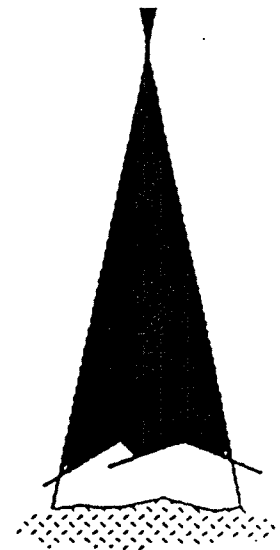


# ENVIROSCAN

AERIAL COMPUTER ENHANCED WEED/POLLUTION MAPPING SERVICE



## DEVILS LAKE AERIAL SHORELINE ANALYSIS

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DEVILS LAKE IMPROVEMENT DISTRICT  
NOVEMBER 1988

## **ACKNOWLEDGMENTS**

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## INTRODUCTION

As a result of man's activities in the watershed and shoreline development, many lakes are showing signs of progressively deteriorating water quality, which threatens the aesthetic, recreational and potable uses of the resource. Identification of potential sources of pollution and over enrichment to a waterbody is essential before control is possible. But determining point and non-point sources of contamination within a watershed or entering a body of water can oftentimes be difficult using conventional aerial or ground survey techniques. The need to document potential inputs quickly and accurately is crucial in the development and implementation of any watershed or lake management plan.

Aerial Shoreline Analysis (ASA) is a state-of-the-art remote sensing technique developed to detect and define potential pollution inputs to lake, estuary, and river systems in nearshore areas. ASA utilizes an aerial platform for data collection, that provide a more encompassing perspective of an area than that gained from ground level alone. The target shoreline is photographed in both the infrared and visible regions of the spectrum. Imagery data are analyzed for sources of contamination to the subject watercourse. More specifically, the methodology possible identifies point and non-point toxic, septic, runoff or other nutrient enrichment sources, effectively locating specific sites of suspected pollution for further ground truthing. The imagery data set generated by ASA provides a permanent record of current land use impacts on a waterbody that can be used for future comparisons.

Aerial Shoreline Analysis was conducted on selected shoreline areas of Devils Lake, Oregon. Objectives of this investigation were to provide Devils Lake Improvement District with a database that both identifies suspected pollution sites in nearshore areas of the lake and ranks severity of impacts on water quality. This information should be used by City staff to develop a ground truth sampling scheme to inspect specific areas of indicated pollution. Specific objectives of the investigation were to :

1. Conduct ASA on Devils Lake

2. Prepare a final report, including a complete set of imagery generated, tabulated analysis of each site, and a summary narrative describing general characteristics of and significant pollution sources detected.

We have endeavored to present the following technical information in a format that can be easily interpreted and applied by lake managers for enhancing the water quality of Devils Lake. The concise report is separated into a standard introduction, methods, summary results and discussion section, followed by a detailed results section containing tabulated data with location maps. In the methods section is a user's guide to aid in establishing a ground-truthing protocol. In addition, a complete set of infrared and visible slides are included.

## METHODS AND MATERIALS

### DATA COLLECTION TASK ONE

The data collection phase of the project included flight planning, flight operations, and processing of the imagery collected. The planning began in late Spring 1988 and continued throughout the summer due to weather conditions. Areas selected were for the most part developed lots with some serviced by on-site waste disposal systems, and were of concern to the lake management authorities. The entire lake shoreline was targeted for image collection in this case.

The data collection team obtained aerial section charts of the ASA target and operations area for flight planning and performed a preflight inspection of the survey areas. Flight planning for ASA programs included such factors as distance from the base of operations airport to the operations areas for calculation of fuel consumption and flight time planning, locations of the targeted areas, location of all obstructions to the data collection aircraft such as power transmission lines crossing rivers or lakes in the area, towers from television and radio stations in the general vicinity of the flight lines and an evaluation of airspace for controls such as Military Operations Areas (MOA's) and Military Training Routes, Low Level (MTR's). Also reviewed were all radio frequencies required for operations in the target area and all airfields that could be used for emergencies should any develop. All conditions that would have a possible impact on the data collection flights were highlighted on the operations aerial sections charts for review and use during operations.

A set of 7.5 minute quadrangle maps of all targeted shorelines were obtained for use in the flight and film catalog section of the flight planning. Sunlight conditions play a major role in overall effectiveness of the data collection missions utilizing the ASA camera system. From a planning standpoint, the target shorelines were plotted onto the 7.5 minute quadrangle maps and flight line and direction were plotted off shore on the same maps. These maps were used for the daily flight operations and as film cans logs.

The flight protocol for ASA mission requires that shoreline be filmed in both the infrared and color visible portions of the spectrum. Under the flight protocol, imagery was collected at the rate of approximately 10 frames per mile with each frame providing coverage of about 500 feet of target shoreline with a 20% overlap. In cases where the

aircraft encounters a sharp turn in the shoreline, the image collection is halted while the aircraft turns to a more accurate camera angle. In the data section of this report which follows, these turning points are evident when the same site appear from a different angle in the overlap.

### DATA INTERPRETATION

Editing of the imagery involves sorting by ASA flight codes for location and correlation to the map position. Flight target maps, flight film logs, and imagery codes were utilized to determine the map position for each image collected. New 7.5 quadrangle maps were used and each image position was coded onto the map for use by the interpretation team. New codes were assigned to each image for use in the interpretation and final report. These codes depict map position and location. While the Task 1 codes on the imagery was used to keep track of locations which were photographed, the new code is a map position which is easier to use by the interpretive staff and the client. These coded positions began at the starting point of the filming on the lake and proceed counter clockwise around the perimeter. This code system uses 1 as the first position and proceeds through the end of the imagery in numeric order.

The ASA interpretation protocol reviews each position for a number of parameters and conditions. The imagery was viewed through the ASA Image Enhancement System (IIS) to get an overview of conditions at that map position and zoom in on suspected problem areas. This system will load imagery for up to three consecutive map position in both the visible and infrared so the technician can have a continual view of the target shoreline. The imagery was collected with a 20% overlap to ensure survey continuity. The IIS provides setting for 20X and 80X magnification which allows both an overview and a close up look at any suspect sites.

The first step in analysis was to review the visible image to get an overview of conditions at that position. Lake bottom type, patterns of aquatic plant coverage, beach type and patterns, type and level of development and other land use practices are observed. Any visible differences in natural patterns were noted. The infrared image was then compared to the visible imagery, and each lot on both images was observed for conditions that would indicate point or non-point source pollution inputs to the lake. The 80X feature is utilized to review suspected pipe intakes/outlets and other conditions in greater detail.

For each map position under review, comments were recorded on a data file, and each position receives a check under one or more of the headings below as a quick reference guide.

A-Nonpoint Septic

B-Point Septic

C-Nonpoint Runoff

D-Point Runoff

E-Nonpoint Toxic

F-Point Toxic

G-No Apparent of Nutrient or Toxic Conditions

The format for the data section is outlined below with a typical set of comments included.

Map Position	A	B	C	D	E	F	G	#HOMES	RATING
43	.			.				6	5

At the left center of this position and on the beach is a suspected septic seep area as noted by the wet pattern on the beach. This is a suspected nonpoint nutrient source. To the immediate left of this seep is a defined area of macrophytes indicating seepage into the lake at this site. To the left of this is a white house. At the left of this house is a large white, suspected drain pipe that should be investigated for point source contamination. The upland area is natural forested.

All reproduction of the imagery was produced in slide format for inclusion in the final report. All data files were printed by the processing computer.

Finally, rating of each map position was also assigned on a scale of 1 to 5. The individual number and the corresponding meanings of the ratings are presented below.

1. Little or No Observed Problem Conditions
2. Minor Problems Observed
3. Some Suspected Evidence of Pollution Input
4. Many or Major Suspected Pollution Inputs
5. Suspected Major Problem Site

The rating system provides a level of problem assessment and was used to classify noteworthy conditions. These assessment rankings can be used to target areas of greatest concern for further inspection, sampling and corrective measures. Ratings in the 1 or 2 range have minor or no observed conditions that would lead to pollution of the lake involved. 3 is a mid range rating indicating that suspect conditions were present. The

ratings of 4 and 5 indicate significant problems exist at that position that warrant further investigation.

The imagery is attached as an appendix to this report. Each image is numbered and the number will correspond to an image position on the map in the results section. This map shows each image position as well as providing the rating and pollution input information. The code is: Image Position Number-Type of Pollution Input (see codes above), Position Rating (see codes above). An example would be: D26-A,E,5. This would mean that that was image position D26, that there were suspected impacts from nonpoint septic and nonpoint toxic, and that the rating for this site is 5.

#### USER'S GUIDE

It should be noted that ASA analysis is performed by technicians that have a wide range of experience in water quality problem and aerial imagery interpretation. The findings that are listed in the results section are a summary of the analyst's opinion of what is occurring at each location based on evidence contained in the imagery. In some cases, this evidence may be explained by causes other than those suggested in the analysis based on local information. It is important to review this data and provide additional local input where appropriate. For example, in Position No. 28 there is an area that shows typical signs of toxic inputs in the linear form of an unvegetated bottom within weed beds, and the evidence of disturbed soils on the upland areas. From just the imagery this appears to be an area where something has leached from under the trees into the lake. It was suggested at the meeting where this imagery was presented to interested parties that there had been a boat house that probably had been removed from this location. That would also explain the condition that is evident in the imagery. This type of input is critical in the end use of this imagery. As it is reviewed by local user groups, some of the conditions described will have simple explanations, but the majority will be suspected input sites.

The Aerial Shoreline Analysis data presented in this report should be used by the ground truthing team in the design of sampling methods aimed at quantifying nutrient and toxic loading into the waterbody in question. The first step will be to identify what sites to visit and how those sites should be sampled. For quick reference the first two lines of each image description identify possible types of pollution occurring at that location and also state the relative amount of evidence of contamination that can be defined by ASA, as

discussed above. Thus the sampling team will know if simple grab samples for nutrients will be most appropriate or if more sophisticated equipment and sampling regimen are required. For instance, is the source of pollution point or non-point pollution? For, non-point nutrient addition from septic sources is far more difficult to sample and define than is a piped effluent.

Another use of the ASA data is the estimation of types of water quality problems that a manager or regulating agency may have to deal with if water quality is to be maintained and/or enhanced. It can be determined by assessing whether a lake or river is being threatened by non-point runoff due to development pressure or if the use of on-site waste disposal is contributing to the loading of nutrients in unacceptable levels. It will also enable an agency to conduct an effective public education program to inform citizens of problems for which they as users of the system may be responsible. Watershed do's and don'ts are easily illustrated by comparing results of particular activities with contrasting practices. As an example, impacts on water quality due to over fertilization of lawns and gardens could be compared with non-impact yard practices.

## DISCUSSION

Collection and processing of aerial imaging for Devil's Lake was relatively time-consuming for a number of reasons. Several separate aerial missions were required to adequately collect imagery of the lake due to problematic weather conditions that complicated data collection. Also, delays were experienced in outside laboratory processing of infrared imagery.

The overall data that appears on the imagery collected for Devils Lake were quite good. ASA Methodology identifies areas of suspected point and nonpoint runoff, septic, and toxic conditions. Point source inputs are identified as those that originate from a pipe discharging into the lake. Nonpoint sources are those that show evidence of impacting the water quality of the lake, but flow from the source toward the water across or below the sediment surface. The only point discharges that were observed were from nonpoint storm water drainage effluents pipes. Straight pipe discharge from septic systems were not the evident at Devils Lake. There were however a number of areas identified that should be checked for suspected inputs of pollutants of a nonpoint source nature. This discussion will focus on the type and location of major impacts to the lake. The suggestions as to the type of impact on the lake should be used in future planning of remedial action.

Runoff conditions are evident in many areas of the lake. As a lakeshore community becomes increasingly more urban, and density of homes and buildings increase, the influence of stormwater runoff can play an increasingly important role in contributing nutrients to a lake system. With the advent of more development in the watershed, the possibility of more contaminants entering the lake is increased. As the lake is the low point in the watershed, over time any pollutant that is introduced into the system has the potential to move to the lake. The increased level of development also provides a more direct flow of water over impervious additions to the watershed. Many of the contaminants that would normally be filtered out by riparian vegetation and movement through the soil profile now move directly to the lake via surface water runoff. With this natural filtration removed, this flow directly contributes nutrients and toxics to the lake.

In the imagery collected for Devils Lake, there is considerable evidence of this type of overland flow pattern on developed portions of the lakeshore particularly along

the western shoreline. Specific instances are noted in the results section presented in the back of the text. In many cases, there is street runoff that flows directly into the lake. In addition, there is some evidence on the imagery that septic systems located on the lakefront can provide nutrient inputs via this route, as septic problems are indicated with patterns of nutrients migration into the drainage ditch systems that lead to the lake.

Septic systems serve a large number of homes on the Devil Lake Watershed, both in the nearshore and upland areas. The impact from septic systems on lake environments comes from two different perspectives. In cases where there is direct hydraulic failure of a septic system, there can be flow of both nutrients and pathogens into the lake from nearshore homes. In these cases, the drainfields will show up on the collected imagery in a couple of different ways. If a drainfield experiences hydraulic failure, septic leachate is forced into the drainfield in excess of the field's ability to handle the water volume resulting in a hydraulic failure that leads to leachate flow on the ground surface. Prior to the occurrence such a condition, ASA Imagery shows highly enriched areas in linear patterns in the drainfield area. Mortality to lawn areas over the drainfield can occur in extreme cases. Increased availability of nutrients as the septic leachate moves into the root zone of the grass will lead to luxurious growth in minor cases and actual death from nitrogen toxicity in extreme cases. These patterns will also continue to the lake in cases of extreme failure. There is evidence of this type of failure in the imagery that was collected for Devils Lake at certain sites, and these are pointed out in the results section.

In other cases where older systems are located near a lake, just above the water table, there can be a dramatic inflow of nutrients to the lake through ground water even if the system is not hydraulically failing. The lake edge intercepts and is an extension of the ground water table in the soil around the lake. This ground water table will follow the geology of the soils as it moves away from the lake, but in most cases, the on site sewage (septic) systems of shoreline homes are located very close to the ground water table. With a limited depth of the soil profile over the water table, these shoreline homes may over extend the capacity of the soil to cleanse waste water.

The key nutrients to control in lake management schemes are phosphorus and nitrogen. Nitrogen moves fairly well through the soil and can move right through a drainfield into the ground water if the drainfield is located too close to the water table. This will effectively provide a route of input to the lake by ground water movement.

Phosphorus is another by-product that will have a dramatic impact on the trophic state of the lake. Phosphorus is the key nutrient in most lake restoration schemes, because it is the limiting nutrient to aquatic plant production in the lake. By limiting phosphorus inputs to the lake, plant growth can be reduced over time and lake water quality improvements can occur.

An average family inputs about 10 pounds of phosphorus to a septic system each year. Phosphorus can enter the lake as result of conditions of direct failure as mentioned above, or by overloading bonding sites in the sediment under the drain field. Phosphorus is removed from septic effluent by adsorbing to charged sites on clay particles in the sediment profile. P is normally not mobile in soils because it has a high negative charge that will attract to the positive charged sites on soil particles forming a tight bond. When a system has been in use for an extended period of time, and the location of the septic field is near a lake or the ground water table limiting the amount of soil the waste water flows through before reaching the ground water, the sites available for P bonding can be used up over time. When the soil runs out of charged sites to bond Phosphorus, it will move into the ground water and flow toward the lake. Patterns that indicate this type of flow often appears in the aquatic plant beds offshore. At the point where the ground water table with a significant phosphorus load intersects the lake bed, aquatic plant growth is excessive and is distinctly banded. In extreme examples, this macrophyte banding can be traced direct by to the drainfield of the home situated on the adjacent lot. Under this condition, a septic system can be providing efficient treatment of waste water in terms of pathogens, and bacteria, but be moving nutrients directly into the lake. Phosphorus can flow into a lake even when a septic system works well if the sites in on the soil particles in the drainfield are taken with other charged particles. Soil types will also play a role here. Sandy soil will increase the flow of water through the soil, and limit the number of bonding sites for charged particles further. In many cases around Devil Lake, the soil types appear to have a considerable amount of sand in the mix.

A considerable number of sites portrayed in the imagery collected for Devils Lake show evidence of this type of introduction. Sites showing evidence of ground water movement are indicated on each of the image positions. This source of input to the lake could contribute a significant amount of the nutrients flowing into the system on a yearly basis.

As the City is considering options that would include the addition of sewer service to some of the outlying areas of the lake shore, both forms of enrichment from septic systems should be taken into consideration. As the majority of the homes on the lake are older, there could be considerable movement of phosphorus into the lake from systems that are not hydraulically failing. A number of these suspect locations are pointed out in the results section. It should also be noted that the ground water table is indeed very close to the surface, limiting the area that is effective in waste treatment on a majority of the nearshore lots. On the West Shore of the lake, there are a number of sites that show evidence of ground water flow into the lake from the bluff, with very little area for effective water treatment. Other problem areas are the peninsulas. These are highly developed, and there is very little relief from lake level to the highest elevation on these features. This would leave very little sediment profile available for waste water treatment and P bonding, and there is ample evidence on the imagery collected that there are problems in these areas. Both of the peninsula areas should be targeted as a high priority area for further evaluation based on ASA analysis.

Toxic inputs to lake environments have an impact on the overall water quality of the lake, and in extreme cases, endanger plant and animal life in the lake. Smaller toxic inputs to the lake such as those identified in the results section normally do not have the overall impact on total lake water quality that excessive nutrient loading will have, but they can be very damaging in the local area near input sites. These conditions are normally detected on the imagery as areas where there is an abnormal amount of dead vegetation or buildup on the lake bottom that is not in line with the baseline growth in that area. When this type of pattern occurs and is detected, it is analyzed in greater detail to determine if some type of correlation occurs with any other portion of the imagery.

The majority of the areas that have been identified as potential toxic sites in the results section seem to be associated with potential runoff or storm drain input sites to the lake. These channels or pipes could carry chemicals and other materials that are potentially damaging to aquatic plant life. When compared to septic and runoff inputs described in this report, the toxic inputs for this lake are minor and the effects quite local. These conditions should be examined as time warrants.



shows toxic effects along the shoreline and possibly into the water. Dead vegetation both on the bank and in the inside of the dock line are indicators of toxic conditions. This property also has substantial areas in the back yard that are exposed dirt with some garden activity present. This would be a runoff source as well for applied fertilizers and pesticides because of the lack of vegetation between the water and the exposed areas. There is evidence of nutrient movement in the drainage ditch that moves along the road leading to these shoreline homes on both the IR and color imagery. The two homes to the right of house 1 on this image show some indication that nutrients are moving to the lake possibly from a drain field. Many of the second tier of homes in this position show evidence of nutrient movement toward the lake as well.

D6	A	B	C	D	E	F	G	#HOMES	RATING
			•					16	3

A number of homes in this position show evidence of enrichment in the form of over-fertilization. Most notable are the levels present in the IR for the house on the left of the point at the entrance to the small cove. The homes in the cove are covered on an additional image position. On the right of the canal mouth is an area that is made up of exposed earth. This would be a source of sediment input to the lake during runoff periods.

D7	A	B	C	D	E	F	G	#HOMES	RATING
			•					12	3

This position is a close-up of the cove area that is pictured in position D6. There are 12 homes in this cove and these are included in the 16 homes recorded for D6. There are points on both sides of this cove where street runoff directly accesses the lake and would contribute nutrients and contaminants such as oils to the lake during rain events. The majority of these homes have landscaping that is well suited to lakeside environs. The lawns stop well short of the waterline and in many cases the homes use products like bark and gravel to landscape. That will reduce the input of fertilizers from these homes. However, the bark will contribute salts. The cleared lot on the right of this position on the point of the cove shows signs of toxic conditions. There are patterns on the pavement of the road draining across this lot to the lake. Where these patterns move from the pavement to the lot, the vegetation is absent. There are a number of piles and tires on this lot indicating that materials may have been deposited here. As dead vegetation occurs from these piles to the lake, they should be checked for toxics.

D8	A	B	C	D	E	F	G	#HOMES	RATING
			•					1	4

This position is dominated by lots cleared for development on the lake shore. There are several roads ending in cul-de-sacs in this image. Each of these is providing a runoff channel capable of moving materials to the lake. Both of these areas show distinct signs of runoff down the road and across the cleared lot at the lower portion of the image to the lake. The

circle on the left and above the shoreline shows evidence of oil deposits on the color image. Runoff moves from that point down and into an area that is cleared for construction to the next road end. From that point there is very clear evidence of sediment movement and erosion toward the lake. At the shore line, this water flow causes bank erosion, and deposits in the lake are visible. The lawn at the only home on the shoreline in this image position shows signs that are typically associated with a drainfield, note the lines in the lawn on the IR image. Between this home and the lake is an area that has been cleared. The exposed dirt is different from the surrounding geological formation indicating that it has been brought in for fill, or that it has been treated.

D9

A	B	C	D	E	F	G	#HOMES	RATING
.		.	.				4	4

This position shows the home described in D8 to the left of the image, one new home site in the center and 3 older homes on the right of the image. The home described in D8 has a number of areas on the inshore lake bottom that indicate fill material is moving into the lake during runoff. The next home to the right of this is under construction and the shoreline is tree-covered. There is a point source runoff area that originates under the trees on this lot and leaves deposition on the lake bottom moving to the right in a narrow band. This should be checked. The three homes to the right of this are older in construction and show evidence of drainfields that are in various stages of repair. The center home, blue and grey with a small peaked roof shows an area both on the IR and Color image that would indicate a failing system. The lawn appears dead and forms distinct H shaped patterns moving from the house. Excessive nitrogen often has this effect in failing drainfields. There are patterns on the lake bottom offshore of this home and the house to the right of it that indicate organic runoff entering the lake.

D10

A	B	C	D	E	F	G	#HOMES	RATING
.							6	5

This image shows the conditions described in D9 at the three homes in the left of the position. There is also a very evident band of macrophyte growth parallel to the shoreline in the area that would indicate subsurface movement of nutrients from the ground water into the lake. This area may be a source of septic inputs to the ground water. Each of these homes shows some evidence of organic build-up offshore in plume type patterns.

D11

A	B	C	D	E	F	G	#HOMES	RATING
.		.					3	4

This image has overlap from D10 on the left beginning at the trailers, and is dominated on the right by a large public access. There is organic deposition at the lot line between the trailers and the home to the right. Plant growth in that area would indicate nutrient inputs here. Moving to the right, the cove that is present is eutrophic beyond baseline levels of the lake in this area. Aquatic plant growth is excessive indicating input of nutrients at this location. There may be a stream or runoff impact here adding nutrients to the system. The IR image shows excessive fertilization of the lawns adjacent to the access. The set up of the

pavement in the access area allows direct access of runoff to the lake. The area on the lake bottom adjacent to the grey boat house shows a considerable amount of organic build up that is different from baseline conditions. There may be a runoff point from the road that runs behind the trees contributing to this deposit.

D12	A	B	C	D	E	F	G	#HOMES	RATING
	•		•					4	3

There are three homes and a trailer that dominate this position. The shoreline is steep and there is minimal lawn development at these homes. Emergent vegetation is growing in along the shoreline. The home next to the trailer may have some septic problems. Digging is evident in the color image appearing in the back yard of this home as straight line patterns. This area is red in the IR image. There is also evidence of runoff from the streets moving across the two lots at the trailer and the home to the right that may be impacting the lake.

D13	A	B	C	D	E	F	G	#HOMES	RATING
			•					5	3

These homes are on steep banks with limited use of landscaping. The offshore weed patterns would indicate that there is limited movement of nutrients through ground water. The lot with the A frame to the left of this position and the home to it's right show signs of runoff patterns from the surrounding uplands. Both lots have areas that are not vegetated contributing to this type of flow. There have been aquatic weed control efforts targeted toward the water lily growth at the new beach area in the center of the image.

D14	A	B	C	D	E	F	G	#HOMES	RATING
	•		•					7	4

The shoreline is heavily developed at this position. There is a pattern that should be investigated in front of the trailer in the left of this position. The lower level of this lot has a pattern that may be associated with a failing septic system as the vegetation is growing excessively in a linear pattern toward and into the water. There are organic deposits offshore from this line. The lots to the right of this trailer have areas that are not vegetated and could contribute sediment to the lake during storm events. The barge that is providing pile driving services has a number of oil barrels on the deck and evidence of spills on the deck. It could be checked for oil containment equipment.

D15	A	B	C	D	E	F	G	#HOMES	RATING
			•		•			6	4

This position is dominated by a cove with a wetland in the background and a grass carp exclusion structure in the lily bed centered in this cove. This area is highly productive and above baseline levels for this portion of the lake. Filamentous algal growth is heavy against the shoreline indicating nutrient inputs at that point. There may be a stream that contributes to the nutrient loading of the lake at this location in the back





there is a plume of organic material moving into the lake from this upland area. To the right of the yellow float there is another organic deposit that seems to be associated with a drainage ditch along the property line of the house with the white square on the roof. This channel would drain the street above. The IR image shows both deposits. On the right of the empty lot between the low brown house and the grey home is another site that has been impacted by runoff and possibly toxics. There is an area that is devoid of baseline vegetation which would suggest runoff inputs. For the most part, the homes show no sign of septic failure. The grey home mentioned above shows heavy use of fertilizer on the IR image.

D22	A	B	C	D	E	F	G	#HOMES	RATING
			•					5	3

This position is relatively free of evidence of nutrient or toxic inputs, There is one area to the right of the grey house that is a runoff input site. On the IR image there is sediment moving in a plume into the water. There is also an exposed construction site on the IR image, but the shoreline is well vegetated between this construction and the lake and there is no evidence of runoff.

D23	A	B	C	D	E	F	G	#HOMES	RATING
	•		•					5, Resort	4

On the left of this image position is a public access that receives drainage across several apartment parking lots . At this access there is a large amount of exposed sediment. The house with the red roof shows patterns in the front (lakeside) lawn that are normally associated with a drain field. In the apartment parking lot, there is evidence of movement of debris and toxics to the lake.

D24	A	B	C	D	E	F	G	#HOMES	RATING
	•		•					10	3

The resort lawn near the lake has been heavily fertilized compared to background lots. To the left of the resort and the right of the first home, there is evidence of a runoff channel. Note the grey structure moving up the hill away from the lake. There are a number of linear patterns in the lawn of the white ranch house with the large front yard that would suggest a buried pipe or septic system running toward the lake. The healthy grass forming this pattern is apparently receiving nutrients in greater abundance than the surrounding lawn, indicating that there is a concentration of nutrients in this area.

D25	A	B	C	D	E	F	G	#HOMES	RATING
	•		•					4, Motel	4

On the left of this image position is a home with a deck over the lake and a yellow boat in the side yard. There is a very defined runoff pattern from the road to the lake along this lot line, as well as evidence of toxic effects of the runoff on the vegetation. Aquatic weed control activities have been targeted toward the water lily growth in front of these homes. The house next to the one described above shows evidence of nutrient concentration

In the lower yard near the lake, as well as just off the left corner of the house. The motel area shows runoff patterns draining across the road and parking lot to the water. The hill is scarified from the parking lot to the left side of the dock. Adjacent to the small building with the motel sign is a lawn area showing high nutrient concentrations moving toward the lake. Possibly this area receives waste water from washing or fish cleaning activities. This could be an area of old septic influence as well.

D26	A	B	C	D	E	F	G	#HOMES	RATING
			.		.			1	4

In the cove to the right of the motel are two additional runoff sites receiving water from the uplands and parking lots. There is a fire pit in this image that is contributing organic material to the lake during runoff events. There is a white linear pattern in the lily growth to the right of this cove in front of the lawn area and exposed dirt. This may be an old dock structure but could be some type of toxic impact on these plants. This should be confirmed. At the end of the canal there appears to be a toxic effect on the vegetation, possibly from a runoff pipe or from the road.

D27	A	B	C	D	E	F	G	#HOMES	RATING
			.	.				0	3

This position is mostly marsh land. There is a very evident drainage canal from the golf course across the highway that could contribute fertilizer and pesticides to the lake during runoff events. The aquatic plant growth in this region would suggest that nutrient levels are high here. There are no evident toxic impacts on the plants that would indicate herbicide movement however.

D28	A	B	C	D	E	F	G	#HOMES	RATING
			.		.			0	2

This position is totally undeveloped marsh land. There is one access point that is used for fishing and swimming. Street runoff can reach the water here and there is a lack of aquatic vegetation from the baseline levels in this area that would suggest that there is some impact on the growth. The fact that this impact is evident in a defined region and not totally adjacent to paths would suggest that there may be some movement of compounds that would impact vegetation. This trail should be checked for dump sites and trash.

D29	A	B	C	D	E	F	G	#HOMES	RATING
	.		.					5	4

The left half of this image is largely forested. There are a number of dead trees in this forest area. There is no distinct pattern to this mortality so it could well be normal. The first three home show little evidence of nutrient contribution to the lake. The first is new construction and the lot largely undeveloped. The next two lots are landscaped with natural materials that do not require fertilizer use. This landscaping leaves a direct path for storm water runoff to the lake down the street and across

this driveway. The last two homes show evidence of septic systems that may be impacting the lake. The low blue home on the right of the image shows signs of nutrient movement from a drain field, but there is new fill behind a bulk head that may limit further impact to the lake in the short term. These two homes are discussed further in the next position.

D30

A	B	C	D	E	F	G	#HOMES	RATING
.		.		.			6	5

There is a large area that shows some type of toxic condition to the left of the lot line of the yellow house (this is also pictured on position D29). This area is under the tree line and shows up as various shades of grey and yellow in the lawn. Directly offshore from that area is a region of dead water lilies that is in a direct line from the lake to road. There may be a correlation between these two conditions. Each house in this position shows evidence of septic systems located very close to the lake. These patterns are most pronounced on the two lots in the center of the image with boat houses 10 feet apart. The home on the left appears to have dead grass in a linear pattern just in from the lake. There is also some type of toxic pattern in the lawn at the end of the drive next to a trash pile. The next home also show nutrient movement toward that water from the area next to the junk pile. IR imagery also demonstrates this pattern. The next to the last home on this position shows drainfield septic patterns as well on both the color and IR imagery.

D31

A	B	C	D	E	F	G	#HOMES	RATING
.		.					6	4

There is apparently a drainage pipe at the waterline about 20 feet to the left of the red boat house in the vacant lot in the left center of this position. Most of the homes on this image show signs of septic systems and nutrient enrichment in very close proximity to the lake. The home to the right of the boat house mentioned above shows signs of toxic effects and high enrichment in the same area. This often indicates that there is a failing septic system present. To the right of this home is a vacant lot and the next home has a very heavily fertilized lawn on a steep slope over the lake. This would add nutrients during runoff events. The last home on this image, the light blue home with the camper out front also shows signs of septic failure.

D32

A	B	C	D	E	F	G	#HOMES	RATING
.	.						2	5

The home with the white hobie cat and the orange deck furniture shows very probable signs of septic failure and lake impact. There are a number of toxic spots in the back lawn moving right to the lake shore bulkhead. At the point where this pattern meets the bulkhead, there is a substantial isolated pattern of aquatic growth.

D33	A	B	C	D	E	F	G	#HOMES	RATING
	.							7	3

The majority of these homes are on a bank over the lake and are heavily wooded with minor landscaping. The nutrient contribution of these homes appears to be low with the exception of the home mentioned in D32. Offshore patterns would indicate that also.

D34	A	B	C	D	E	F	G	#HOMES	RATING
			.		.			12	3

The three roads which access the lake are likely sources of runoff during periods of rain. The white house with the new wood deck appears to be a source of nutrient loading, the wooded lot should be checked for trash dumping. The white house immediately left of the wooded lot has a dead lawn and comparatively clean waterscape, caused perhaps, by toxic input. There have been aquatic weed control activities performed here; note the straight line pattern in the lily growth to the left lot line of the home with the T dock

D35	A	B	C	D	E	F	G	#HOMES	RATING
			.					6	3

This shoreline is relatively clean, save for the growth off of the wooded lot. This is the area noted for run off in #D34. There is straight access for runoff from the paved road to the lake at the public access for nutrients and road oils to be washed down. The only other growth is off of the red house with the backyard greenery which appears to be heavily fertilized. There is a void in the vegetation that would normally be associated with toxic conditions in front of the three homes in center image. This could also be a result of grass carp feeding.

D36	A	B	C	D	E	F	G	#HOMES	RATING
			.					9	4

Growth here is correlated with the two houses on the slight bluff on the pictures left, which also coincides with the junction of several paved roads which would greatly accelerate the flow of nutrients to the water. A goodly amount of landscaping has been performed around the two houses to the right of the aforementioned homes. This could lead to increased run off due to the bare soil, and the likelihood of increased fertilizer use on these properties. The new fill area has a wet spot with clear flow to the lake on the left of the spot. The home with the A frame type roof shows signs of septic system within 10 feet of the shoreline, with bleached areas visible on the color image in a linear fashion and evidence of over enrichment visible on the IR. There is an organic buildup in a linear pattern in the water off this home as well that could be a plume. The lawns overall provide a great amount of nutrient load, as clippings or other debris are dumped in the woods and in the low bushes near the waters edge of the canal as the IR indicates.

D37

A	B	C	D	E	F	G	#HOMES	RATING
.		.					4	5

The heavy growth of lilies is in the area formed by two slopes meeting in a short canal, the same situation as the previous shoreline. This is the richest bay yet in terms of aquatic plant growth and there is drainage from the area of the golf course. Each home on the left of the canal shows movement of nutrients toward the lake. There are a number of hot spots in the lawns, and on the IR imagery each of these lots show higher levels of enrichment with increased proximity to the lake. There is also areas that have been dredged to within feet of the homes. There is very little room for a septic system on these lots and the drainfield would be within feet of the lake. Direct access is a possibility. There are also piles of plant matter being left at the head of the canal which will leach into the water.

D38

A	B	C	D	E	F	G	#HOMES	RATING
		.					10	5

This canal acts as a catch basin for runoff from the surrounding slopes and possibly, the golf course. Every home on the image to the right of this canal shows evidence of septic failure, each home has a pattern of organic deposition on the areas just off the lot into the lake. The sites resemble plume conditions and originate from a source point. This shoreline is below a sloping neighborhood of homes. The road running perpendicular to the shore is acting as a channel for nutrients to empty into the lake in the vicinity of the empty wooded lot. There is evidence of a failing septic tank at the small house with a brown roof and blue garage, uphill from the rightmost home on the shoreline, leading straight down to the plant growth offshore. This is the most obvious evidence of septic failure so far observed.

D39

A	B	C	D	E	F	G	#HOMES	RATING
.		.					5	5

The shoreline has houses on bluffs ranging from gentle to steep slopes, all of which are below another hill with homes on it. There are two roads acting as nutrient chutes to the water. Additionally, the house on the far right of the slide nearest the canal has a unusual pattern in the lawn on the IR imagery. This could be some type of drainage or a fertilizer application that was made incorrectly. The house with the A frame roof and deck show signs of nutrient movement to the lake from an area associated with the drainfield. This is evidenced by IR imagery that shows a pattern of enrichment moving to the shoreline and an established bed of emergent grasses at the end of this trail.

D40

A	B	C	D	E	F	G	#HOMES	RATING
		.		.			1	4

The paved surface of the main road running uphill, away from the basin, facilitates downhill transport to the lake. The dead vegetation at the junction of the two roads indicates the presence of a toxic source, perhaps

extending down from the house which has large sections of dead lawn, located above the junction. There is some evidence of sedimentation entering at this point in the water on each image. Note the coloration of the water in this area.

D41	A	B	C	D	E	F	G	#HOMES	RATING
					.			1	2

These slides present another view of the canal area described in slide #D40. One can see that dumping of some sort has been occurring on the slope which was not seen in slide #D40, and that vegetation has been completely denuded in this area. Possibly this is a construction start up site. There is considerable sediment visible in the water in both the color and IR image. The one house in this image shows signs of organic matter contribution to the lake, as there is deposition of organic matter to the left of the lot

D42	A	B	C	D	E	F	G	#HOMES	RATING
		.	.					5	2

This shoreline is fairly clean of growth, except for the proliferation of lilies in the area of the wooded lot. The lilies are also near docks, which may indicate septic outflows. The wooded lot may be used for dumping refuse.

D43	A	B	C	D	E	F	G	#HOMES	RATING
	.							3	3

The homes in the center of this slide show a number of points at which organic materials are moving into the lake. On both sides of the red boat house are input points, the site on the right runs through an area which contains dead vegetation. To the right of this is an area that has two homes spaced very close together which can result in insufficient septic drainage space. There are similar observed nutrient inputs in this image.

D44	A	B	C	D	E	F	G	#HOMES	RATING
	.		.					3	3

The new fill area appears to have been placed over a small inlet to the lake, there is some evidence of nutrient movement in the exposed dirt demonstrated by the established growth moving linearly towards the water. The fill over the stream or inlet may mask other nutrient sources as well. The next home shows some evidence of a drain field in the back yard, but there is good buffering between it and the lake. In the compound of homes to the right of the image, large areas of pavement and landscaped grounds, built on a slope, would greatly increase loading of nutrients from back lots. There is a pipe visible next to the boat house on the covered lot in center image that should be checked to see if it is drainage or irrigation intake.

D45	A	B	C	D	E	F	G	#HOMES	RATING
		.	.					3	3

There is a pipe extending outward, just to the right of the grass carp enclosure in the water, between the enclosure and the long white dock. It is in this area that the majority of growth is occurring. Septic release would be causal in this type of situation. Additionally, the house above the long white dock has a well fertilized lawn, relative to the surrounding land, contributing to the nonpoint runoff. The pipe could be drainage, based on it's size , but is also has a float marker on it which could mean otherwise.

D46	A	B	C	D	E	F	G	#HOMES	RATING
	.		.		.			5	3

There are signs of toxic effects on the lawn in front of the cabin (with the dormer window) on the right of the slide, in a pattern moving towards the water. This could be from failing septic system or from some other contribution of the home. The other lots to the left of this home show some evidence of slight septic system related enrichment, but no major failures. The large tree near the bottom right of the slide has been impacted and is dying. There are also large patches of vegetation missing or dead throughout this area and long gravel driveways, increasing the rate at which nutrients may access the water

D47	A	B	C	D	E	F	G	#HOMES	RATING
			.					1	(summer camp)
			3						

The summer camp grounds see an enormous amount of human activity during the summer months. These grounds have been reduced to an almost bare dirt status. Those two factors would exacerbate normal runoff incomes. There are no visible signs of septic problems in the lawns near the cabin by the pool, but there is high growth patterns in the lake near the end of the tree line, indicating that nutrients may be moving down through this area in a drainage ditch.

D48	A	B	C	D	E	F	G	#HOMES	RATING
			.					1 +	5

The "+" is for the camp discussed in #D47. An identical situation exists for this camp area . At the end of the cabin line on the right of the resort property is a small building that is showing signs of septic failure. There are linear patterns moving in a line away from the building to an area which appears to be a drain field, that has caused toxic impact to the lawn. The tree line behind this area may carry drainage to the lake as there is organic build up in the water off-shore. Each cabin shows nutrient movement toward this tree line. The house to the right of the resort has a bulkhead between it and the water, reducing the amount of runoff into the lake and lessening the plant problem off their shore, relative to the summer camp.

D49	A	B	C	D	E	F	G	#HOMES	RATING
							.	7	3

This shoreline shows a gradual increase in plant growth from no growth at the leftmost house, to medium growth at the middle homes. The homes to the left of this position seem fairly clean. There is some organic build up off the dock at the home with the radio transmission tower. There are a number of homes crammed into a small neck of land, on small lots with little room for septic tanks and functional drain fields. Each of these homes show some signs of drain fields in their yards, but no major problems are visible. The area is relatively flat and does not seem to be suffering from runoff problems.

D50	A	B	C	D	E	F	G	#HOMES	RATING
	.							5	4

The homes to the right of the wooded lot show signs of septic inputs. There are heavy organic buildups off each lot, especially the two lots on each side of the covered boat dock to the right of the people in the water. There are three structures on this property which show nutrient movement patterns in the lawns moving to the water from the home on the left.

D51	A	B	C	D	E	F	G	#HOMES	RATING
	.							2	3

The new home shows signs of organic sediment build up on the bottom, just off the boat house. This may be coming from the tree line and lot to the left of the new home. There is little additional evidence of impact on this position.

D52	A	B	C	D	E	F	G	#HOMES	RATING
	.							7	4

The heavy growth of dark, organic matter off the properties is indicative of a failing septic field. There is a line in the water just to the left of the point which leads to the mass of organic matter, and there is also a dark band of green on the lawn of the house near the point which may indicate a failing system. The houses are situated quite closely together which may not be allowing for a sufficient drainage field.

D53	A	B	C	D	E	F	G	#HOMES	RATING
	.							1	4

Basically the same shot as described previously. The line from the boat shelter in front of the hobie cat is very evident here. This should be traced back to it's origin under the tree cover. There is a band of organic material along the point, extending to the swimming beach. This could be coming from the septic problems of the previous image position.

D54

A	B	C	D	E	F	G	#HOMES	RATING
.							1	2

The shoreline is fairly clean. Some of the septic impacts from the homes around the corner are apparent to the left of the swimming area.

D55

A	B	C	D	E	F	G	#HOMES	RATING
.	.						7	5

There are three sites in this area which appear to be septic related. There is a hot spot on the house lawn five docks to the left of the right hand side of the slide, indicative of a failing system. Finally, there are linear patterns on the lawn of the house on the point which could be a bad drainage field.

D56

A	B	C	D	E	F	G	#HOMES	RATING
.							8	4

The lawns in the area to the right of the canal show symptoms of septic problem. There is a linearity to the dead spots which is representative of failing fields. The property on the left hand point, adjacent to the left canal, shows a high degree of fertilization, particularly in relation to the surrounding areas.

D57

A	B	C	D	E	F	G	#HOMES	RATING
.							9	4

This area also shows the same (though less pronounced) mottled, patterned lawns indicative of septic leakage. The last house on the right in particular, shows symptoms of septic failure when seen in IR.

D58

A	B	C	D	E	F	G	#HOMES	RATING
.		.					3	4

This area suffers from the same problems shown on the previous slides of the same area, it is especially evident in the front lawns on the last 7 homes. Additionally, there is an accelerated runoff due to its location under a steep slope, near two paved roads. There appears to be a great deal of organic matter at the end of the canal which could also be caused by the failing drain fields.

D59

A	B	C	D	E	F	G	#HOMES	RATING
		.					0	3

This position shows the front yard mentioned on the previous image. This small finger of land extends from the road. There are no houses on it, but its proximity to the nearby houses and their septic systems have helped to generate lily growth which can continue to get nutrient input from runoff

from the surrounding slopes . There are a number of piles of wood that appear to be set for burning. This material would enter the lake after a burn during a storm event.

D60	A	B	C	D	E	F	G	#HOMES	RATING
			.					0	1

This is a slightly different view of the previous slide area.

D61	A	B	C	D	E	F	G	#HOMES	RATING
	.		.					3	3

These homes are built on rather steep slopes located directly below another hill. Terracing as was done here is very helpful in easing nutrient input during rainfall, but will not eliminate it. There is evidence of septic or runoff problems at the large blue house at the extreme right. One can see a streaked pattern near the shore which shows up in the IR imagery. This pattern may be caused by septic leakage.

D62	A	B	C	D	E	F	G	#HOMES	RATING
			.					6	3

This heavily wooded slope appears to get most of its nutrient input from the surrounding hills, particularly the recent landscaping of the large house in the upper right which removed a great deal of ground cover. There are organic deposits in a number of areas here that indicate runoff into the lake.

D63	A	B	C	D	E	F	G	#HOMES	RATING
	.							2	2

The drain field in the lot in mid-picture is showing some signs of septic tank problems. It is much more evident in IR imagery, appearing as a pattern moving towards and into the lake.

D64	A	B	C	D	E	F	G	#HOMES	RATING
							.	1	1

There is no evidence of nutrient input in this imagery

D65	A	B	C	D	E	F	G	#HOMES	RATING
			.					1	2

There is quite a bit of organic growth in this area, particularly near the point. There is very little development here, which leads one to think that there must be extensive runoff from the surrounding hills and/or dumping being done in the wooded area near the point.





D74	A	B	C	D	E	F	G	#HOMES	RATING
			.					0	2

On the left is the construction and bare ground mentioned in the previous image. The runoff from this lot appears to be impacting the wetland vegetation. The IR images show a band of dead vegetation adjacent to the graded area. This undeveloped piece of land would appear to be receiving nutrient input from its proximity to the nearby road. There is a dead spot on the slope near the road which may be from erosion or from use as a parking spot.

D75	A	B	C	D	E	F	G	#HOMES	RATING
			.		.			0	3

This undeveloped land looks to be a site for some type of dumping. There are piles of junk on the shoreline and dead vegetation between this trash and the lake. There is also trash just off the road near the shoreline and evidence of vegetation loss near the shore.

D76	A	B	C	D	E	F	G	#HOMES	RATING
			.		.			0	2

This park shows a dramatic absence of lilies right off the boat launch. This may be the result of a boat traffic, or it may be due to the inflow of auto exhaust, gas and oil from the long parking lot. There is straight runoff to the lake on this road. There is also some organic build up just off the picnic area.

D77	A	B	C	D	E	F	G	#HOMES	RATING
			.					0	2

This is an undeveloped piece of land with no apparent nutrient income. There is, however, what appears to be a farm just visible in the upper part of the slide. If so, farms are excellent sources of fertilizer runoff into the system.

D78	A	B	C	D	E	F	G	#HOMES	RATING
			.					0	2

See above #D78.

D79	A	B	C	D	E	F	G	#HOMES	RATING
							.	2	1

The homes are on a bluff over the water. The lake here is well protected with a fringe of wetlands that would help to absorb nutrient inputs from these homes and streets. There are no evident toxic patterns in this wetlands.

D80	A	B	C	D	E	F	G	#HOMES	RATING
							.		1

The homes are on a bluff over the water. The lake here is well protected with a fringe of wetlands that would help to absorb nutrient inputs from these homes and streets. There are no toxic patterns evident in this wetland.

D81	A	B	C	D	E	F	G	#HOMES	RATING
							.	0	1

The homes are on a bluff over the water. The lake here is well protected with a fringe of wetlands that would help to absorb nutrient inputs from these homes and streets. There are no evident toxic patterns in this wetlands.

D82	A	B	C	D	E	F	G	#HOMES	RATING
			.					0	1

There is a runoff channel down the road which has cut into this bank. The homes are on a bluff over the water. The lake here is well protected with a fringe of wetlands that would help to absorb nutrient inputs from these homes and streets. There are no evident toxic patterns in this wetlands.

D83	A	B	C	D	E	F	G	#HOMES	RATING
							.	0	1

There is no development here with the exception of the fill area that is used for lake access, and the boat launch in the back of the canal. There is no evidence of inputs from these properties. The rest of the shoreline is wetland.

D84	A	B	C	D	E	F	G	#HOMES	RATING
			.					6	2

There three causal features in this slide which will greatly exacerbate the runoff of nutrients into this area; the presence of a large apartment complex and homes on a bluff, the amount of paved land near waters edge and the large dirt parking lot across the canal at the bottom of the slide. These three items will markedly increase runoff nutrient input into the lake.

D85

A	B	C	D	E	F	G	#HOMES	RATING
		.					2 +	2

Great amounts of paved roads and parking lots, and intense development of the area will be necessarily increasing the runoff. The presence of RVs could result in the dumping (legal or otherwise) of grey and black water tanks into the surrounding bushes or water. These homes do not have any area available for septic systems. The assumption is that they are on city sewer systems. There is a dredging program in progress on the IR imagery. The sediment containment structure appears to be doing a good job of protecting the lake.

W I L D L I F E R E F U G E  
W I L D E R N E S S

LINCOLN CITY

Wecoma Beach

BM E 192  
99  
Oceanlake

BM F 661  
23  
D RIVER  
STATE WAYSIDE

De Lake  
Canyon Drive  
Park

Nelscott  
BM L 295  
387

50000  
FEET

4982

4981

4980

4979

57' 30"

4978

4977

