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To: Clearwater Association

Subject: 2009 Groundwater Intrusion Overflight of Clearwater Lake

From: Alan W. Cibuzar
Kristin Dupre
John Reynolds
A.W. Research Laboratories
16326 Airport Road
Brainerd, MN 56401
Phone: (218) 829 7974
Fax: (218) 829 1316
Email: awlab@awlab.com

Introduction

For the past 35 years, A.W. Research Laboratories (AWRL) has used low altitude remote sensing imagery to identify nutrient and toxic conditions in lakes. Remote sensing (aerial imagery) has become a significant tool for Lake Management; it summarizes complex environmental conditions in a prompt and cost-effective manner. These dramatic aerial images demonstrate environmental conditions in a format that is easily understood, and becomes a tool for lakeshore residents to gain a better awareness of their effect on the environment, and with that awareness an increased willingness to rectify problems. Additional advantages of the aerial perspective are it allows the user to see things that would be obscured from the ground, and the recorded images can be reviewed using standard protocols to detect conditions that the users are interested in.

Large areas of the shoreline along Clearwater Lake are undeveloped providing a valuable, diverse aquatic environment. This habitat is essential to many aquatic organisms and has also helped maintain the water quality of Clearwater Lake. As part of an effort to continue to protect this resource, AWRL was contracted for assistance in identifying locations of observable impacts to the lake. On December 2, 2008 and January 6, 2009, AWRL flew a Groundwater Intrusion Overflight (GWI), using remote sensing equipment. Approximately 9 miles of shoreline were flown with a Lake Buccaneer airplane and visible and hyperspectral images were taken with mounted and handheld cameras.

The purpose of the GWI was to detect locations of septic and groundwater influence, ultimately revealing point and non-point sources of nutrients destined for the lake. Once these sources are located and investigated, the concerned parties - whether they are governmental entities, industries, or homeowners- can prioritize actions to minimize the adverse impacts of the pollution. Successful efforts will result in attaining the ultimate goal of improved water quality, along with cleaner and healthier environment for everyone to enjoy. Specifically, this report can be used to achieve these goals by identifying and presenting septic systems and springs, or other conditions, which may affect water quality.

Methodology

For point and non-point source pollution detection, a GWI overflight is a successful methodology used providing a comprehensive view of the lakes, streams, wetlands, and adjacent upland areas. During the first phase of the GWI, AWRL's' Remote Sensing System recorded the shoreline with hyperspectral video cameras, in the visible through thermal region of the spectrum. The images presented are:

- Visible
- Thermal
- Chlorophyll *a*
- Near Infra Red
- Water Penetrating.

Next, the digital flight videos were transferred to still images; a special computer software program was used to replay and resize the flight data. The images were then correlated to geographic maps and analyzed for conditions that impact water quality. The meteorological conditions at the time of the two overflights were as follows:

December 2, 2008	
Temperature:	28° F
Sky:	Clear
Wind:	8 mph
January 6, 2009	
Temperature:	8° F
Sky:	Cloudy
Wind:	0 mph

Analysis Criteria

The focus of this study and the main content of the report is based on the analysis of the septic systems and groundwater intrusion or spring areas, and there impacts within the near shore areas. The warm areas indicated by white on the thermal images are interpreted to be septic systems located on the property or possibly buried material that is warmer than the surrounding area. Septic systems become point sources of pollution when they appear to be discharging to the surface or directly to the lake. Groundwater or spring intrusion areas are also indicated by warm areas on the thermal images. These locations indicate where water is entering the lake in the littoral or shore impact zone. Depending on the water temperature and nutrient component of the discharge, these areas form their own microenvironment for discreet biological communities. The criterion below was also used during this process.

Influences on Lake: Issues with an affect on water quality.

- Septic Point Source - pipe discharging directly into lake.
- Septic Non-point Source - evidence of septic leaching into lake.
- Springs – evidence of groundwater/springs in the near shore area.

Ordinance Non-conformity: Water quality influences based on local or county government ordinances.

- Lake Setback - dwellings set too close to the lake (<100').
- Lot Line Setback - dwellings that appear too close to property line (<10').
- Vegetative buffer less than 75 feet – lack of or amount of natural vegetative strip prior to waters edge or in the near shore area.
- Other - previously unspecified concerns.

Recommendations: Recommendations based on the list below and the previous two criteria.

- Septic/Wastewater Investigation - conduct an on-site inspection of septic system.
- Develop/Expand Vegetative Buffer.

Analysis Criteria Continued

The following information is the Crow Wing County Zoning Ordinances and was used during the evaluation process.

Lake classification:	Recreational Development
Setback:	
Structure	100 Feet from OHW
Sewage Treatment Systems (developed)	75 Feet from OHW
Sewage Treatment Systems (undeveloped)	100 Feet from OHW
Minimum Lot Width:	
Developed (single family dwelling)	150 Feet
(two family dwelling)	225 Feet
Undeveloped (single family dwelling)	150 Feet
(two family dwelling)	300 Feet
Lot Area:	
Developed (single family dwelling)	40,000 Square Feet
(two family dwelling)	80,000 Square Feet
Undeveloped (single family dwelling)	65, 340 (1.5 ac.) Square Feet
(two family dwelling)	130, 680 (3 ac.) Square Feet
Percent Impervious:	
Developed	$\leq$25%
Undeveloped	$\leq$ 15%

User Guide

In the front of the report, clients will find a topographical map, with numbered sites, which correlate with the image locations. The visible image for the detected site is presented first and may contain some colored ovals, circles or arrows indicating areas of interest. A Source Map Color Code is provided to supply information regarding the colors used to mark areas of interest. Three tables are provided below each set of images for each location recorded. The tables are: *Influence on Lake, Ordinance Non-conformity* and *Recommendations*.

Located beneath the tables are notes regarding each individual site. Implementation of the recommendations and notes are crucial to getting the full value of the GWI overflight study. Clients should use these important comments when developing ground truthing plans and priorities. Ground truthing is essentially an on-site validation of the concerns indentified in the aerial images. To ground truth a site, a trained volunteer from the Lake Association will use the report information and present the images and analysis to the property owner of each residence to educate the homeowners on problem areas and discuss the best management practices**.** AWRL can be retained to provide training for association volunteers, consultants or interns. Training is important to ensure that the ground truthing results are accurate and documentation of the observation is complete. It is important that the ground truthing experience should be cooperative and educational rather than threatening to the lakeshore owner.

Located at the end of the report are the summary tables. These tables look at the statistical data generated by the GWI. The data presented in this format is useful in:

1. Prioritizing ground truthing tasks.
2. Establishing budgets and financial requests for restoration of environmental concerns.
3. Establishing a statistical evaluation for ordinance and policy review.
4. Providing a historic record.

Conclusions and Recommendations

The following table presents the analyzed parameters:

Measured Parameter	Totals	Percent
Influences on the Lake		
Septic Point Source	*4*	*3%*
Septic Non-point Source	*19*	*13%*
Springs	*25*	*18%*
Ordinance Conformity		
Lake Setback	*50*	*35%*
Lot Line Setback	*0*	*0%*
Vegetative Buffer less than 75 feet	*39*	*27%*
Other	*27*	*19%*
Recommendations		
Septic Investigation	*68*	*48%*
Develop/Expand Vegetative Buffer	*37*	*26%*

Influence on Lake

The greatest influence on Clearwater Lake observed was the number of springs entering the lake. The locations of these springs' upstream sources should be determined and their headwaters protected. The protection of the springs is key to the sustainability of Clearwater Lake's high quality. The volume and nutrient loading discharged by the springs should be determined. It is recommended that the springs be tested for flow, total phosphorus, chlorides, nitrate, ammonia, total kjeldahl nitrogen, iron, pH and conductivity.

Ordinance Non-Conformity

The greatest non-conformity observed was lake setback. Of the 142 sites analyzed, 35% of them had dwelling set too close to the lake. Crow Wing County requires that dwellings be setback form the ordinary high water mark a minimum of 100 feet. When dwellings are located to close to the shoreline, erosion and runoff increase; subsequently, higher volumes of sediments, nutrients and pollutants are transported to the lake. When new development occurs the setback ordinances should be strictly enforced and existing structures should implement storm water runoff strategies to meet the intent of the zoning ordinance.

The residence located at Site 86.2 should be considered for the DNR's environmental friendly award.

Recommendations-Best Management Practices

The priority listing of best management practices are as follows:

1. Investigate the indicated septic systems and seepage areas for conformity and function. Nutrients may be entering the lake from these septic systems, contributing to the loading of Clearwater Lake.
2. Develop and/or expand vegetative buffers. This can be positively done by publicly recognizing property owners who have kept or restored buffers. The installation of these native vegetative systems will greatly lessen or eliminate the influence of stormwater runoff. The vegetation will also provide terrestrial habitat for the fish populations in the near shore areas, as well as provide aesthetic significance.