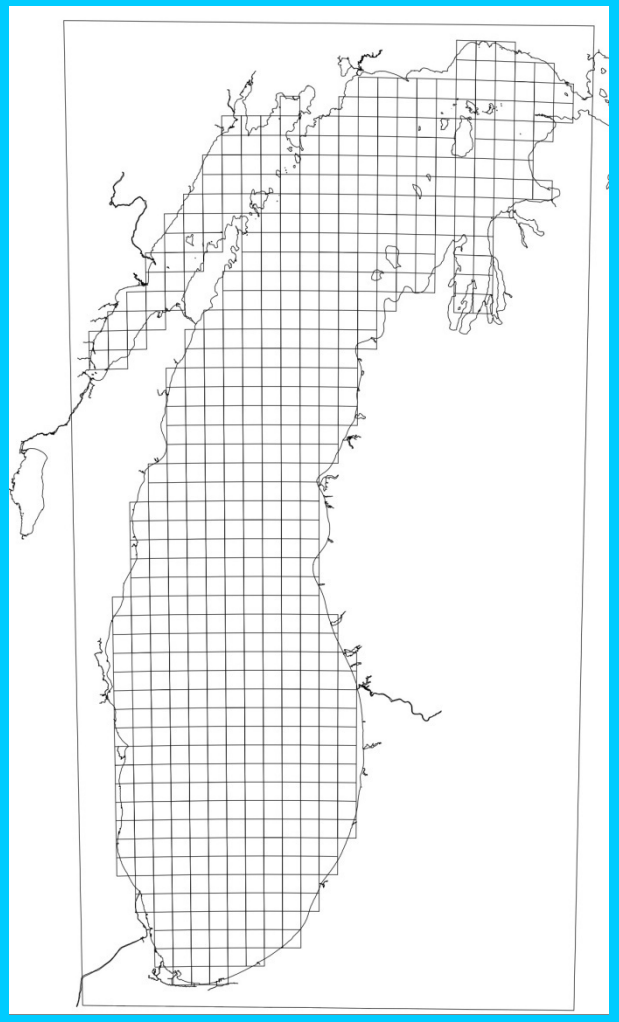
TRAVERSE CITY, Mich. - An experimental system that uses satellite data and computer modeling will help forecast the direction and intensity of ugly, smelly algae blobs in the Great Lakes.

Chicago Tribune 9/17/2009.

# Factors Affecting Lake Circulation

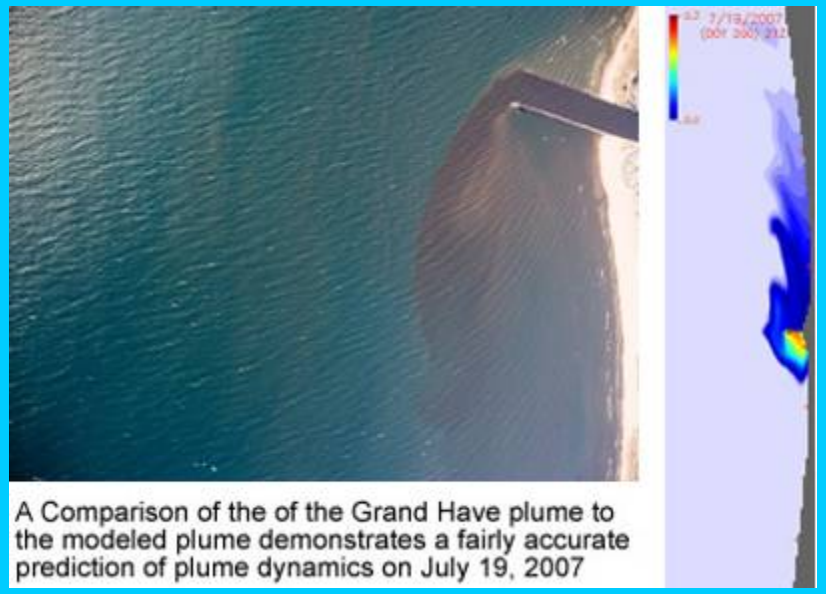
- Wind stress
- Bottom topography
- Earth's rotation
- Temperature gradients

•Numerical Model



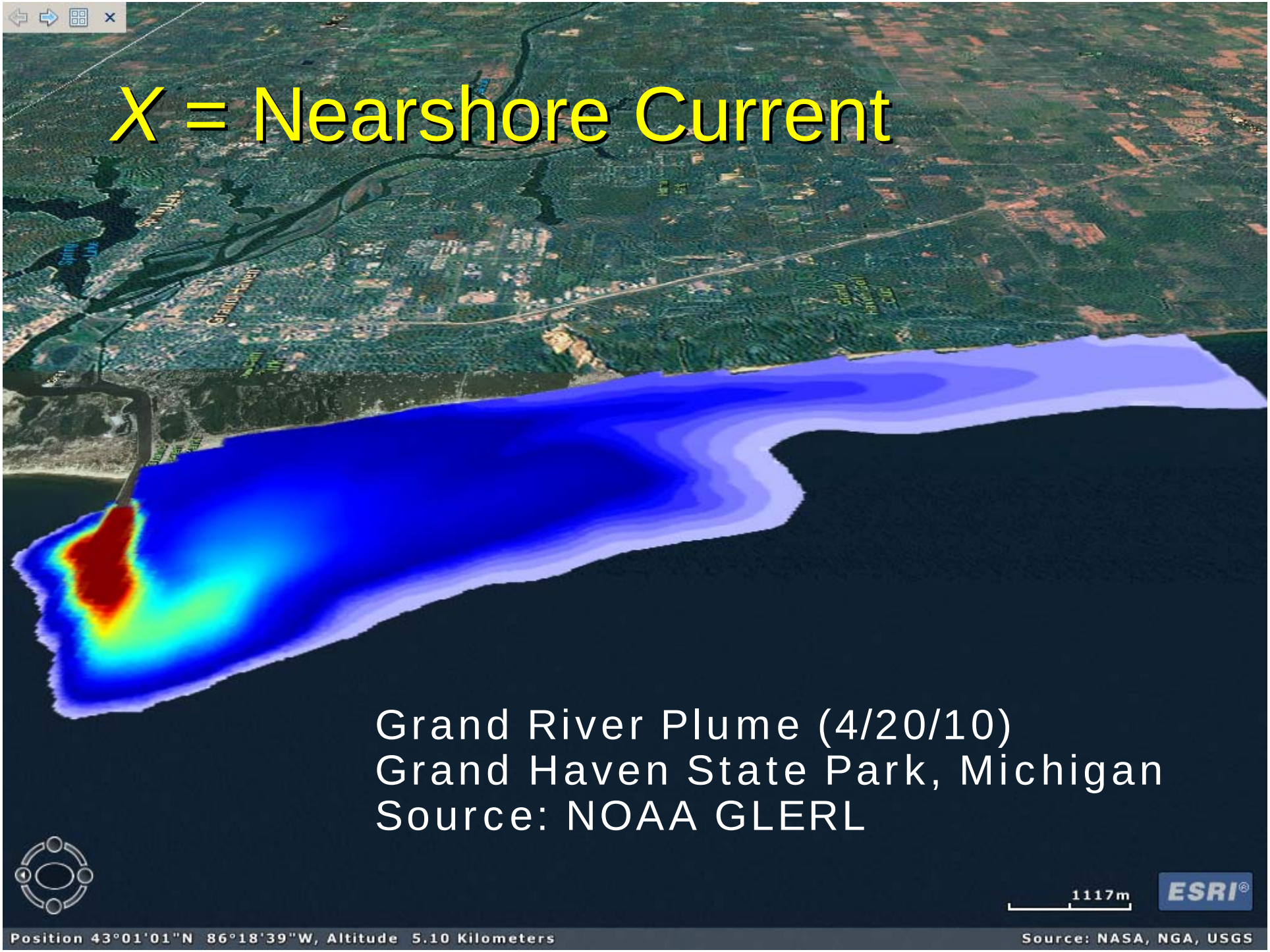
# Hydrodynamic Models

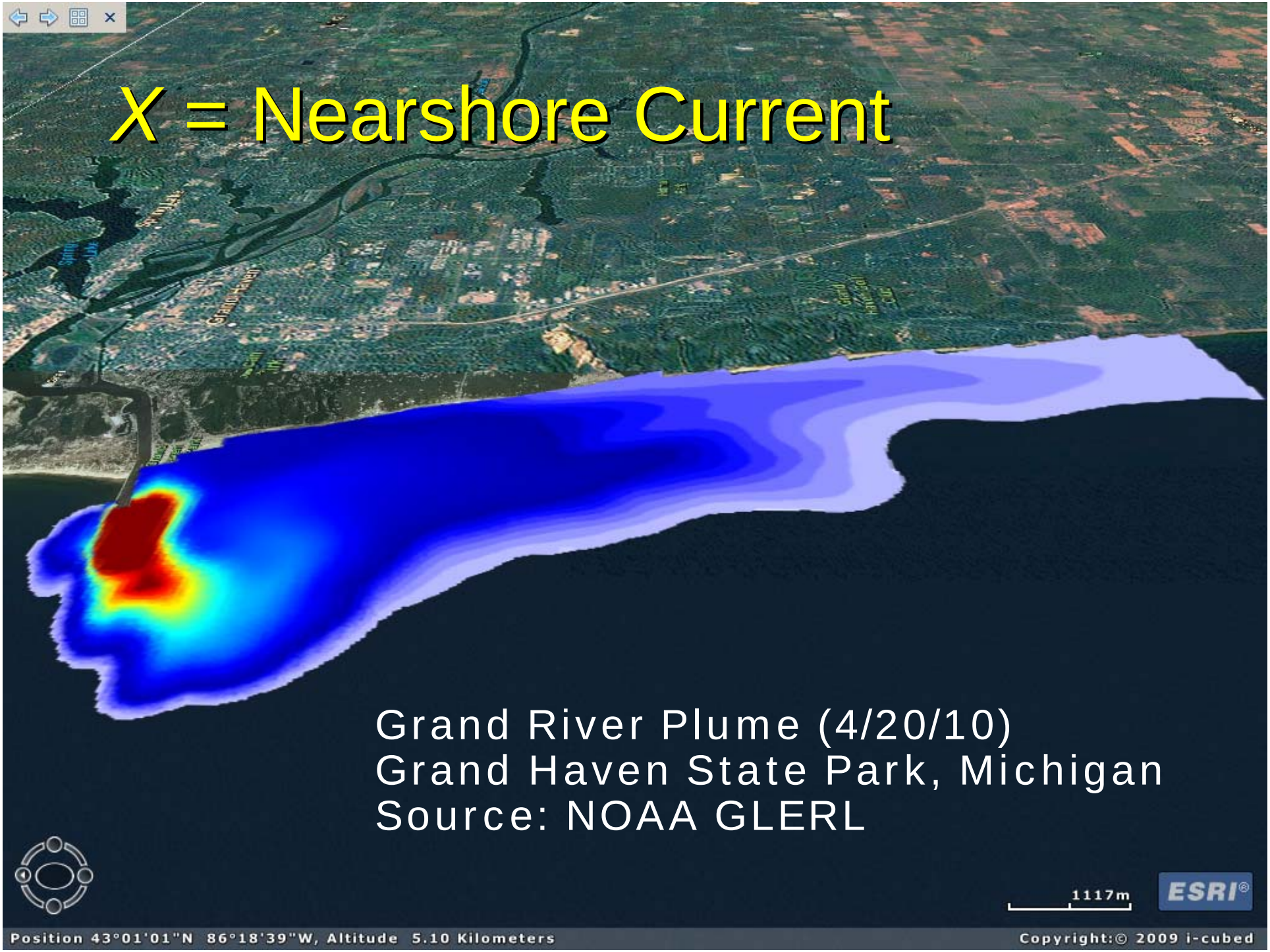
- Three-dimensional models of nearshore flow and *E. coli* transport
- Process-based, deterministic
  - Computationally expensive



A Comparison of the of the Grand Have plume to the modeled plume demonstrates a fairly accurate prediction of plume dynamics on July 19, 2007

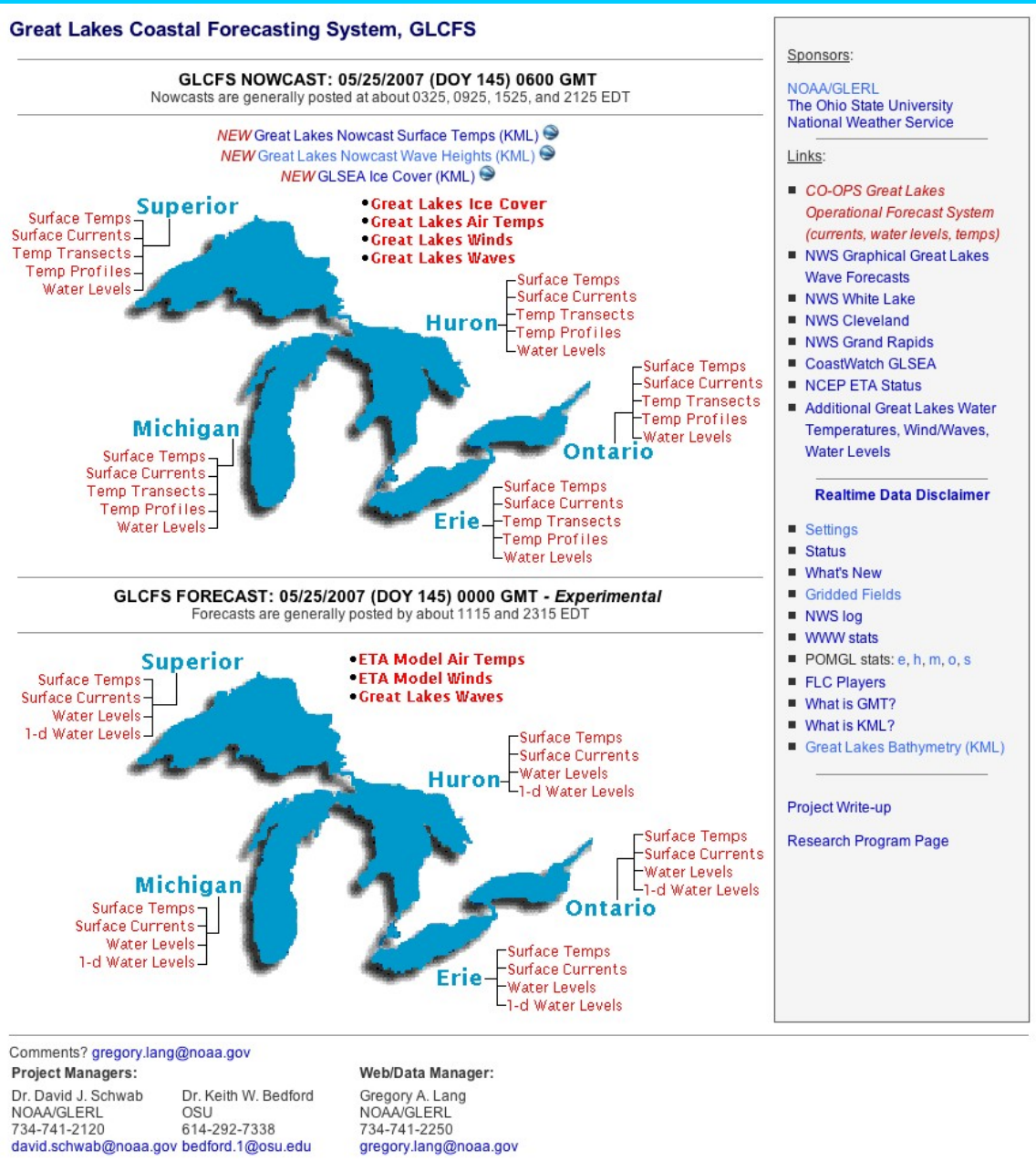
Source: NOAA GLERL


X = Nearshore Current
Grand River Plume (4/20/10)
Grand Haven State Park, Michigan
Source: NOAA GLERL
1117m
ESRI
Position 43°01'01"N 86°18'39"W, Altitude 5.10 Kilometers
Source: NASA, NGA, USGS


X = Nearshore Current
Grand River Plume (4/20/10)
Grand Haven State Park, Michigan
Source: NOAA GLERL
1117m
ESRI
Position 43°01'01"N 86°18'39"W, Altitude 5.10 Kilometers
Copyright:© 2009 i-cubed


Grand Haven, MI
Milwaukee, WI
Indiana Dunes, IN
151
43
894
794
14
41
290
294
355
88
55
90
34
45
57
52
30
65
231
196
35
31
131
421
33

# •Great Lakes Coastal Forecasting System: www.glerl.noaa.gov/res/glcfs




- Five separate models based on POM with 2-5 km horizontal resolution and 20 sigma layers

- Provides nowcasts and forecasts of water level, currents, temperature, and waves (GL wave model)

- Runs automatically 4 times per day for nowcasts, 2 times per day for forecasts (out to 60 hrs)

Publications
Information Sheets
Photo Gallery
Technology Development
GLERL Library
Vessels
Water Levels
Web Cams
Meteorological Data

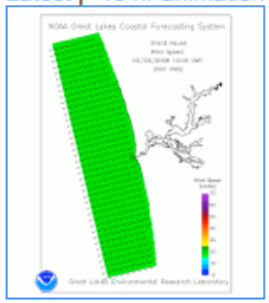
# Grand Haven Area Nowcast

Check out Grand River Plume: Aerial Photos vs Model Simulation (updated Jul 20, 2007)
See also Forecast

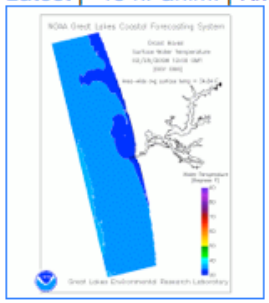
**Timestamp: 02/25/2008 (DOY 056) 12:00 GMT**

The products on this page are updated 4x per day at about 0345, 0945, 1545, and 2145 EDT

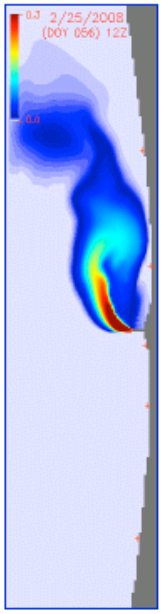
Winds:
Latest | -48 hr animation



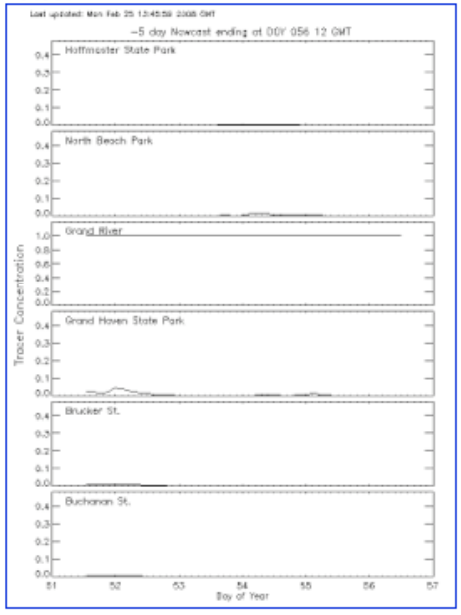
Surface Water Temps:
Latest | -48 hr anim. | KML



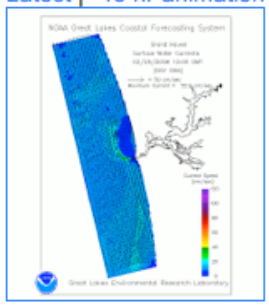
Tracer Concentration:
Latest | -5 day anim. | KML



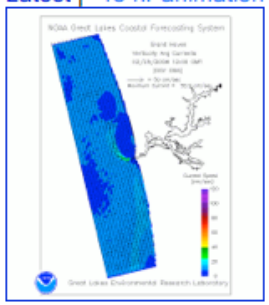

Timeseries at Beaches:
Latest




Surface Currents:
Latest | -48 hr animation



Vertically Avg Currents:
Latest | -48 hr animation



See also: grid1 | grid2 | grid3 (KML)
Bathymetry: jpg | KML  Beach Locations: jpg | KML

Sponsors:

NOAA/GLERL
NOAA CEGLHH

Links:

- GLCFS
- USGS Grand River Realtime Obs

Log
bc_stats
pomgl_stats
Notes
FLC Players
What is GMT?
What is KML?

Project Write-up

Research Program Page

Comments? gregory.lang@noaa.gov

**Project Managers:**

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CILER
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**Web/Data Manager:**

Gregory A. Lang
NOAA/GLERL
734-741-2250
gregory.lang@noaa.gov

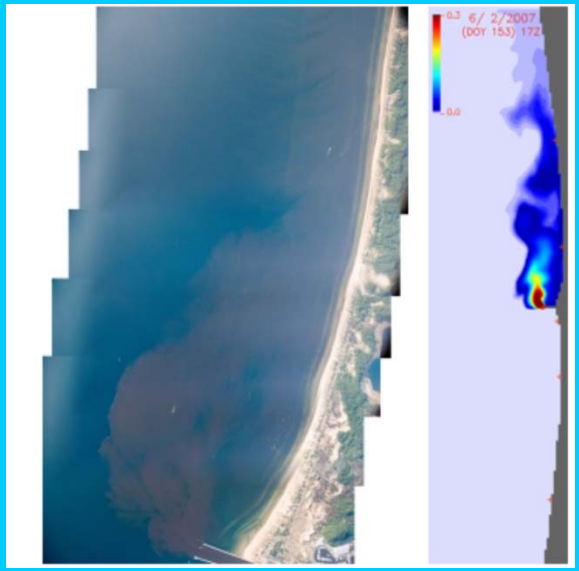
**•Web site: www.glerl.noaa.gov/res/glcfs/gh**

**•48 hr Forecast: /ghf**

top

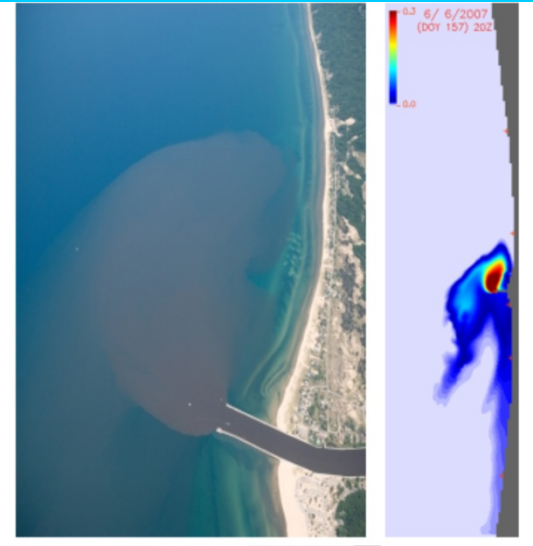
# •Grand River Plume Aerial Photography and Model Simulations

•June 2, 2007



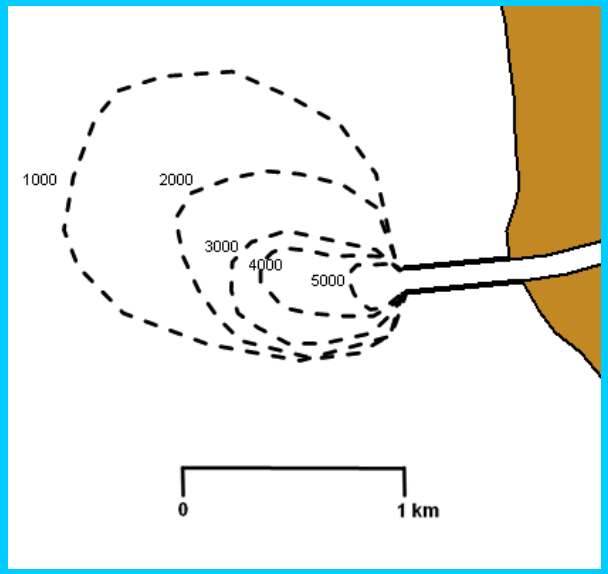

•June 10, 2007


•June 6, 2007

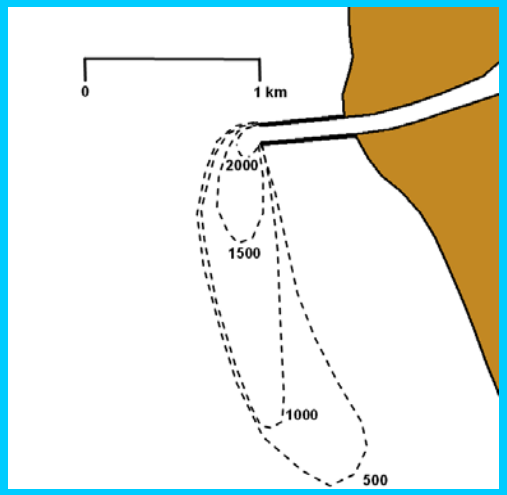



•June 20, 2007

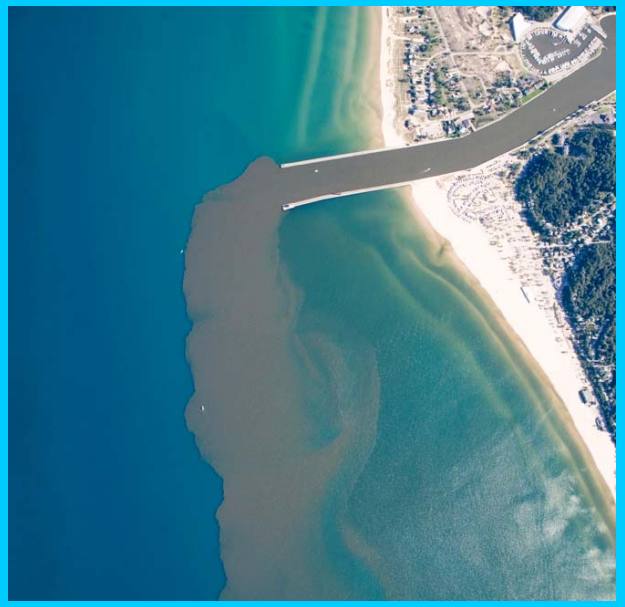
•Sulfur Hexaflouride Tracer Measurements Compared to Aerial Photography



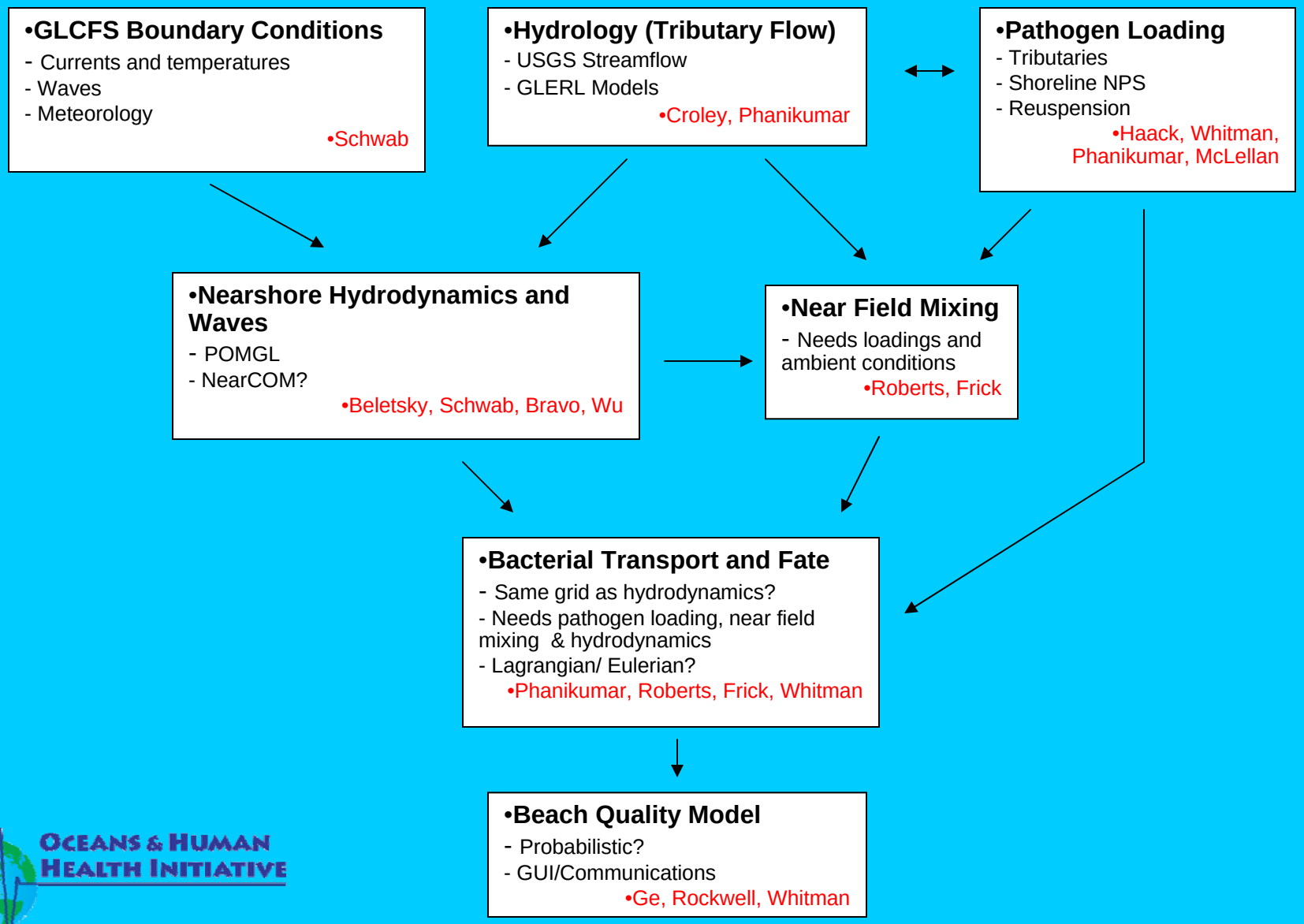

•6/22/2006




•8/8/2006



# •Deterministic Beach Quality Modeling Approach

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## •Predictive Variables for Statistical Beach Forecasting Models

*(Mednick, 2009: Accessing Online Data for Building and Evaluating Real-Time Models to Predict Beach Water Quality)*

•***Near Shore Conditions***

- - Wave height *
- - Turbidity
- - Lake current speed and direction *
- - Water temperature *
- - Lake level *

•***Weather Conditions***

- - Antecedent rainfall *
- - Wind speed and direction *
- - Air temperature *
- - Sunlight *

•***Onshore Conditions***

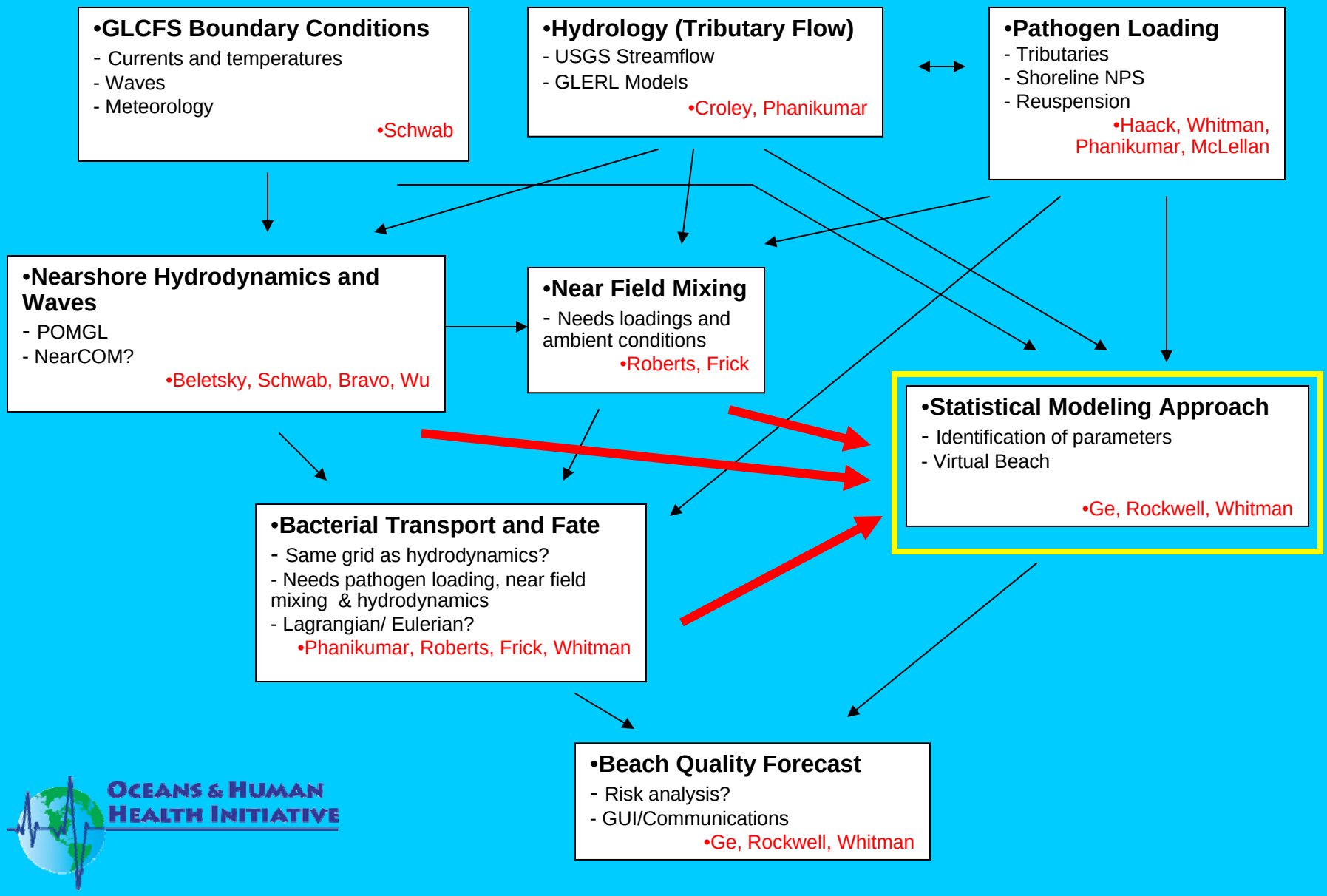
- - Number of bathers
- - Presence of algae
- - Number of gulls

•***Watershed Conditions***

- Stream flow *

•* Available from GLCFS

# •Combined Beach Quality Modeling Approach

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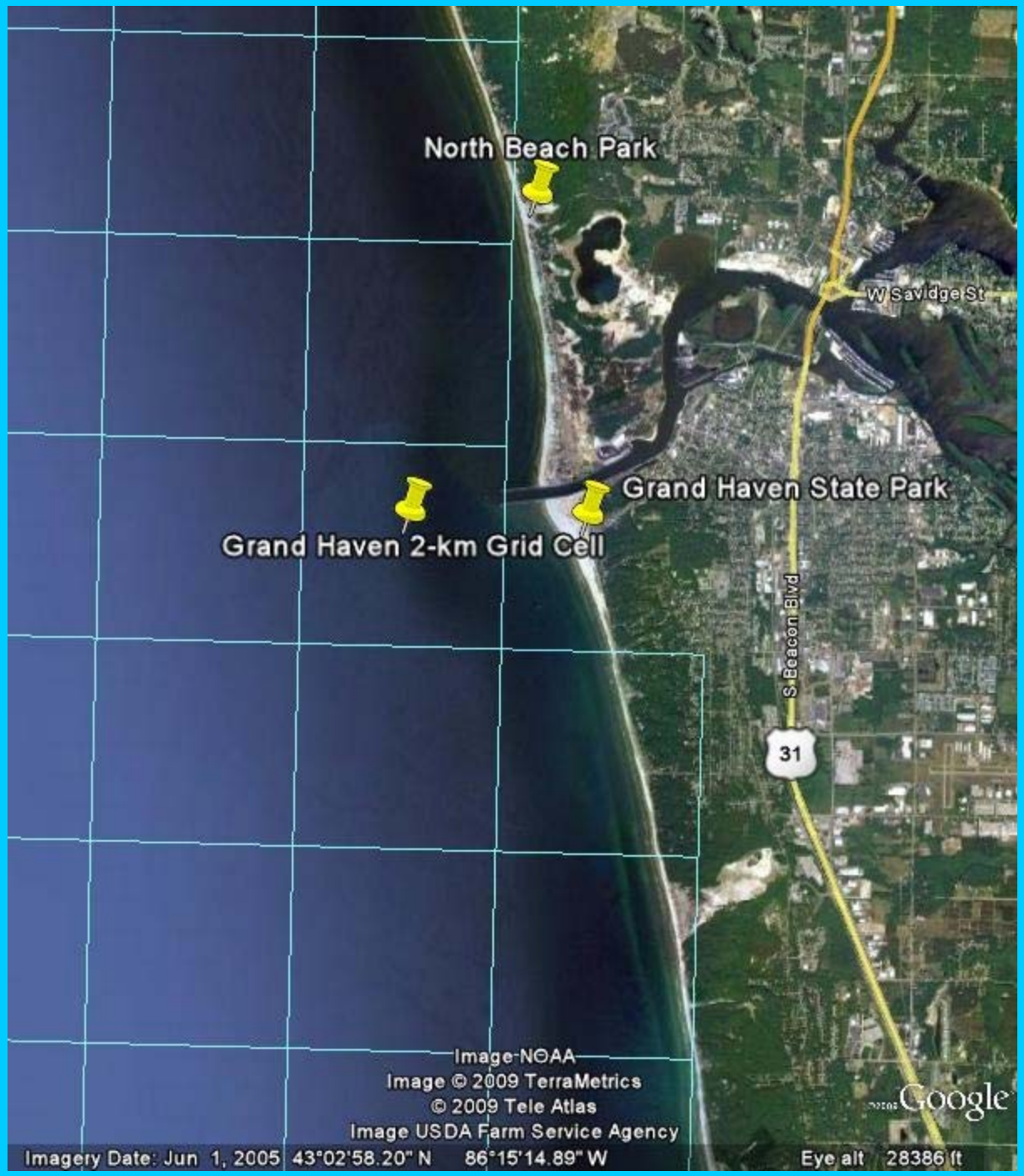

North Beach Park
W Savidge St
Grand Haven State Park
Grand Haven 2-km Grid Cell
S Beacon Blvd
31
Image-NOAA
Image © 2009 TerraMetrics
© 2009 Tele Atlas
Image USDA Farm Service Agency
Imagery Date: Jun 1, 2005 43°02'58.20" N 86°15'14.89" W
Eye alt 28386 ft
Google

## Grand Haven State Park Beach Ottawa Co. Michigan Data from 2002-2009

**VB2 MLR Model : Log10(E. coli)=Const + Coef1 x Var1+…+ Coef3 x Var3**

| Variable | Coefficient | Std. Error | t Statistic | p Value |
|---|---|---|---|---|
| Intercept | -0.0920 | 0.2130 | -0.4321 | 0.6665 |
| OSC0 | 2.0789 | 0.8206 | 2.5333 | 0.0127 |
| WSP3HrAve M | 0.0837 | 0.0280 | 2.9852 | 0.0035 |
| DP24Hr | 0.0616 | 0.0124 | 4.9750 | 0.0000024 |

**R-square = 30.0% Adj. R-square = 28.2% N=115**

- **OSC0** On Shore Current (positive East) at time of Sampling
- **WSP3HrM** Muskegon Wind Speed Ave. of Sample & preceding 2 Hrs
- **DP24Hr** Dew Point Average of Sample Time and preceding 23 Hours

- **OSC0** + coefficient => onshore current increases *E. coli* conc.
- **WSP3HrM** + coefficient => higher wind speeds increase *E. coli* conc.
- **DP24Hr** + coefficient => solar radiation attenuation increases *E. co*li conc.

**North Beach Park Beach Ottawa County Michigan Data from 2002-2009**

**VB2 MLR model: Log10(E. coli)=Const + Coef1 * Var1 + …+ Coef6 * Var6**

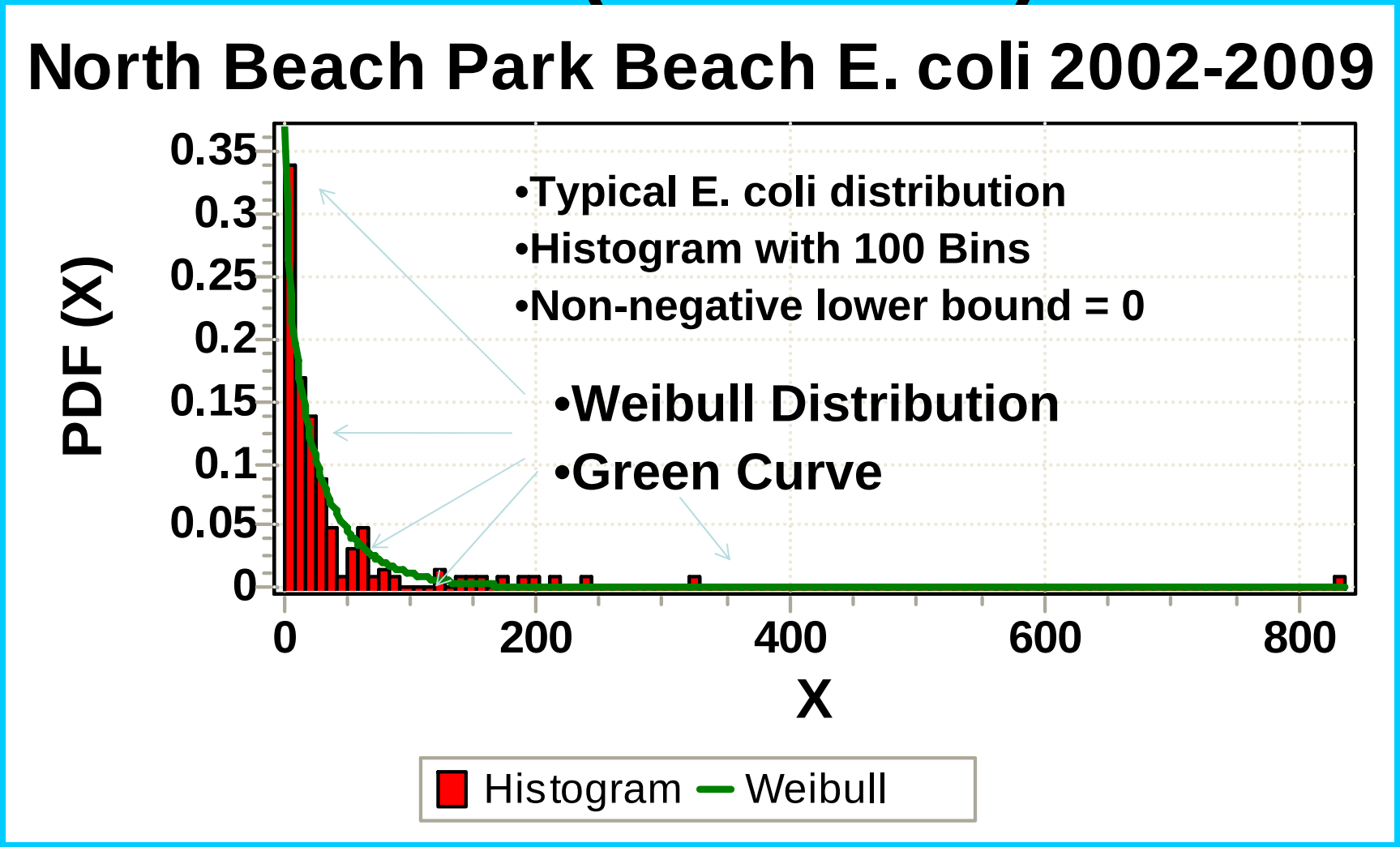
| Variable | Coefficient | Std Error | t Statistic | p Value |
|---|---|---|---|---|
| (Intercept) | 149.4352 | 41.2617 | 3.6216 | 0.0004 |
| $[GRD1d]^{1/2}$ | 0.0058 | 0.0025 | 2.3502 | 0.0204 |
| WVH0 | 0.5436 | 0.1888 | 2.8798 | 0.0047 |
| Year | -0.0745 | 0.0206 | -3.6266 | 0.0004 |
| TP24Hr M | 0.4109 | 0.2018 | 2.0362 | 0.0440 |
| DP24Hr M | 0.0525 | 0.0119 | 4.4062 | 0.0000 |

**R-square =39.6% Adj. R-square =37.0% N=125**

$[GRD1d]^{1/2}$ Sq Rt (Grand R. Flow at Grand Rapids 1 Day prior Sampling)
WVH0 Wave Height at time of Sampling
Year Calendar Year (not Julian Date)
TP24 M Total Precipitation Measured at Muskegon for 24 hours
DP24 M Dew Point Measured at Muskegon averaged over 24 hours

$[GRD1d]^{1/2}$ + coefficient => more runoff increase *E. coli* conc.
WVH0 + coefficient => larger waves increase *E. coli* conc.
DATE - coefficient => *E. coli* conc. declining at NBPB over time.
TP24Hr M + coefficient => more rainfall increases E. *co*li conc.
DP24Hr M + coefficient => solar radiation attenuation increases *E. co*li conc.

# WEIBULL Distribution
# Alpha=0.86 Beta=30
# % E. coli (> or = 200) =3%



# Key Variables For High E. coli Measurements North Beach Park Beach

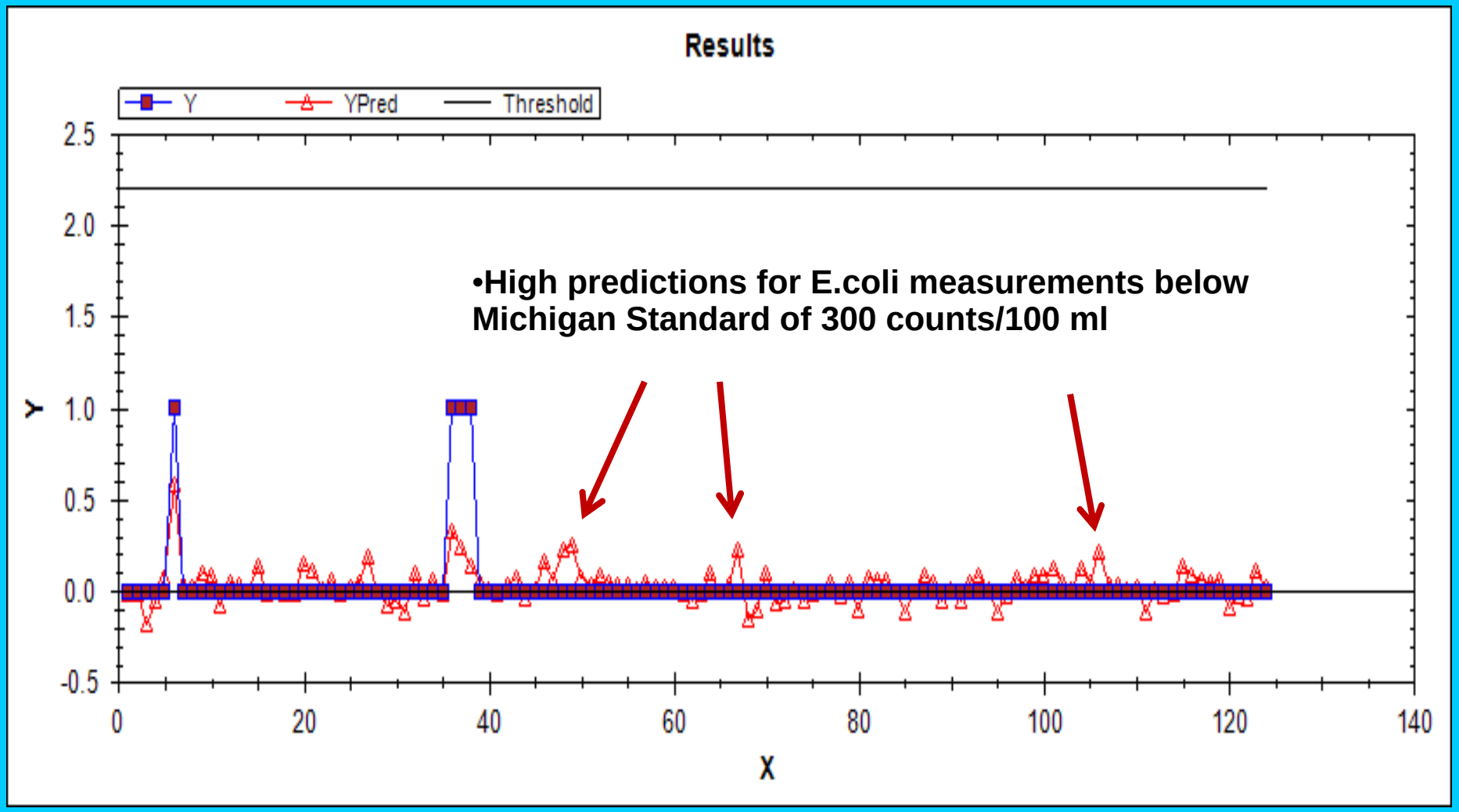
**Key Individual parameters**:

**(1) Onshore current (OSC),**
**(2) Along shore winds (ASW)**
**(3) Air temperature at time of sampling (AT0)**
**(4) Dew point averaged over 24 hours, and**
**(5) Air temperature averaged over 24 hours (AT24)**

**Key Interaction parameters**:

**(1) Onshore current (OSC) and Air Temperature (AT0)**
**(2) OSC and Cube of 3 Hour Average of Wind Speed**
**(3) ASW0 at sampling time and AT24**
**(4) Wave Height at sampling time and AT24**

# Predicted versus Measurements for Binary E.



# Results

- **Operational Forecast threshold values for North Beach Park Beach not found.**
- **Use Binary Logistic Regression to refine Binary E. Coli MLR approach**
- **Test procedure at Beaches having more high E.coli values**

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**Current Conditions**

# NOAAWatch

*NOAA's All Hazard Monitor*

Local forecast by City, State

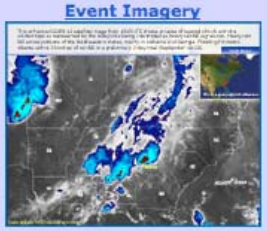
City, St Go

**Weather Warnings**

**Doppler Radar**

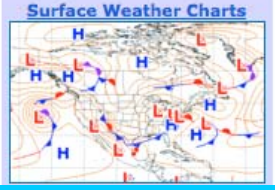
**River and Lake Levels**

**Event Imagery**

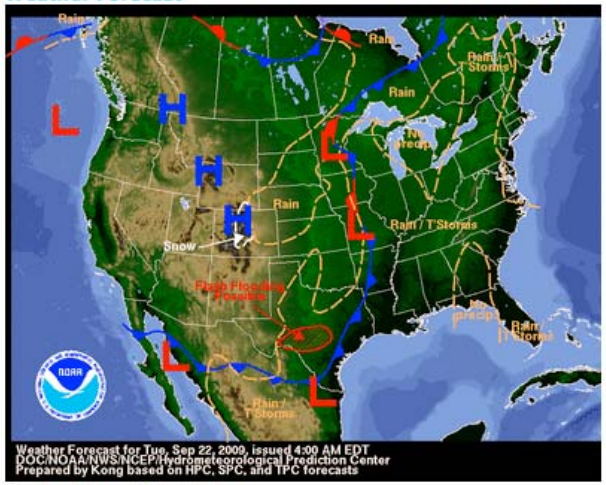


**Drought Outlook**


**Surface Weather Charts**



## Weather Forecast




Weather Map - Click to Enlarge

## Weather Outlook for Tuesday

Tue, 22 Sep 2009 06:45:00 EDT

An upper level low is forecast to move into the central High Plains today where it is expected to remain for the next several days, producing chilly conditions across much of the central and southern Intermountain West and Rockies, with dry and windy conditions along the West Coast. Showers and thunderstorms with some embedded heavy rains area forecast to occur along or near this low's associated frontal boundary which is forecast to push out through the Mid and Lower Mississippi Valley while extending back across southern Texas before stalling and gradually weakening. More scattered rains are forecast from the central Appalachians northward through the Northeast as a string of weak upper level disturbances interact with an axis of above normal moisture. Along the Southeast and Mid-Atlantic coasts, a landfalling tropical wave will produce scattered showers and thunderstorms across the region. Latest local weather forecasts, warnings, watches, and advisories...

## Deadly Flooding Across Southeast

Tue, 22 Sep 2009 07:10:48 EDT

Heavy rains from a stationary storm system across the Southeast since last weekend have caused widespread flash, river and stream flooding, and at least 7 fatalities. Rainfall amounts in central Georgia reached as much as 15.2 inches, with a broad area of 4 to 6 inches from central Mississippi across Alabama, Georgia into Tennessee. Major flooding is reported on several creeks and the Chattahoochee River

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# Future Coordination Activities

## GLRI Beach Model Grantees

1. Erie County NY Department of Health
2. Chicago Park District IL
3. Michigan State University
4. Michigan Dept. Natural Resources and Environment
5. Wisconsin Dept. Natural Resources
6. Regional Science Consortium Erie PA
7. Northeast Ohio Regional Sewer District

# Acknowledgements

**NOAA Great Lakes Regional Collaboration Team**

**Dr. M.S. Phanikumar, Michigan State University**
**Dr. R. L. Whitman, U.S. Geological Survey**
**Dr. J.B. Rose, Michigan State University**

**Richard Wagenmaker, National Weather Service, White Lake &**
**USEPA and USGS Great Lakes Beach Interagency Team Members**

**Michigan Department of Environmental Quality**
**Ottawa County Health Department (End User)**

**Funding from OHHI through NOAA GLERL**
**Center of Excellence for Great Lakes and Human Health**
**Grant Project Number F021307-059594**


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