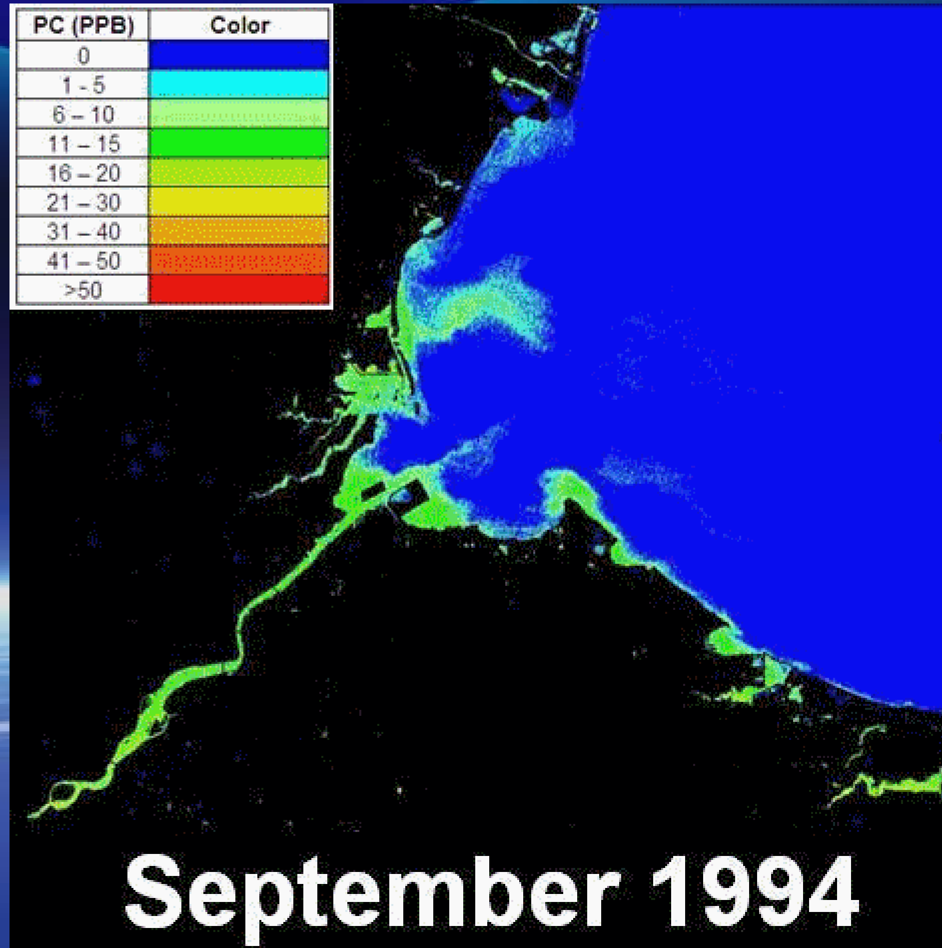


Blue Water Satellite

Using Satellite Imaging to Monitor the World's Land and Water Resources™

What we do

- We use satellite images and patented image processing algorithms to monitor the world's land and water resources
- We provide you with images and data that allow you to
  - Determine land and water body quality
  - Spot problems areas
  - Develop cost effective remediation strategies (cost savings offset image costs)

Some of our Customers

Environmental Engineering

CDM

ENVIRON

AquaTechnex

US Army Corps of Engineers

Oil Companies

bp

Federal, State, Local Agencies, HOA's

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Power Companies

PG&E

AVISTA

ppl

PPL EnergyPlus

NOAA

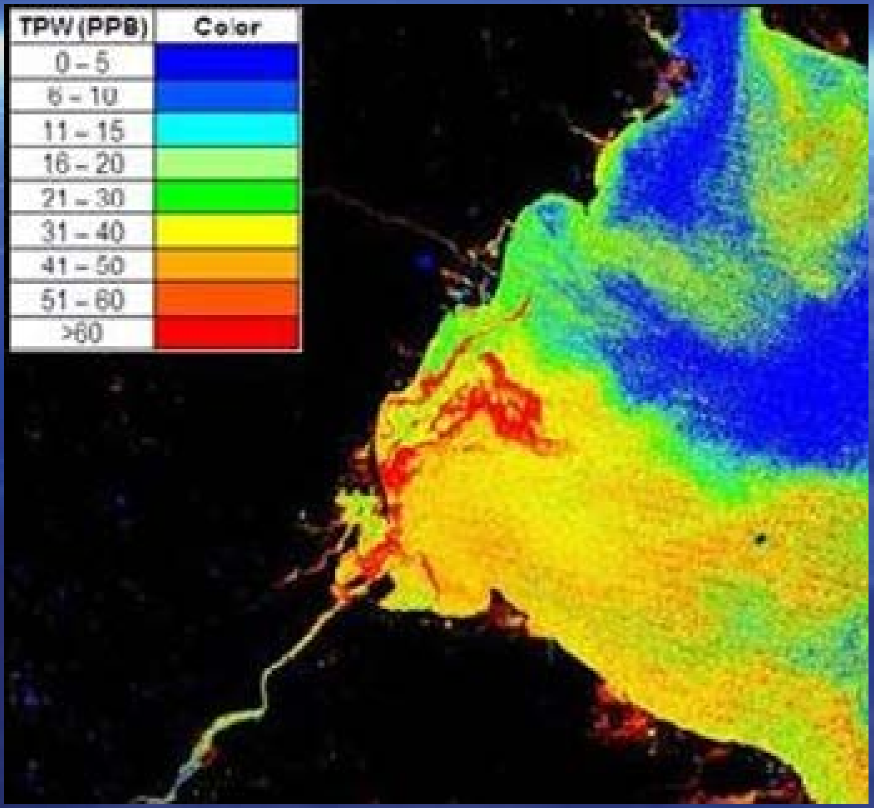
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

Blue Water Satellite

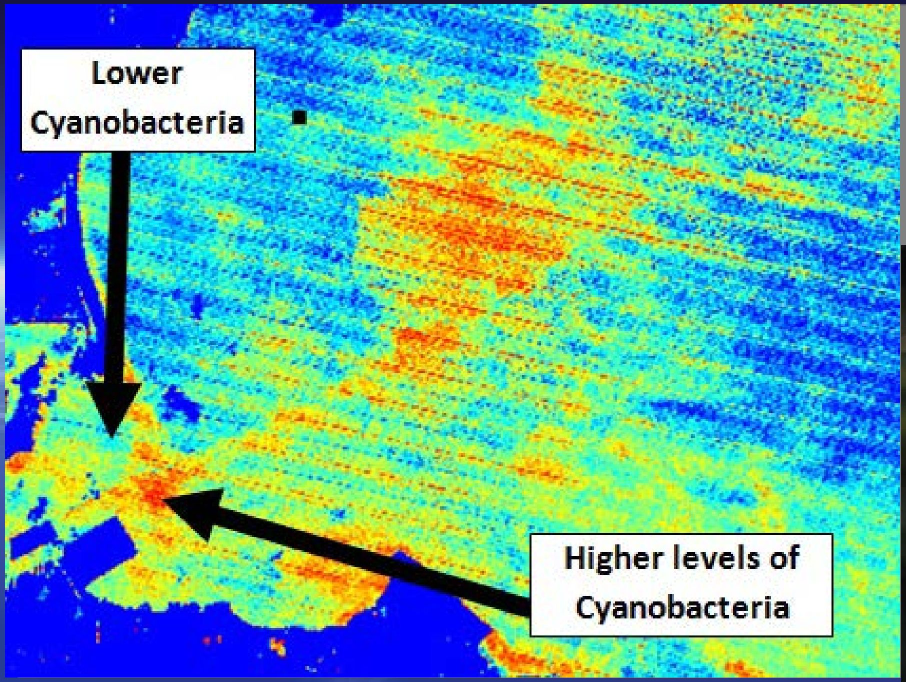
Using Landsat and other satellites...

...to see where the problems are.



TPW (PPB)	Color
0 – 5	
6 – 10	
11 – 15	
16 – 20	
21 – 30	
31 – 40	
41 – 50	
51 – 60	
>60	

You CAN'T tell this……

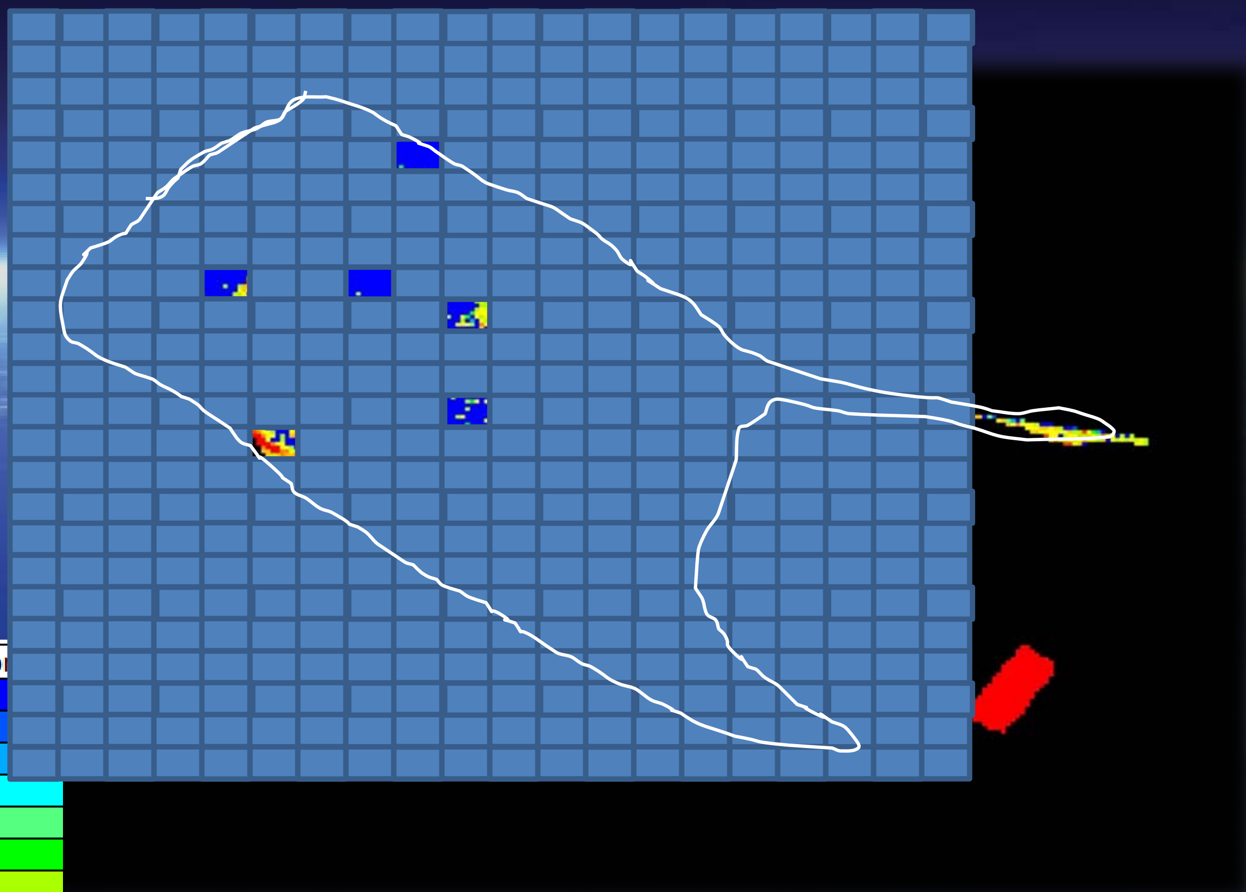


From this.

To make intelligent decisions,

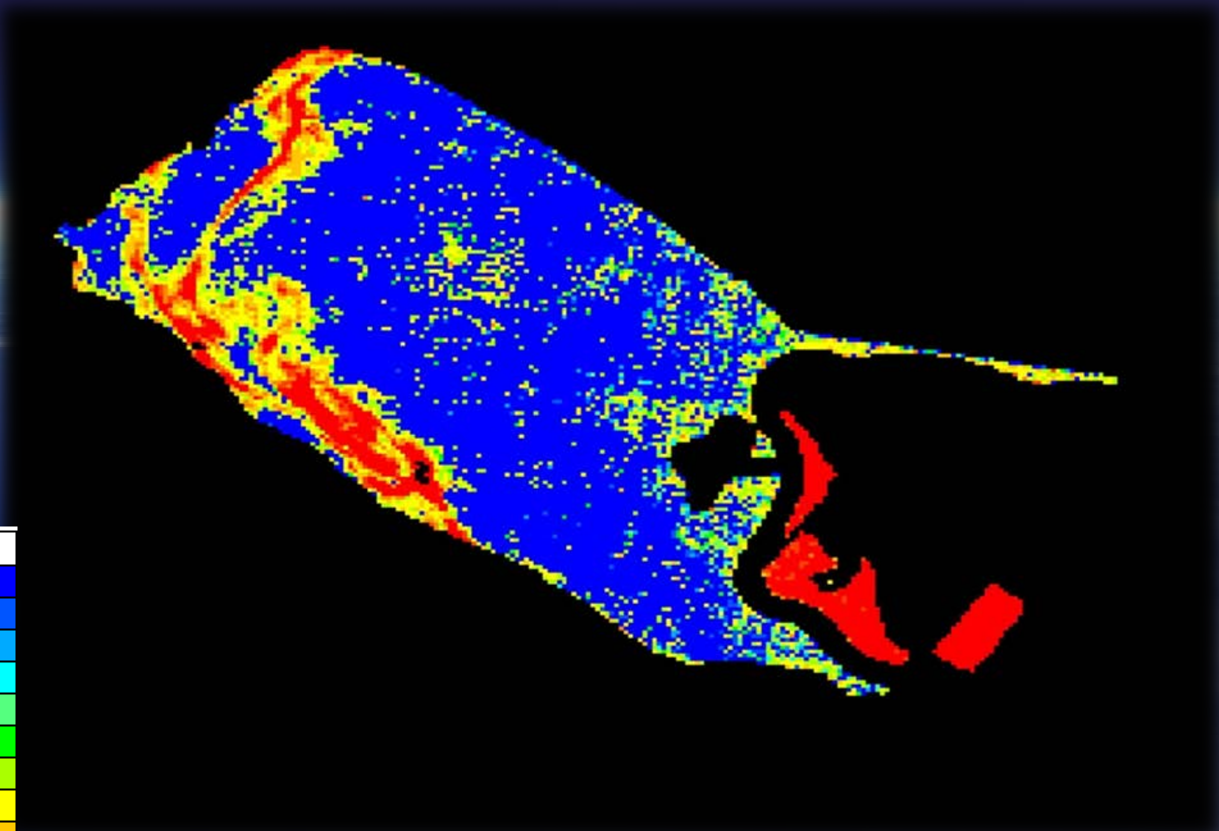
you need more data. BWS=5 samples/acre

Lake Elsinore 10/01/1997 Chl-a Scan



Chl-a (PPB)	Color
0 – 5	
6 – 10	
11 – 15	
16 – 20	
21 – 30	
31 – 40	
41 – 50	
51 – 75	
76 – 100	
101 – 125	
126 – 150	
>150	

Lake Elsinore 10/01/1997 Chl-a Scan



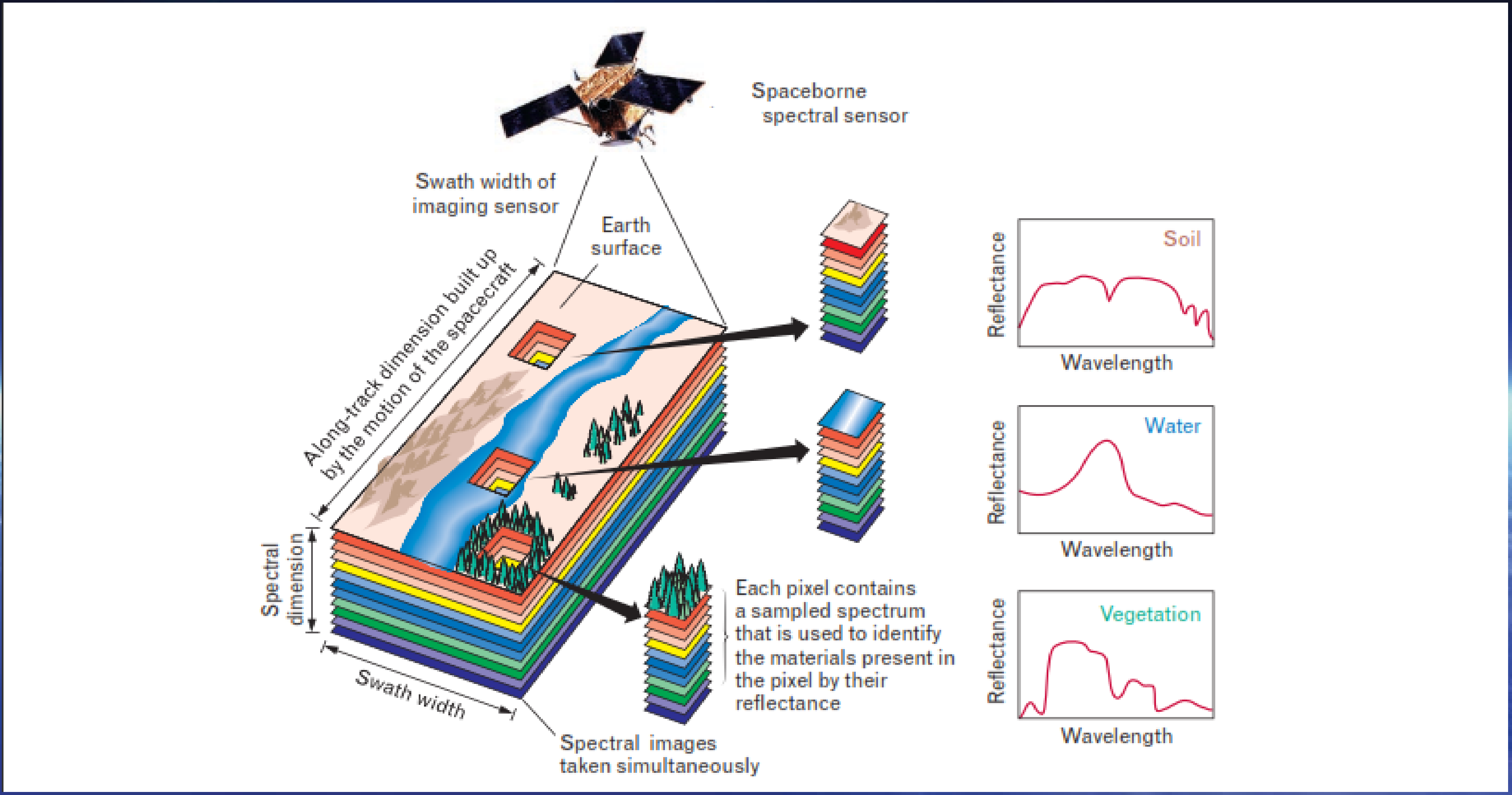
Chl-a (PPB)	Color
0 – 5	
6 – 10	
11 – 15	
16 – 20	
21 – 30	
31 – 40	
41 – 50	
51 – 75	
76 – 100	
101 – 125	
126 – 150	
>150	

Most Water Bodies are not Homogeneous!

Station	Station	Mean Chl a	Mean PC
ST 196	1	187.825	143.5
ST 197	2	371.225	309.225
ST 198	3	122.675	137.625
ST 199	4	616.775	568.525
ST 200	5	106.075	108.975
ST 201	6	65.775	60.625
ST 202	7	42.375	33.2
ST 203	8	51.65	39.7
ST 204	9	52.725	44.225
ST 205	10	32.675	23.1
ST 206	11	53.975	57.05
ST 207	12	52.375	45.05
ST 208	13	35.175	30.45
ST 209	14	30.175	23.6
ST 210	15	28.425	20.675
ST 606	16	26.75	23.55
ST 607	17	31.975	33.7
ST 608	18	33.2	37.275
ST 609	19	71.575	49.175
ST 610	20	143.125	69.55

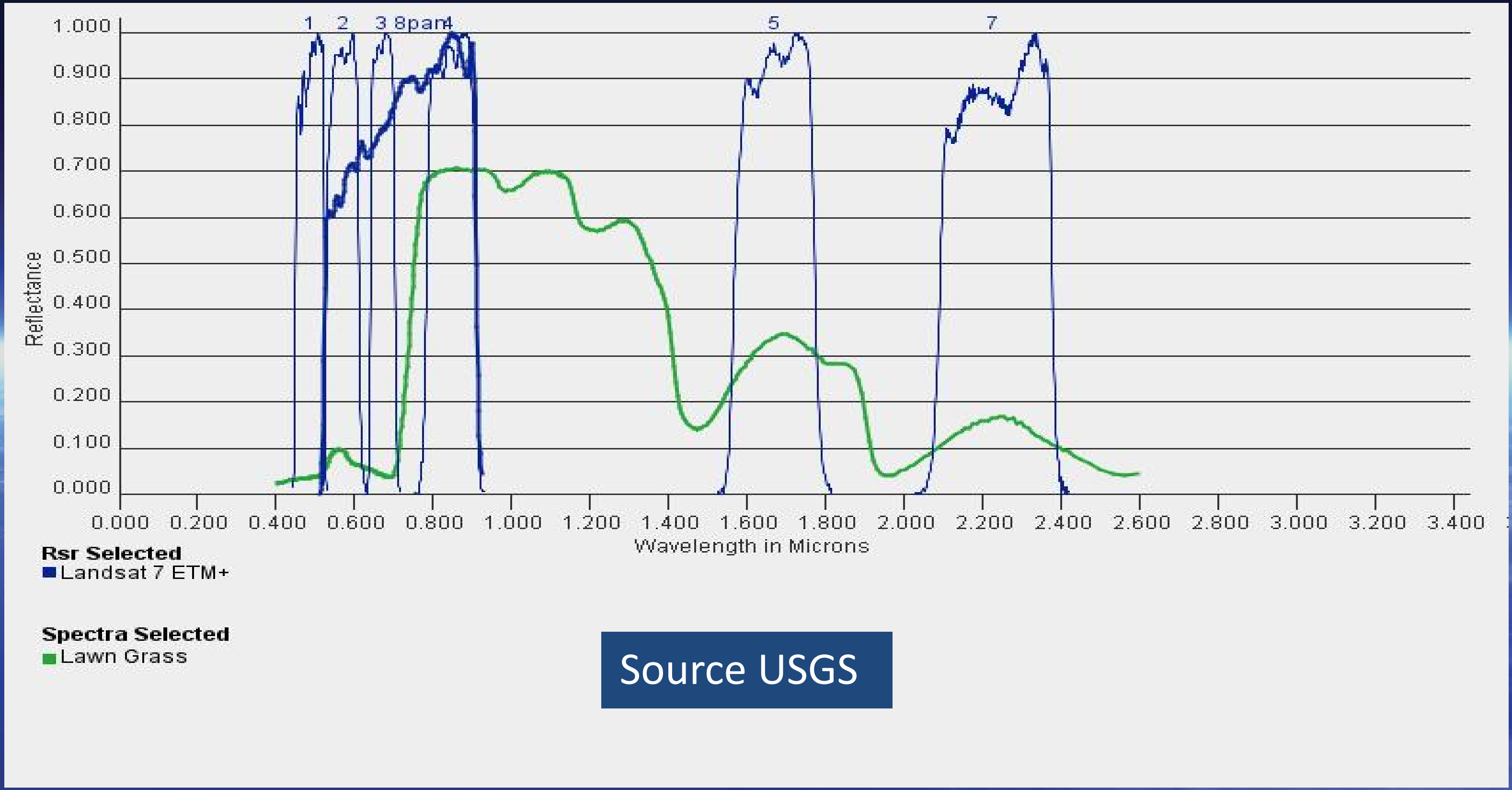
All data from EPA method certified labs in ppb

How it works



Many chemical and biological constituents produce a unique spectral reflectance signature
(Courtesy MIT Lincoln Labs)

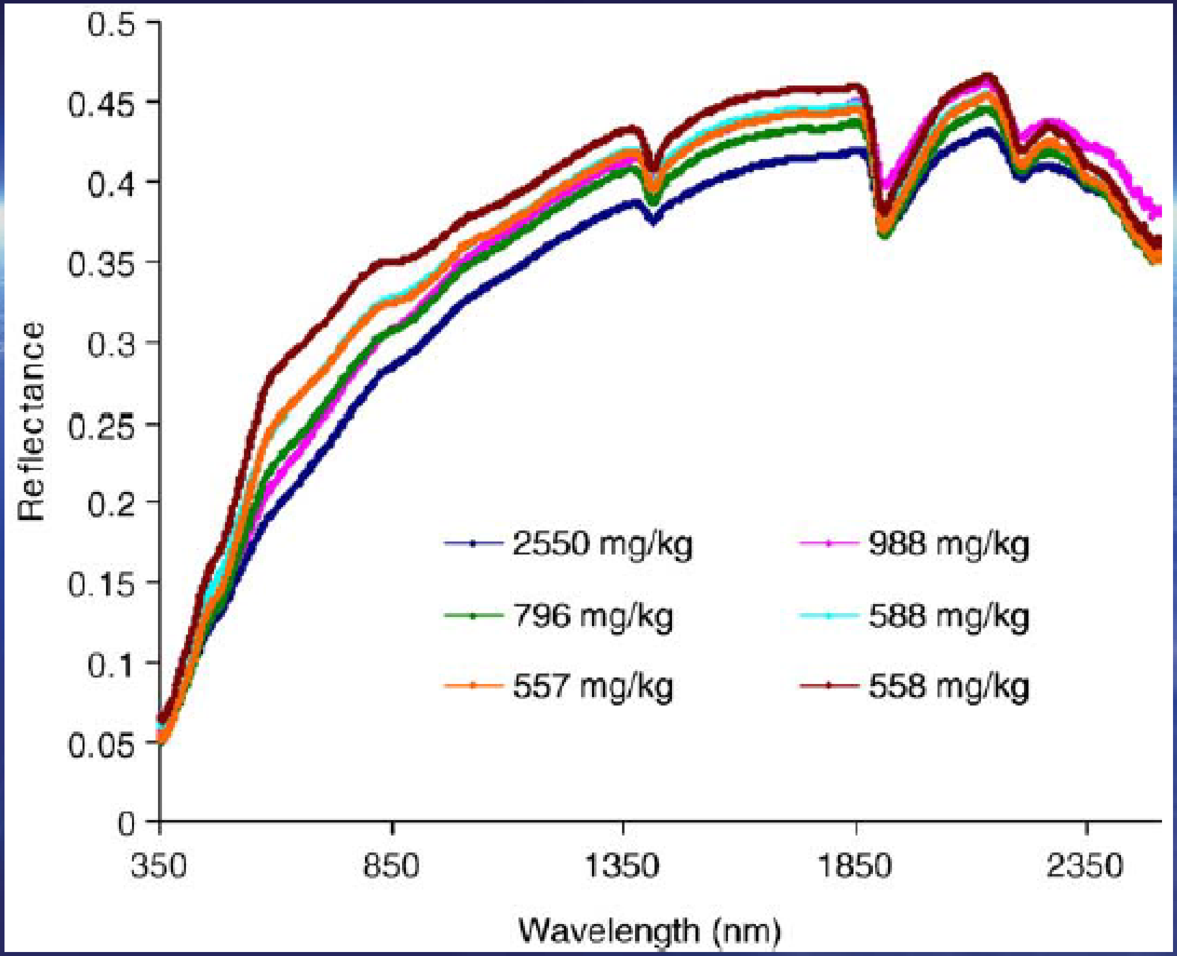
How Blue Water Satellite Works



The ratios between the 7 bands of reflected light is a "fingerprint " for each constituent

Spectral Reflectance Curve Phosphorus on Land

Phosphorus in Soils
Spectra of Soil at Various Phosphorus Levels used in BWSI Algorithm



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

+ NASA Portal
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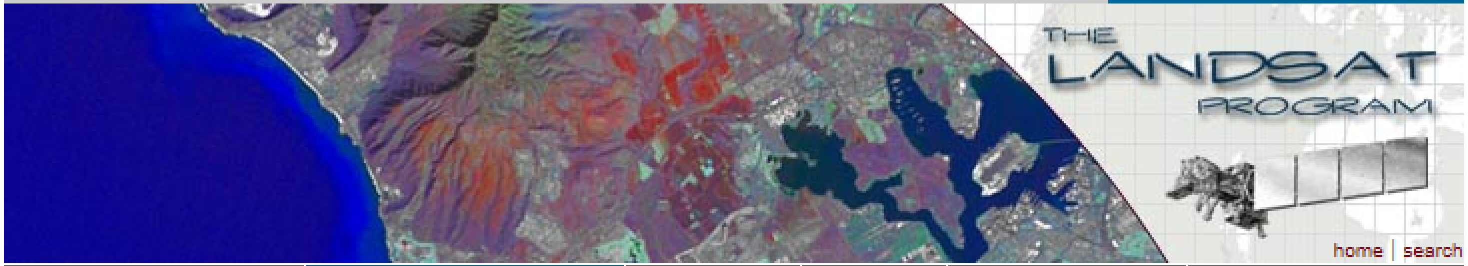

+ ABOUT LANDSAT | – NEWS & FEATURES | + IMAGES | + DATA | + EDUCATION | + REFERENCES

News & Features

+ How Landsat Helps
+ Special Features
+ Science Articles
+ People of Landsat
+ Did You Know?
+ Podcasts & Videos
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landsat news

Landsat Enables Remote Detection of Dangerous Water Pollutants

Nov. 12 • A young Ohio business, Blue Water Satellite, Inc., is using Landsat 5 and 7 data to detect potentially harmful pollutants in water bodies across the U.S. used for recreation and for drinking water supplies. Using Landsat and algorithms developed at Ohio's Bowling Green State University, Blue Water can detect E. Coli, cyanobacteria, phosphorus, and Red Tide. Dr. Robert K. Vincent, a geology professor at BGSU, used NASA and NOAA grant money to help develop the pollutant-detection algorithms.

More information:

+ Bowling Green business goes global [external link]

Years of Research & Peer Review

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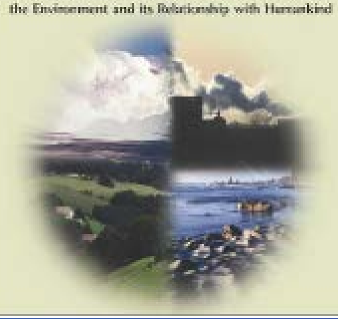
Science of the Total Environment

An International Journal for Scientific Research into the Environment and its Relationship with Humankind



US007132254B2

(12) **United States Patent**
Vincent

(10) **Patent No.:** **US 7,132,254 B2**
(45) **Date of Patent:** **Nov. 7, 2006**

(54) METHOD AND APPARATUS FOR DETECTING PHYCOCYANIN-PIGMENTED ALGAE AND BACTERIA FROM REFLECTED LIGHT

(75) Inventor: Robert Vincent, Bowling Green, OH (US)

(73) Assignee: Bowling Green State University, Bowling Green, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 10/763,138

(22) Filed: Jan. 22, 2004

OTHER PUBLICATIONS

Richardson, Laurie, Remote sensing of algal bloom dynamics, Jul./Aug. 1996, Bioscience, vol. 46, No. 7, pp. 492-501.*

Gitelson, A., et al., Optical properties of dense algal cultures outdoors and their application to remote estimation of biomass and pigment concentration in *Spirulina platensis* (Cyanobacteria), 1995, Jrnl of Phycology, vol. 31, No. 5, pp. 828-834, abstract.*

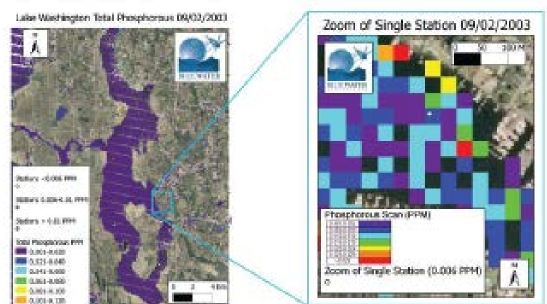
Green, S., 2003, http://www.ucd.ie/~app.phys/stuart/MODEL.HTM, The effect of chlorophyll concentration on airborne hyperspectral reflectance.*

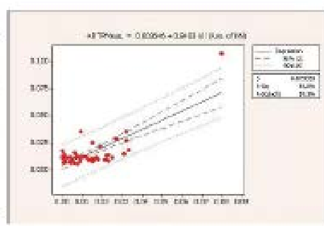
Landsat 7 Science Data Users Handbook, http://ltpwww.gsfc.nasa.gov/IAS/handbook/_htmls/chapter8/chater8.html, last updated Aug. 7, 2001; accessed Dec. 16, 2004.*

Gitelson, A et al. Optical properties of dense algal cultures outdoors and their application to remote estimation of biomass and pigment concentration in *Spirulina platensis* (cyanobacteria). 1995. J. Phycol. 31: 828-834.*

Total Phosphorus Water Monitoring Using Satellite Imagery

Figure 1: BWSI Total Phosphorus Processed Image Example, Lake Washington





show that using the BWSI processed images for Phosphorus screening is certainly historical and future monitoring efforts. The next evaluation shows how the data time of field sample collection and satellite overpass are closer together.

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Mapping the total phosphorus concentration of biosolid amended surface soils using LANDSAT TM data

B.B. Maruthi Sridhar [a,*], Robert K. Vincent [a], Jason D. Witter [b], Alison L. Spongberg [b]

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[b] Department of Environmental Sciences, University of Toledo, Toledo, OH 43606, United States

ARTICLE INFO

ABSTRACT

Conventional methods for soil sampling and analysis for soil variability in chemical characteristics are too

Available online at www.sciencedirect.com

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Remote Sensing of Environment 89 (2004) 381–392

Remote Sensing of Environment

Phycocyanin detection from LANDSAT TM data for mapping cyanobacterial blooms in Lake Erie

Robert K. Vincent [a,*], Xiaoming Qin [a], R. Michael L. McKay [b], Jeffrey Miner [b], Kevin Czajkowski [c], Jeffrey Savino [d], Thomas Bridgeman [d]

Received 2 May 2003; received in revised form 14 October 2003; accepted 28 October 2003

Science of the Total Environment

Mapping the total phosphorus concentration of biosolid amended surface soils using LANDSAT TM data

B.B. Maruthi Sridhar [a,*], Robert K. Vincent [a], Jason D. Witter [b], Alison L. Spongberg [b]

1. Introduction

BWS to Laboratory Data Comparison

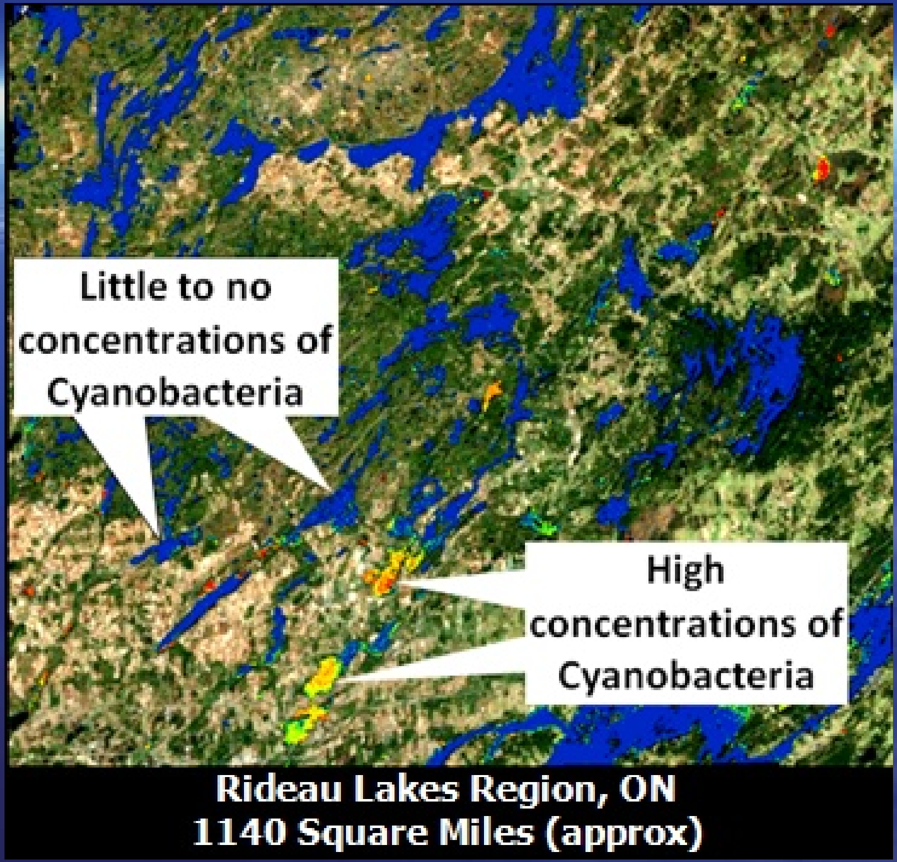
Data comparison Blue Water Satellite, Heidelberg National Center for Water Quality, UNH						
Phosphorus in water ppb datafrom samples taken at Moultonborough NH						
#	Date	Lat	Long	Landsat TP (Averaged) ppb	Heidelberg Data ppb	UNH Data ppb
1	7/16/2011	43 40' 29.9"	71 20' 45.3"	4.7	9.8	5.6
2	7/16/2011	43 42' 23.0"	71 21' 16.1"	11.3	11.6	6.9
3	7/16/2011	43 43' 07.8"	71 24 33.7"	9.3	11.6	8.5
4	7/16/2011	43 43' 34.2"	71 22 32.6"	6.5	12.5	8.6
5	7/16/2011	43 42' 57.4"	71 22' 08.7"	2.6	14.8	9
6	7/16/2011	43 43' 03.2"	71 24' 37.3"	13.4	12.4	11
7	7/16/2011	43 43' 26.0"	71 24' 37.3"	*	16	8.4
8	7/16/2011	43 43' 14.7"	71 22' 58.7"	8.8	11.6	8.5
*In an area where satellite measurement could not be made						
				Δ Landsat to Heidleberg (ppb)	Δ Landsat to UNH (ppb)	Δ Heidleberg to UNH (ppb)
				5.1	0.9	4.2
				0.3	4.4	4.7
				2.3	0.8	3.1
				6.0	2.1	3.9
				12.2	6.4	5.8
				1.0	2.4	1.4
						7.6
				2.8	0.3	3.1
Average of Absolute Value delta (ppb)				**4.3**	**2.5**	**4.2**

Technology

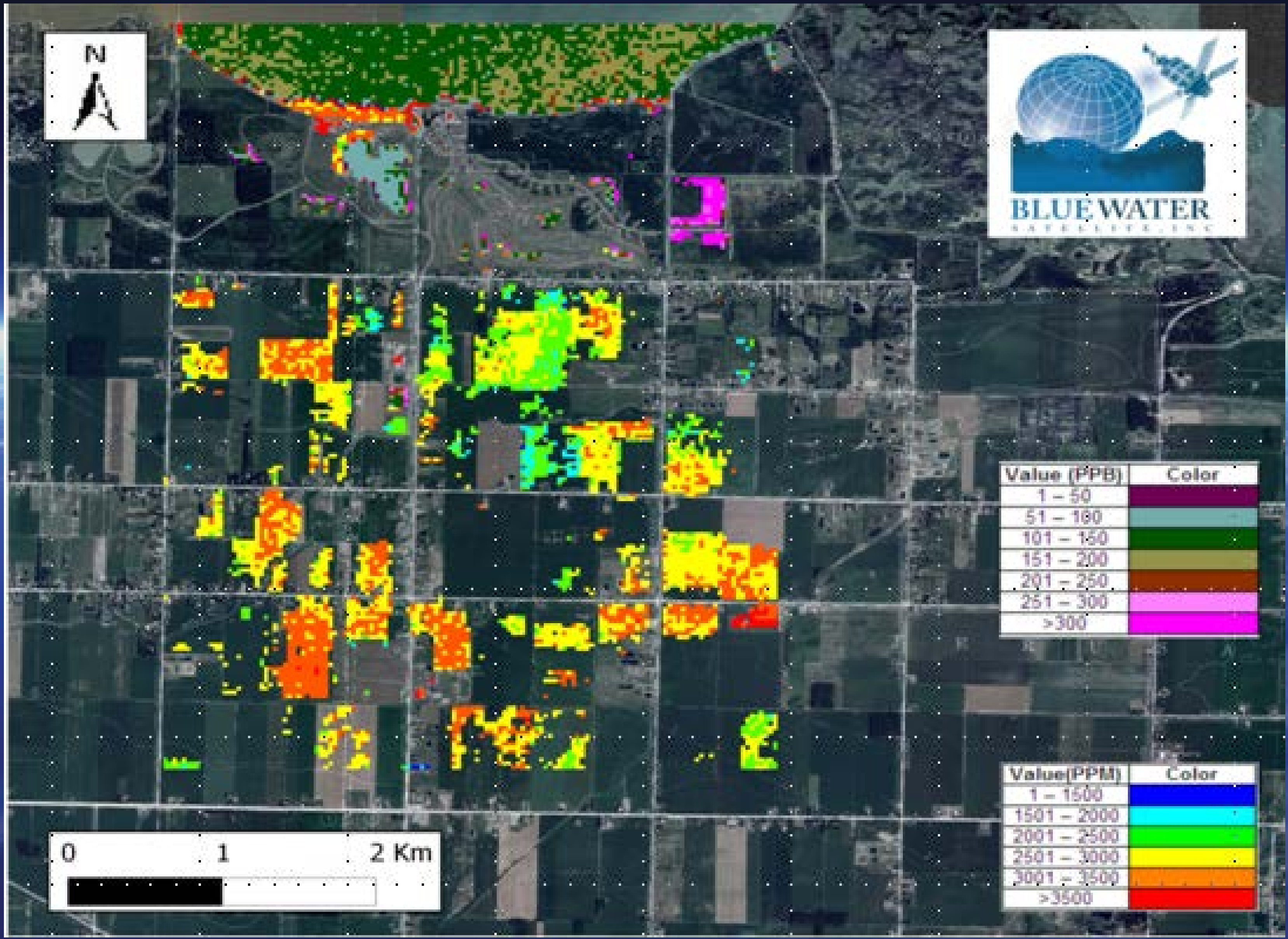
- Uses Landsat and commercial satellites
- Technology Bowling Green State University (BGSU).
- $1 million in funding from NASA and NOAA over 2 ½ years for validation.
- 3 issued patents and 8 pending patents
- Peer reviewed science
- Ability to go back in time to 1984
- 5 samples/acre
- Worldwide China, Australia, Canada, US, Etc.

Case Study #1

Identifying where the problems are
Area with 106 Lakes



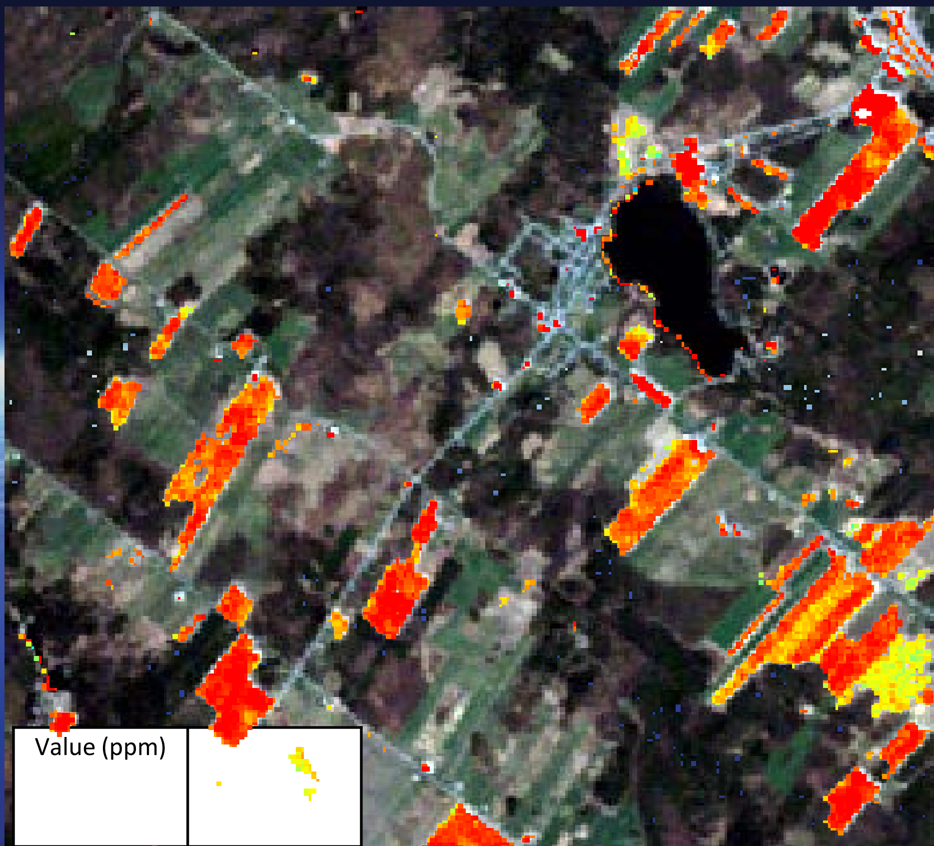
Case Study #2 Sources Phosphorus Land



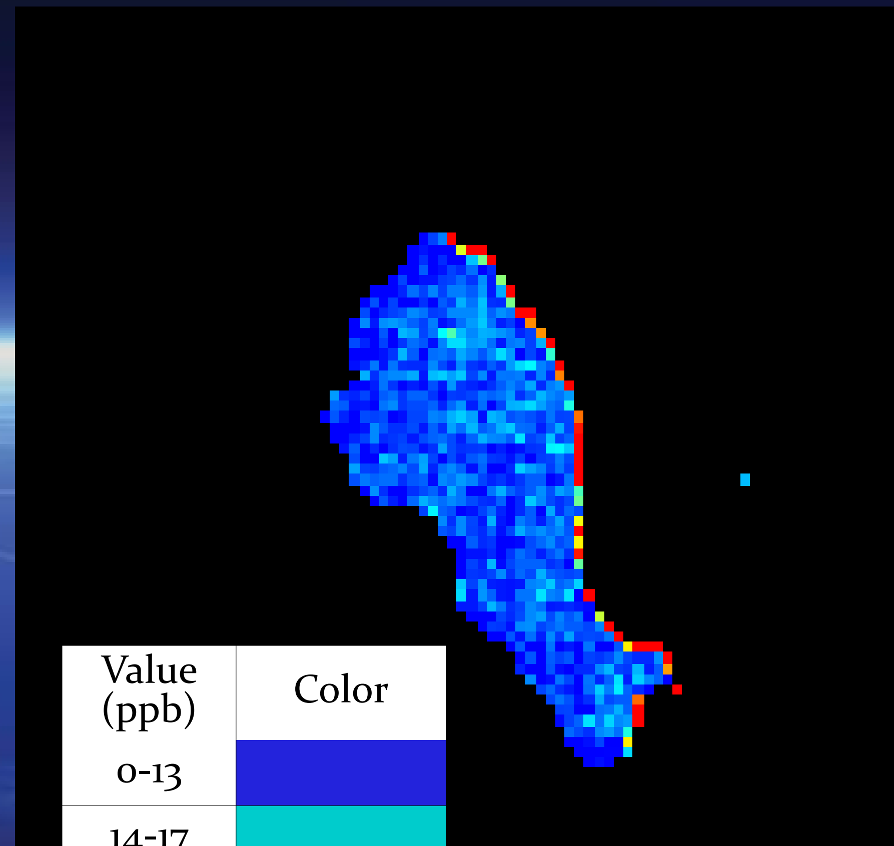
Case Study #3

Identifying Point Source Problems on Land

The image below details Total Phosphorus on Land (TPL) in an agricultural area



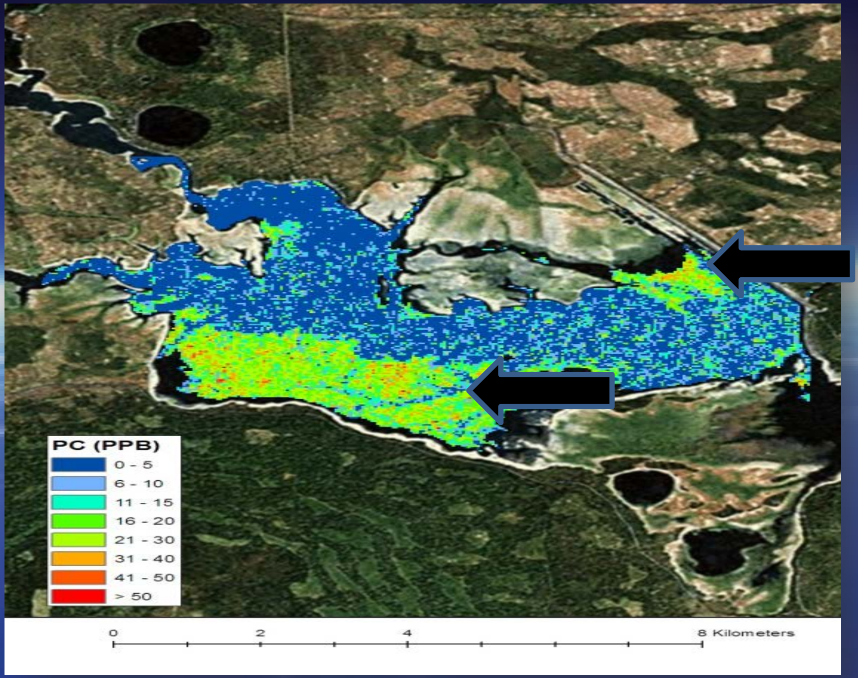
Value (ppm)	
0	
1900	
2400	
2700	
3800	



Value (ppb)	Color
0-13	
14-17	
18-21	
22-26	
27-49	
>50	

Case Study #4
Reducing Treatment Cost

BWSI is the only technology that enables significant savings in treatment costs!



Planned Treatment :

Apply Alum in entire lake	$2,200,000

BWSI Solution:

Target Alum to affected areas	$1,300,000
Cost of Satellite Images	$ 40,000
Total	$1,340,000

Customer Savings:

$860,000!

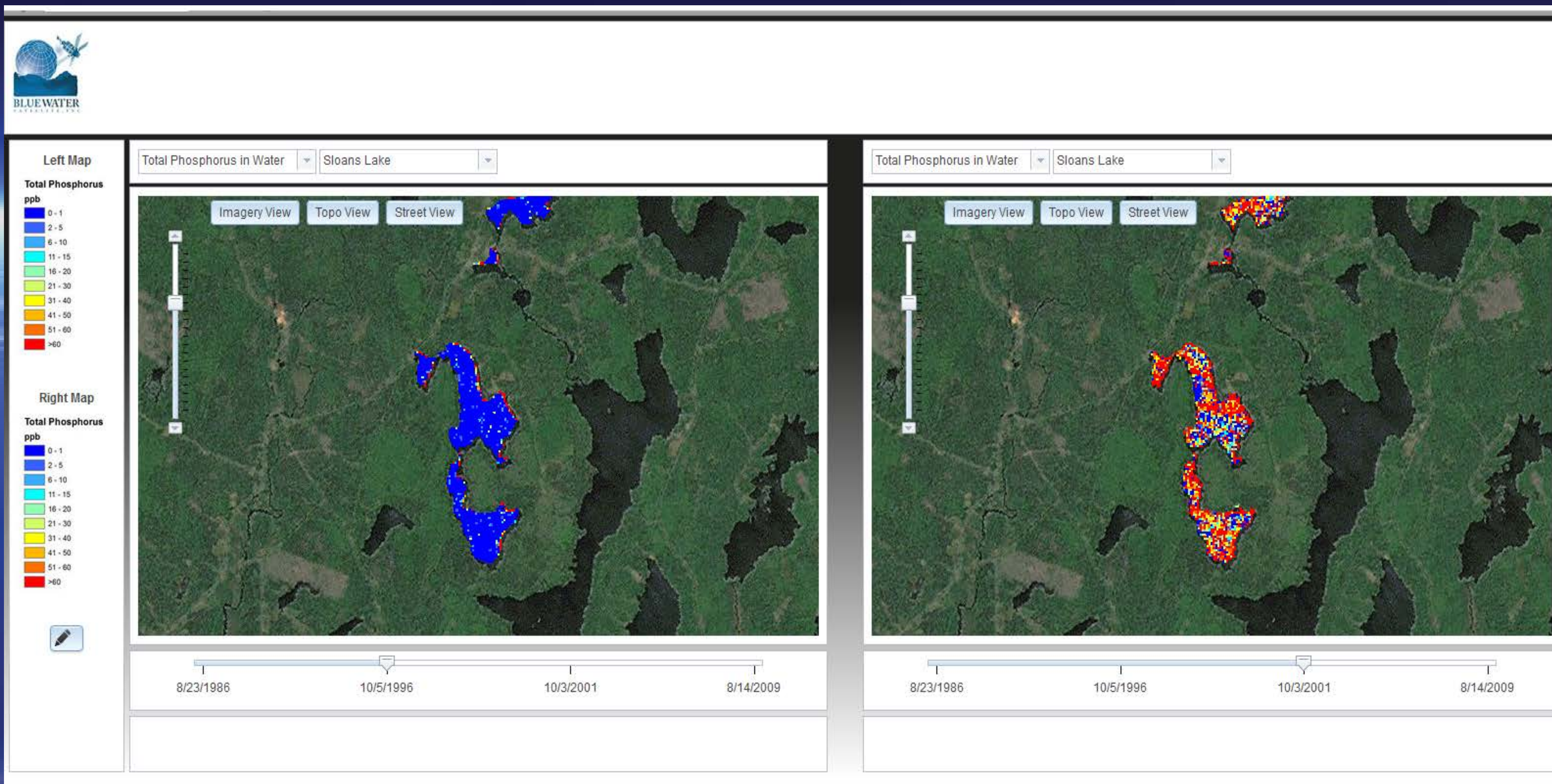
"You really can't get this information in a cost-effective manner any other way. It's a real bargain if you're trying to do comprehensive sampling of the lake. It's the only way to get the information we want in a cost effective manner because it's lake wide and it's a big lake. – Frank Pickett PPL Montana

Case study #5 Risk Mitigation

The Blue Water Satellite Viewer (BWS Viewer™) enables clients to:

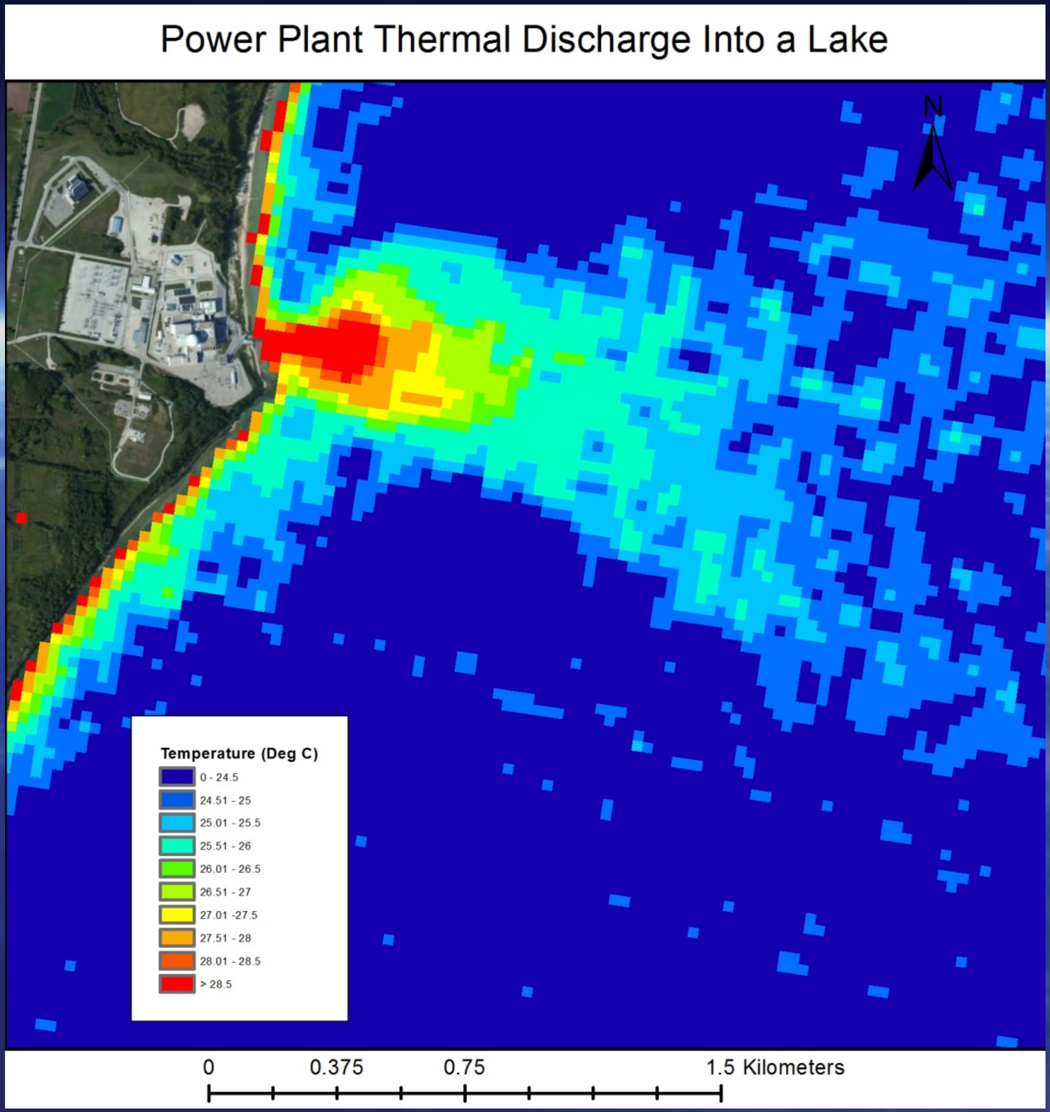
Compare water bodies and constituents

Quickly evaluate current and historic trends



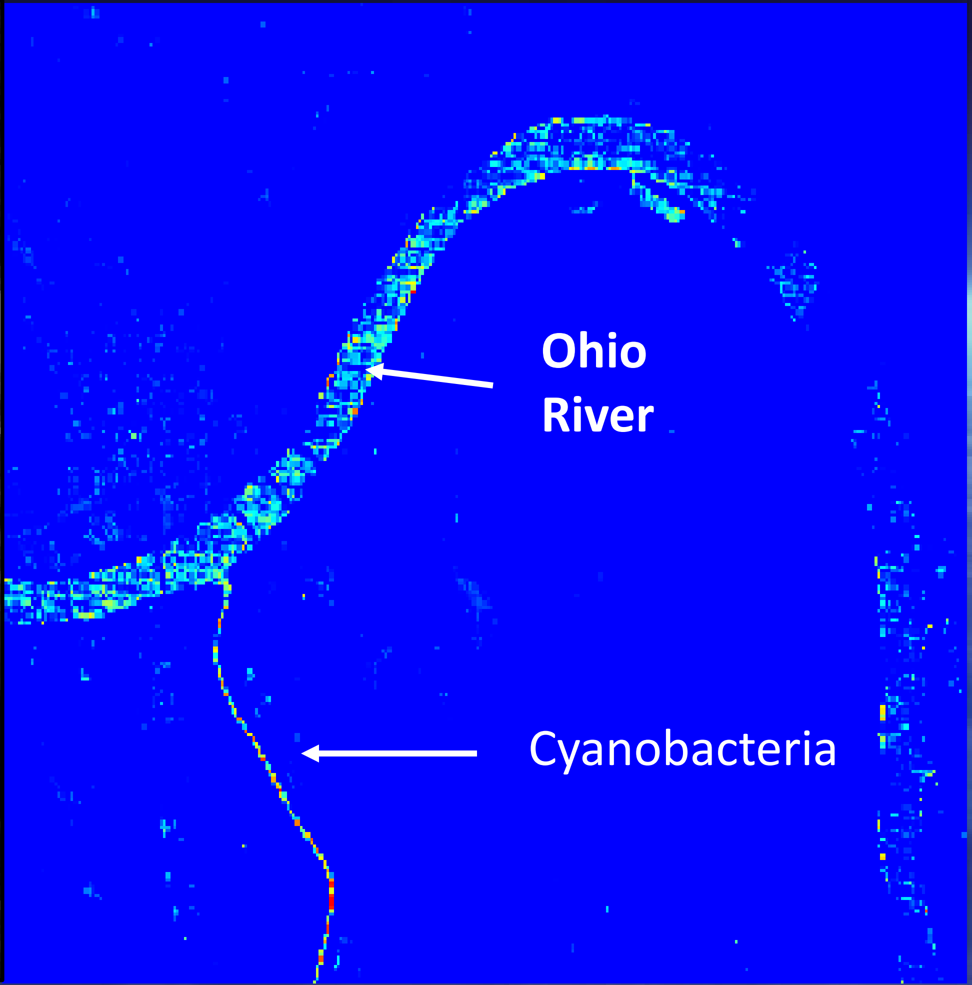
Case Study #6 Temperature Plumes

The image below details temperature in water (Deg C)



Case Study #7 Aid in Determining Problem Sources Ohio River 2008

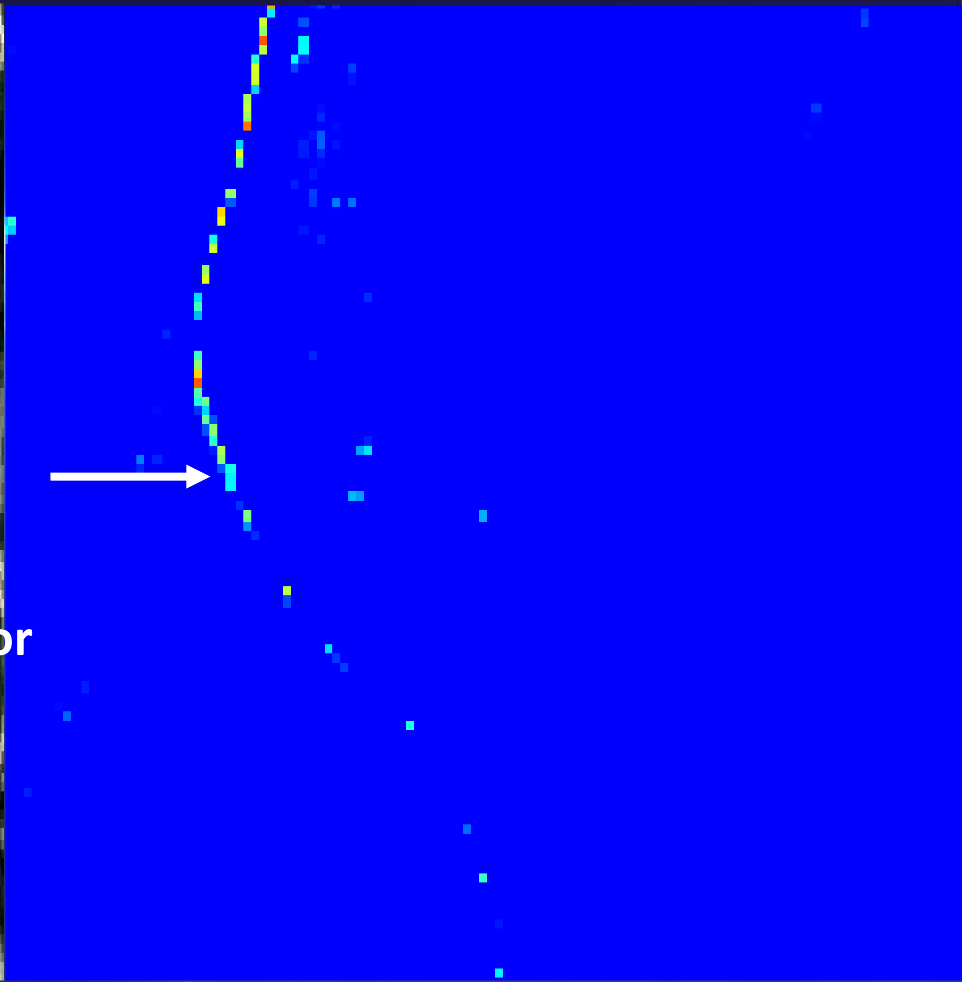
Landsat Natural Color Image



Landsat processed Image

Case Study #7 Aid in Determining Problem Sources
Licking River 2008

Landsat Natural Color Image



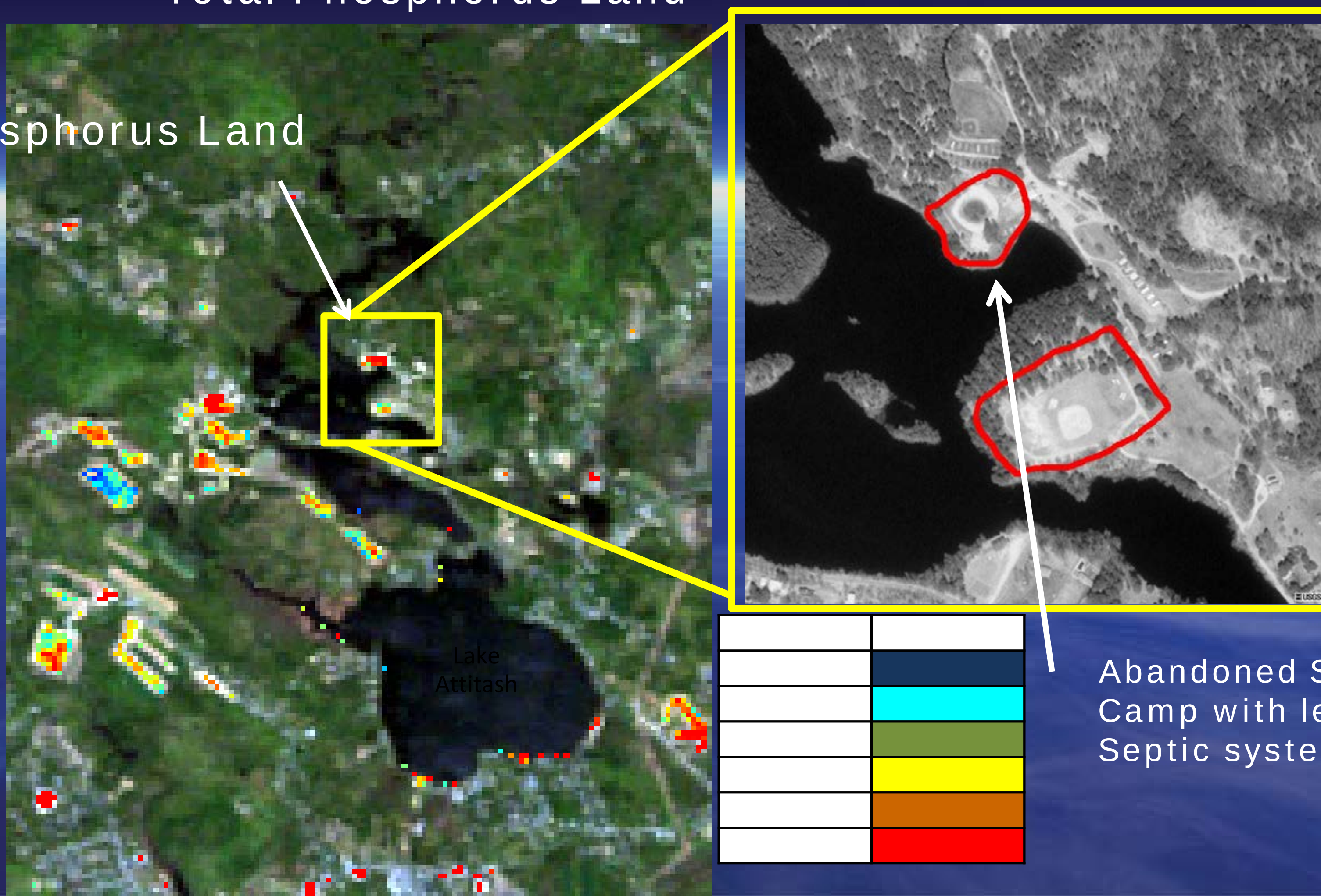
Landsat Processed image

Case Study # 8 Total Phosphorus Land Finding a leaky septic system in abandoned summer camp

Total Phosphorus Land

1998 Aerial Photograph

High Phosphorus Land



Abandoned Summer Camp with leaky Septic system

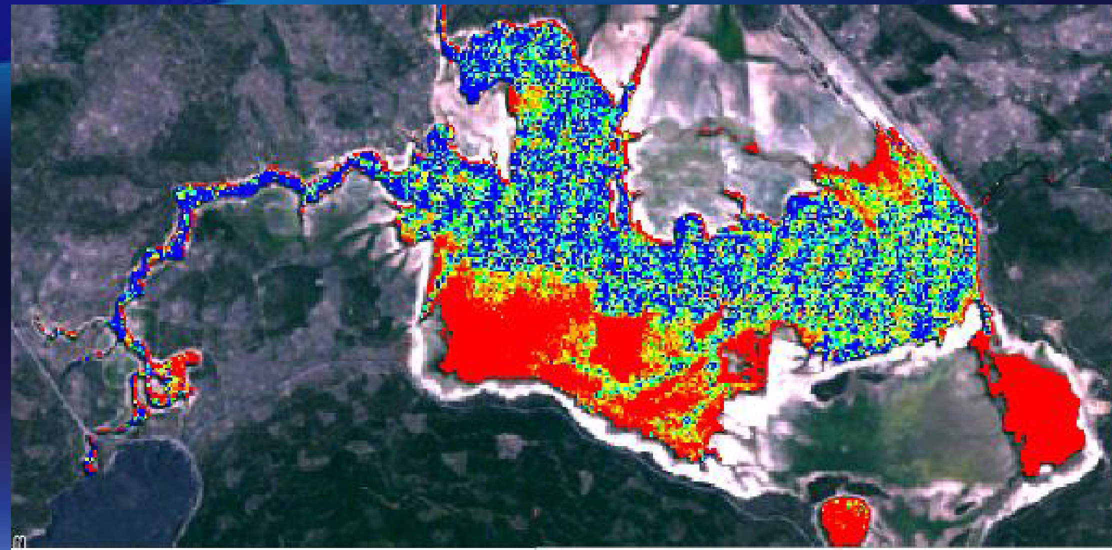
BWS Range and Accuracy

Blue Water Satellite Constituent Accuracy and Range Data		
Constituent	**Range**	**Accuracy**
Cyanobacteria (Phycocyanin)	0-17 ppb	±2 ppb
Cyanobacteria (Phycocyanin)	17-60 ppb[A]	±17 ppb
Total Phosphorus Water (TPW)	0-20 ppb	±6 ppb
Total Phosphorus Water (TPW)	20-100 ppb	±11 ppb
Total Phosphorus Land (TPL)	0-4000 ppm	±530 ppm
Chlorophyll-a	1-155 ppb	±22 ppb
Temperature	1.9 - 27.6^{o}C	± 1.52^{o}C
Aquatic Vegetation	Relative	Presence/ Absence
Note: ppb = parts per billion		
Note: ppm = parts per million		

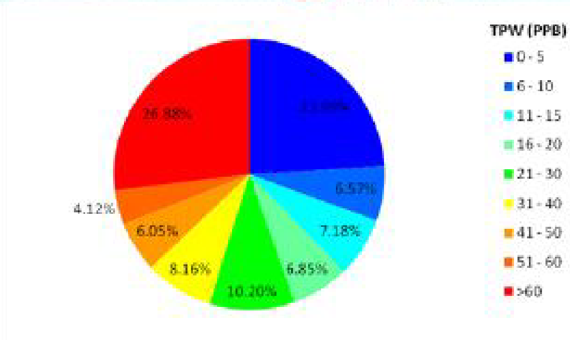
[A] Above 60 ppb will measure 60 ppb

Blue Water Satellite Deliverables

- Geo TIFF file for each image (for ArcGIS)
- Processed images (pdf, tiff, or jpeg)
- Custom report (sample page as shown)
- Accuracy data
- BWS Viewer ™ (optional)



TPW (PPB)	Color
0 - 5	
6 - 10	
11 - 15	
16 - 20	
21 - 30	
31 - 40	
41 - 50	
51 - 60	
>60	

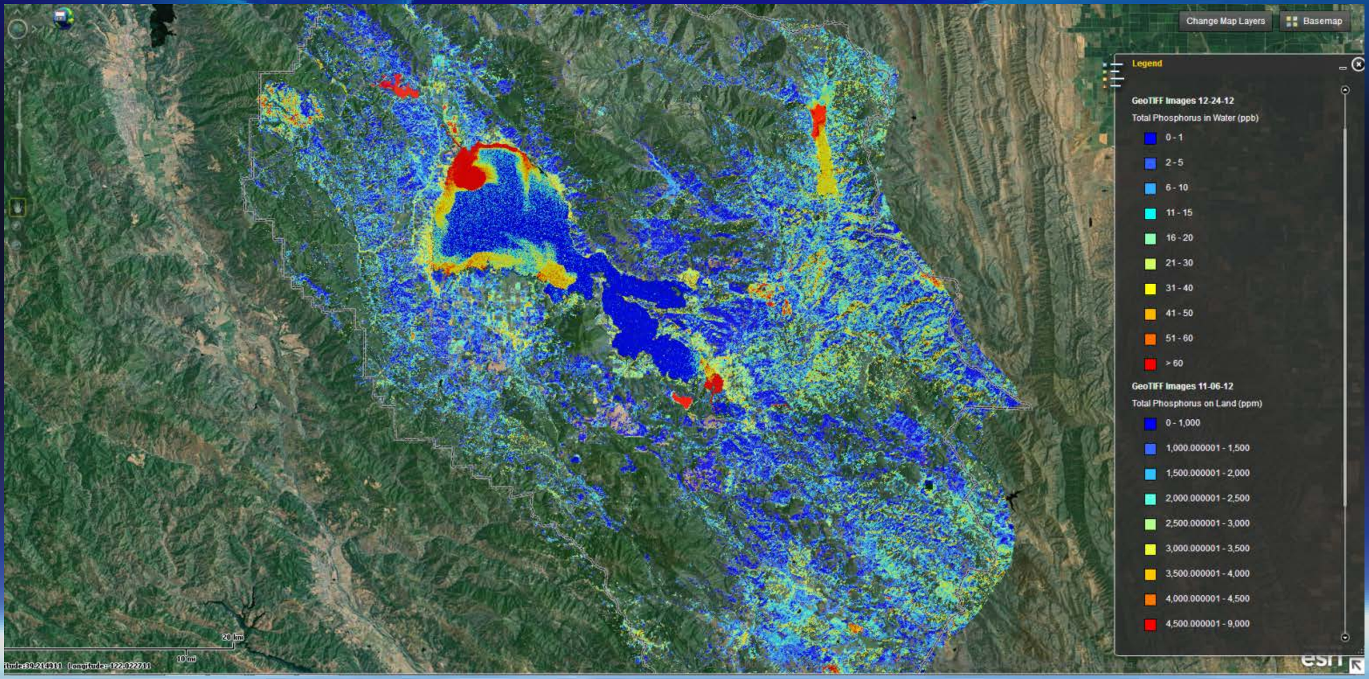


TPW (PPB)	Area (Acres)	Percent of Lake
0 - 5	1174.24	23.99
6 - 10	321.81	6.57
11 - 15	351.38	7.18
16 - 20	335.15	6.85
21 - 30	499.78	10.20
31 - 40	399.64	8.16
41 - 50	296.23	6.05
51 - 60	201.93	4.12
>60	1315.91	26.88

Color scale (above left) indicates ranges of concentration of phosphorus in parts per billion as represented in scan image (top).

Pie chart histogram (above) indicates percentage of water within view delineated by concentration ranges.

Table (left) indicates actual acreage falling within each range of concentration of phosphorus.

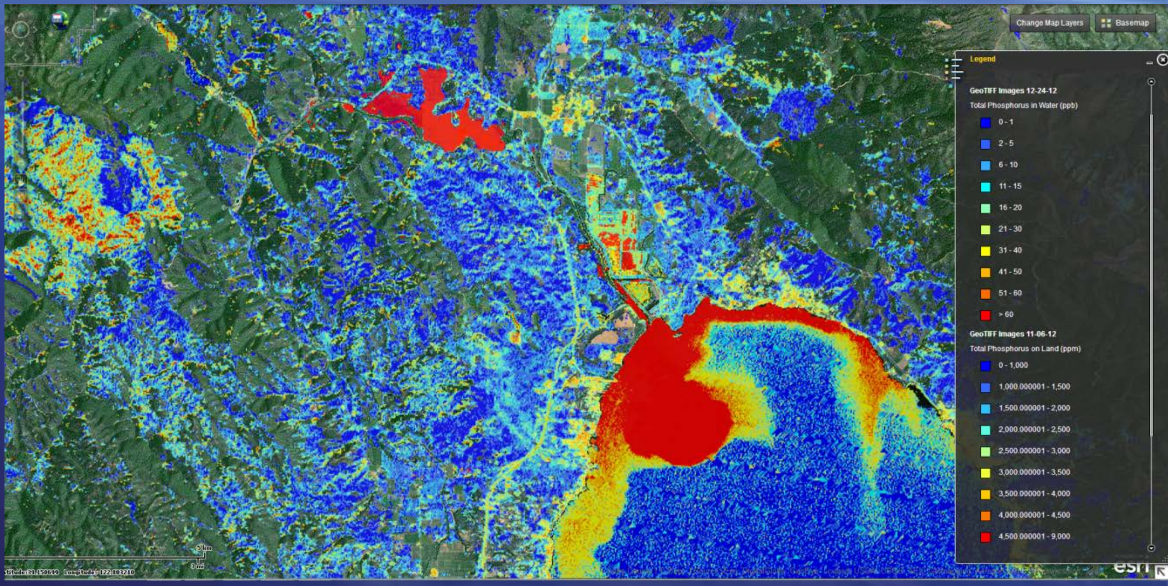


Phosphorus on land and in water analysis

http://gispublic.co.lake.ca.us/BWS/

Blue Water Satellite Customer Example: Clear Lake, California

Lake County makes BWS data available online for public outreach



zoom

Blue Water Satellite

BLUEWATER
SATELLITE, INC

No one sees it like Blue Water Satellite.

No one.

For additional information 855-885-5648 ext 1