

# Sampling Plan to Determine the Cause(s) of Taste and Odor-Causing Compounds in Lake Mary, Arizona.

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## **Goals and Objectives**

The ultimate goal is to determine those species capable of producing the taste and odor (T&O) causing compounds, 2-methylisoborneol, geosmin, or cyclocitral. It is believed that the majority of the T&O compounds within the lake are produced by cyanobacteria but little data exists to prove or disprove this fact. Cyanobacteria, while more closely related taxonomically to prokaryotic bacteria, behave ecologically much closer to true algae. Specifically, the goal of this project is two-fold; identify and isolate those cyanobacteria capable of producing T&O compounds and secondly to determine those limnological conditions conducive to their growth so that lake management activities can be recommended to decrease the overall biomass of cyanobacteria. To achieve this goal requires explicit understanding of reservoir limnology. Such a perspective should ultimately be tied to engineering and/or lake management solutions aimed at alleviating the T&O problem.

To date, the only lake management activity has been the installation of a lake circulator in an attempt to increase mixing zone area and reduce cyanobacterial biomass. Lake circulation as a stand-alone operation rarely results in achieving all desired goals and outcomes. Rather grandiose claims are sometimes made about the ability of lake circulation as a panacea for all lake restoration. Achieving desired goals and objectives in a lake or reservoir almost always requires a combination of management activities/restorative techniques that are specifically tailored to the lake or reservoir in question. What often works in one lake, reservoir, or general area does not work as effectively in another. Another goal of this project should be to examine the efficacy, and associated limnological changes, of lake circulation in achieving the desired goal of reducing T&O compounds being produced within the lake.

Lastly, realistic goals, objectives, and timeframes need to be realized early in the process. There very likely will not be a magic bullet or panacea by which the reservoir is instantaneously “fixed”. It usually takes a good bit of trial-and-error, and time, to achieve desired goals and objectives. Additionally, reservoir water quality is constantly changing due to climate, watershed inputs, fluctuating water levels, seasonality, etc. Therefore, lake management should be on-going and pro-active in order to address these changes. Ultimately, it is far less expensive to solve water quality problems, including T&Os, at their source rather than at a treatment plant.

## **Sampling Plan**

In order to cover as much spatial variability as possible, in the most parsimonious fashion, means careful selection of sampling sites. Reservoirs usually exhibit zonation not only throughout the water column but also longitudinally from incoming river to dam. There are, at a minimum, three zones each described below.

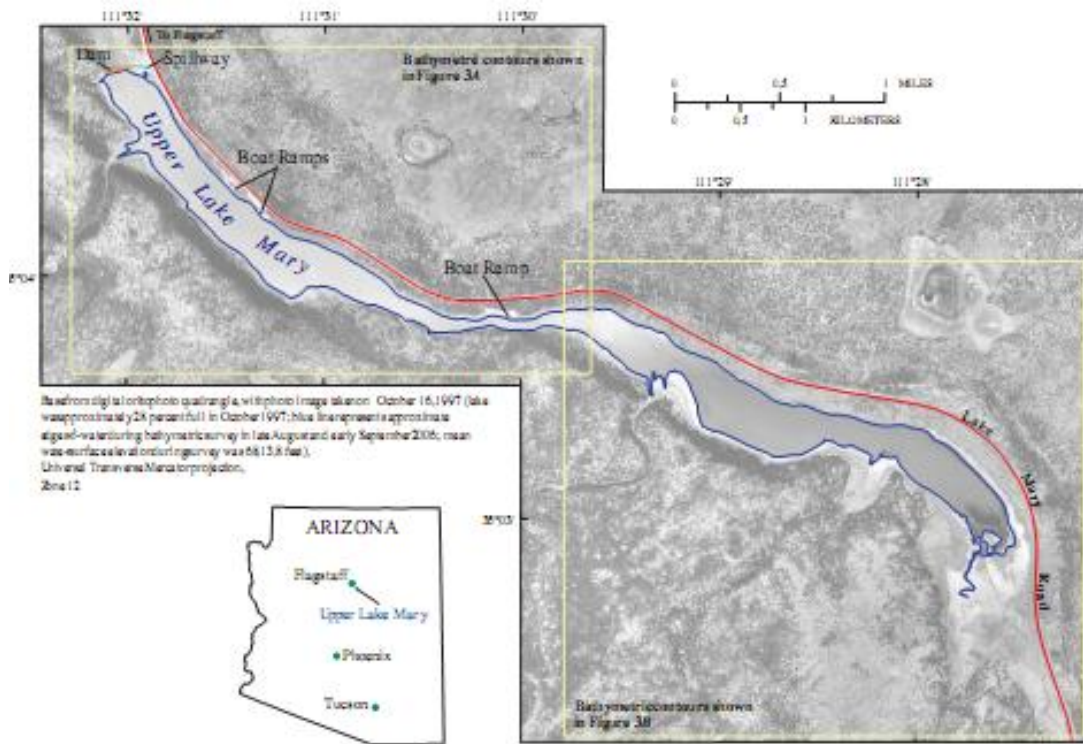
Riverine – Closest to the incoming water source. Usually the most turbid and productive in terms of algae growth.

Transitional – Intermediate in primary production and found between the riverine area and dam.

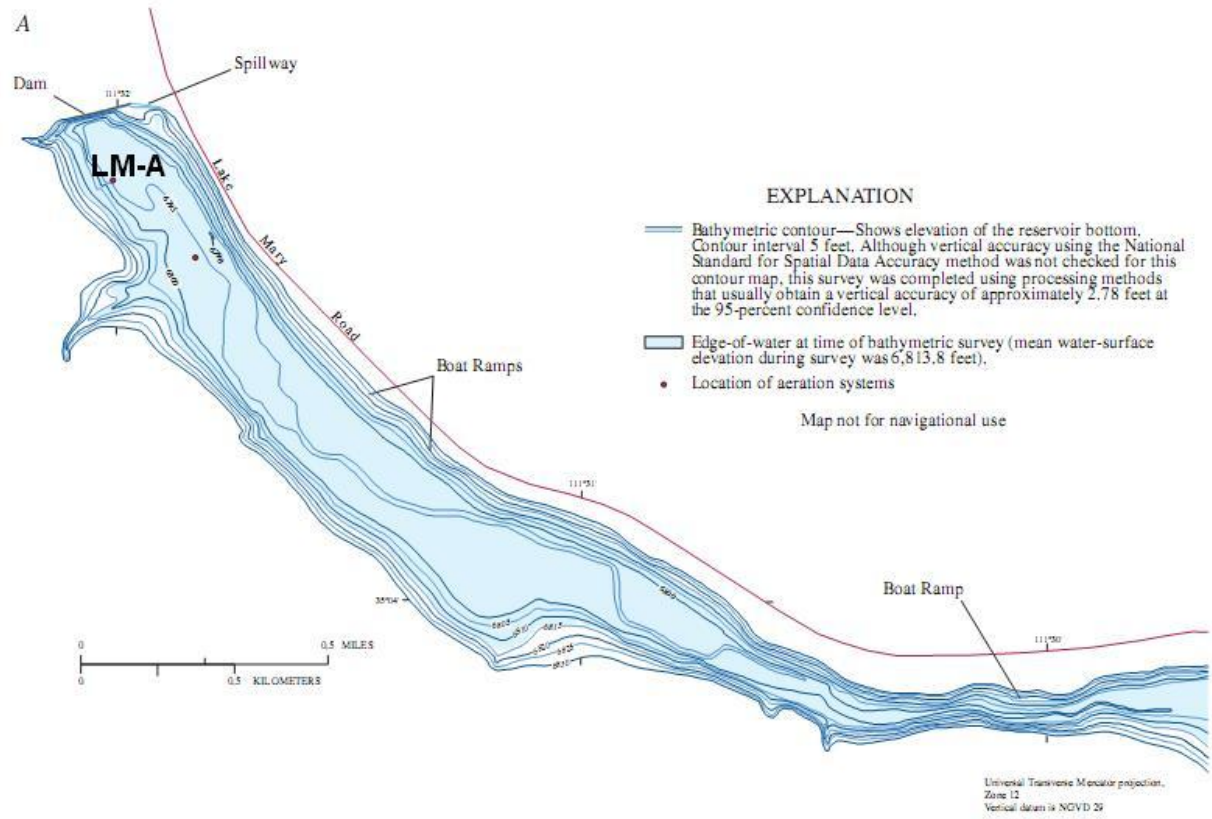
Lacustrine – Usually the lowest in primary production and algae growth. Most suspended sediments have fallen out of the water column and the water is generally clearer. This is often the most “lake-like” area of the reservoir.

The following figures are from the USGS Open File Report 2008-1098 entitled *Bathymetric Survey and Storage Capacity of Lake Mary Near Flagstaff Arizona*. Suggested sampling sites are overlaid onto Figs 2 and 3 that would encompass a minimum amount of spatial variability of the zones described above.

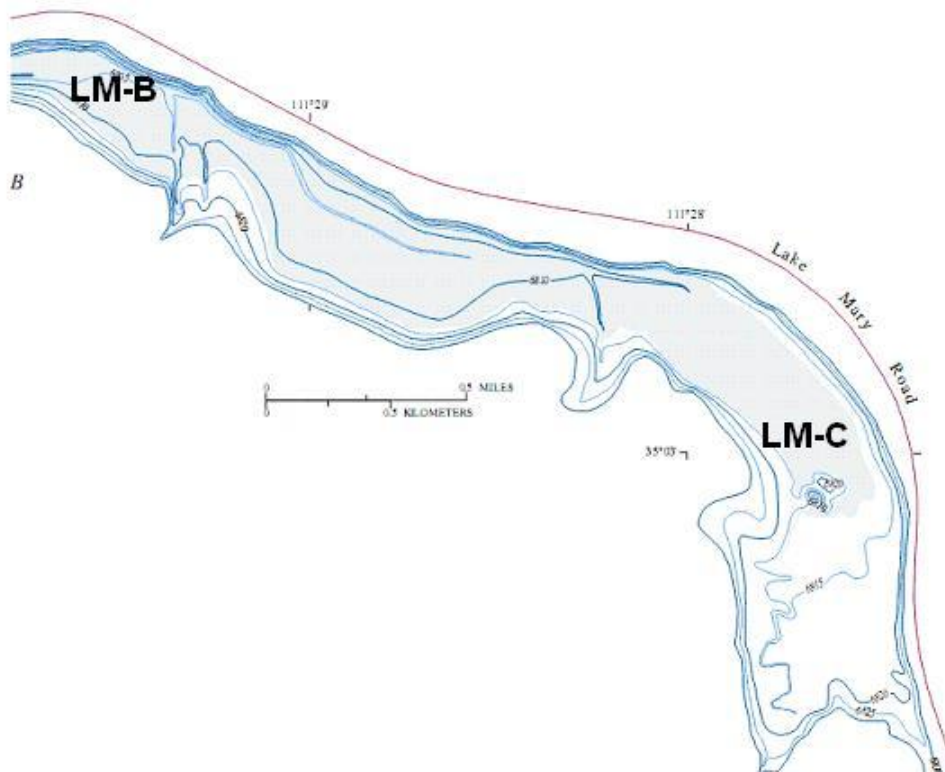
**Figure 1.** Imagery and aerial photography of upper Lake Mary, Arizona



**Figure 2.** Bathymetric map showing the location of site LM-A



**Figure 3.** Bathymetric map showing the locations of sites LM-B and LM-C.



At each site, profiles should be taken through the water column of water temperature, dissolved oxygen (mg/L and % saturation), pH (SU), specific conductivity ( $\mu\text{S}/\text{cm}$ ), and ORP. Measurements should be taken from just below the water surface to 0.2 m. above the sediment.

A 4-liter beta-style sampling bottle should be used to collect the following at each site:

- Total alkalinity and hardness
- Fe and Mn (total and dissolved)
- Total phosphorous
- Ortho-phosphate
- Ammonia
- Nitrite
- Nitrate
- Total Kjeldahl Nitrogen
- Total Organic Carbon
- Dissolved Organic Carbon
- 2-methylisoborneol
- Geosmin
- Chlorophyll/Pheophytin *a*
- Algae count and identification.
- Turbidity

Minimum detection levels for nutrient concentrations (total P, ortho-P, ammonia, nitrite, nitrate, and TKN) should be biologically relevant (down to 0.02 mg/L or less).

The depth(s) from which samples should be collected depends on reservoir conditions. For example, it's doubtful site LM-C is deep enough to warrant collecting samples at depth surface samples should be adequate. If the reservoir is not thermally stratified, collecting from just below the waters surface and 0.2 m above the sediment should suffice for site LM-B and LM-A. If the reservoir, or any particular site, is thermally stratified samples should be taken from just below the waters surface, immediately above the thermocline (identified as the greatest change in water temperature), and 0.2 m. above the sediment.

Dissolved Fe, Mn, ortho-phosphate, and dissolved organic carbon should be filtered from the beta-style sampling bottle directly into the bottle used for transport using a peristaltic pump, clean silicone tubing, and a 0.45µm filter capsule.

Secchi disk depth should be recorded at each site.

In an effort to concentrate algal cells from within the lake, plankton tows (using a 10-20µm Wisconsin-style plankton net with reducing cone) should be performed. Tows should be just below the waters surface from site LM-A to site LM-C. If algal biomass is high and clogging of the net occurs, samples should be collected at some mid-point, the net emptied and cleaned, and the tow continued. In order to quantify algal cells, the exact distance traveled (or the volume of water through the net) needs to be collected in the field.

Because T&O causing cyanobacteria can also grow periphytically, artificial substrate samplers (inert clay or concrete bricks attached with either rope or stainless steel chain placed into the water at depth near the surface, a mid-point, and 0.2 m. above the sediment) should be used. Samples should be collected from this artificial substrate using butyl rubber with a 1.0 cm<sup>2</sup> square cut into it. This template should be placed over the substrate, the area of the opening brushed using a toothbrush, and the toothbrush rinsed using DI water into the sample bottle.

All algae samples (tows, periphyton and phytoplankton) should be placed into 500 – 1000 mL, plastic, amber bottles and preserved with Lugol's solution so that the final dilution in the sample bottle is 4-5%

### Sampling Schedule

Generally, sampling should occur weekly during the growing season and bi-weekly during the rest of the year. During the winter, it is common for a thin layer of ice to form on the reservoir. This makes using a boat unsafe and the ice is too thin to walk on. During this period, sampling can only occur off of a pier.

The following sampling schedule is advised.

May – October: Weekly

Nov. – April: Bi-weekly (during ice-over, only pier sampling will occur)