Monitoring to Determine Geosmin Sources and Concentrations in a Northern Colorado Reservoir

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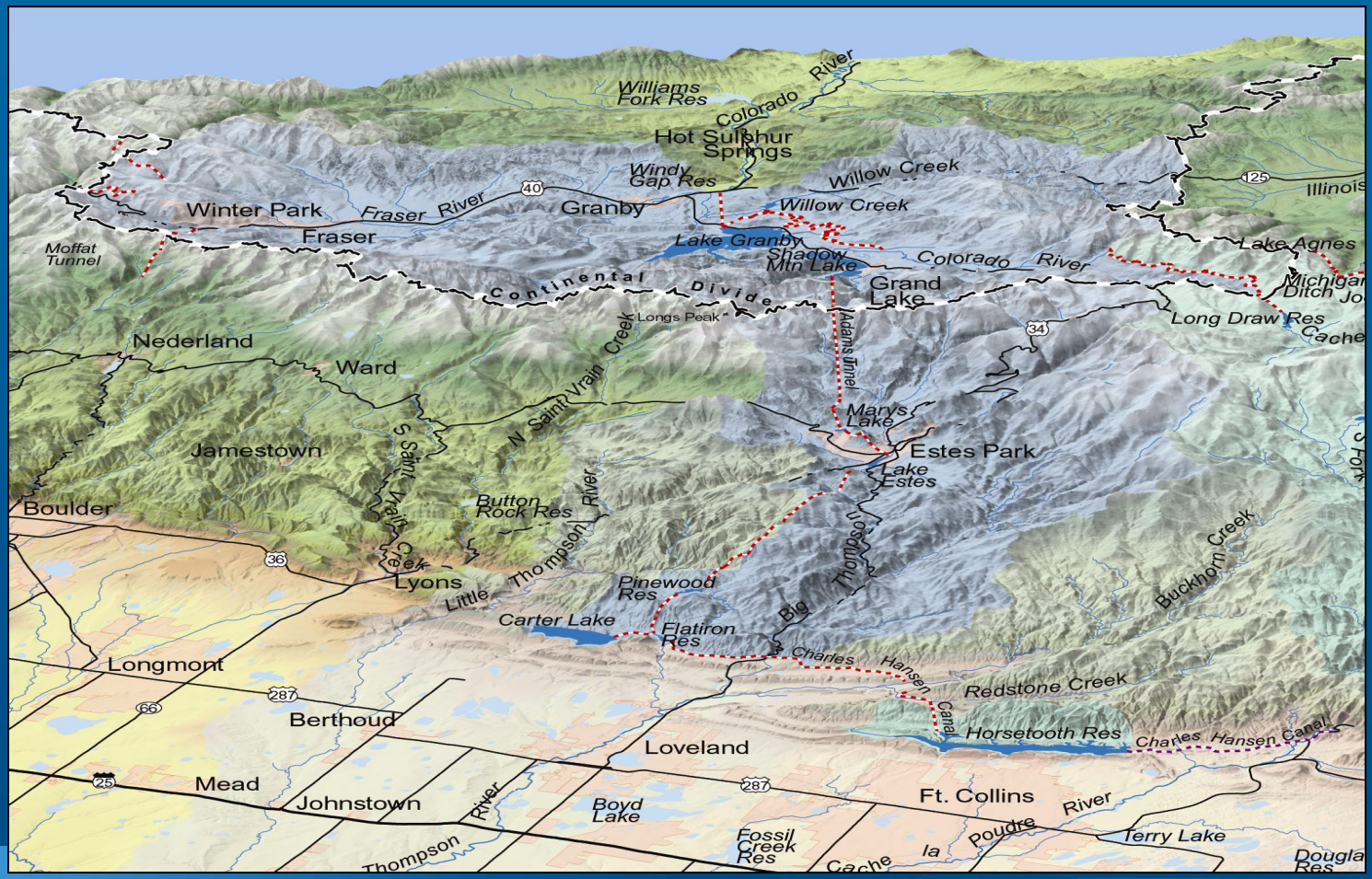
Overview

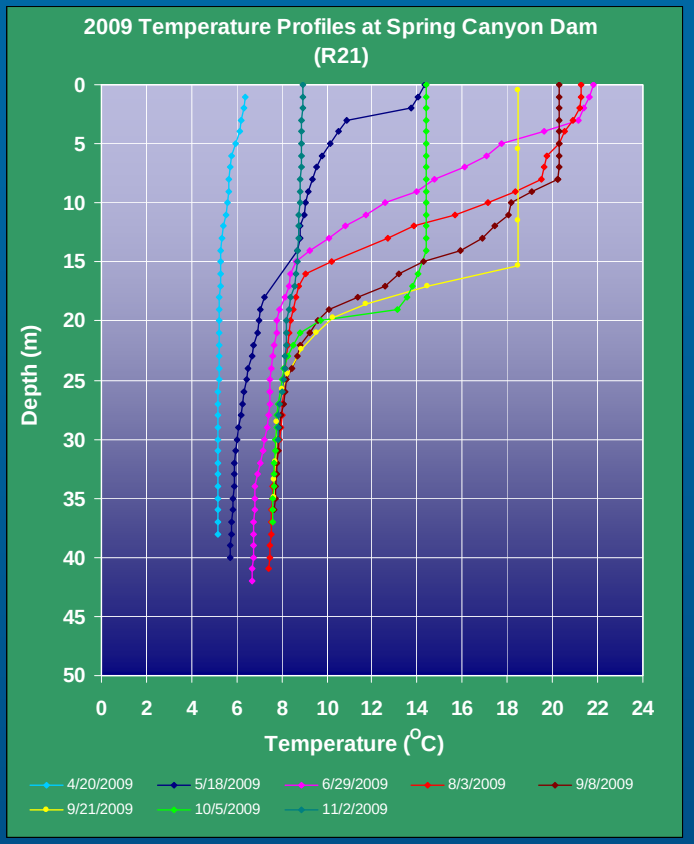
- Horsetooth Reservoir & Colorado Big Thompson (CBT) Project
- Geosmin & effects on drinking water quality
- 2008 geosmin episode at Fort Collins Water Treatment Facility
- Monitoring response on Horsetooth Reservoir and CBT Project
- 2008 & 2009 results and major findings to date

Photo by L. J. Maher

Colorado Big Thompson (CBT) Project & Horsetooth Reservoir

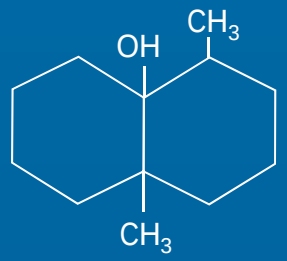


Horsetooth Reservoir



- 156,735 acre-feet capacity
- 80 ft. (24m) mean depth; 188 ft (57 m) maximum depth
- 1.0 – 1.5 years hydraulic residence time

Geosmin in Drinking Water Supplies



- Produced by some species of cyanobacteria (blue-green algae) and actinomycetes (filamentous bacteria)
- "Earthy" odor detectable at <5 ng/L (ppt)
- Typically released after cell lysis and death
- Very difficult Taste & Odor (T&O) compound to remove during water treatment
- Does not pose public health risk, but affects public perceptions about aesthetic quality of water

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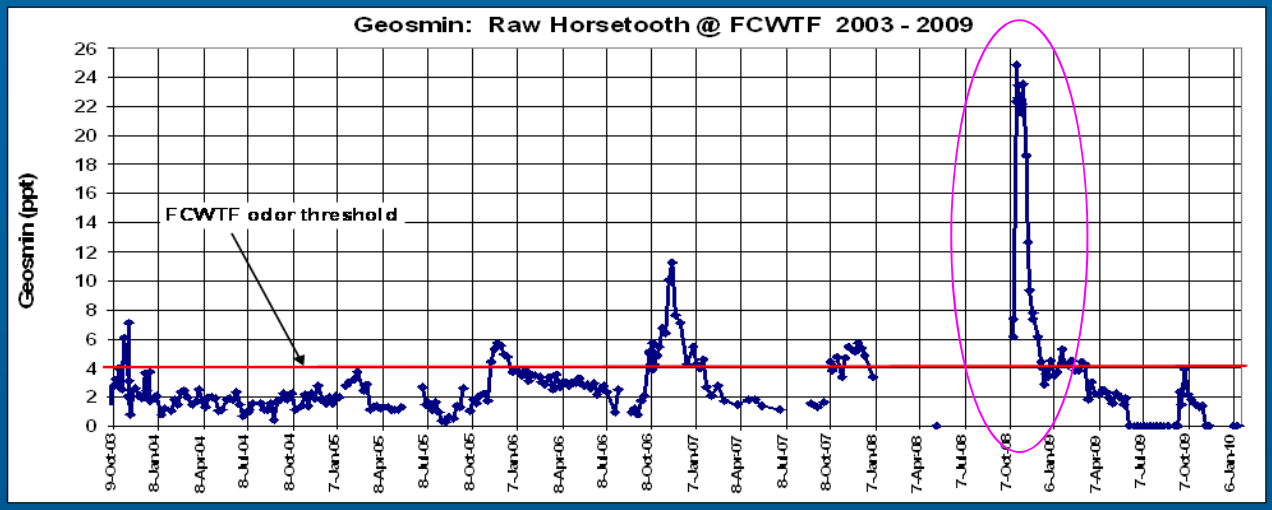
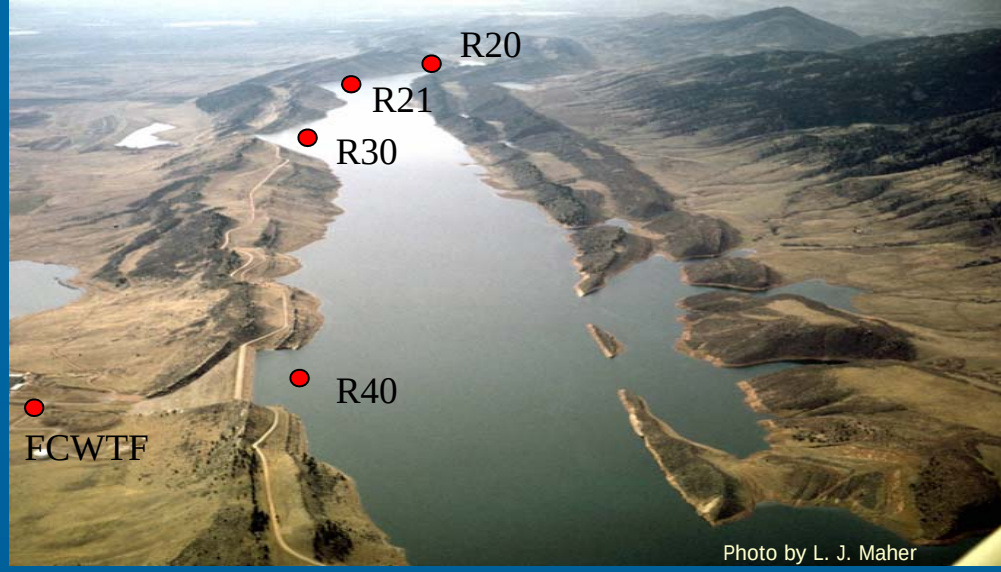
City of Fort Collins 2008 Geosmin Outbreak & Response



- Caught by surprise – peak concentration of 25 ng/L
- Treatment Response: Fed PAC and adjusted flow blend
- Monitoring program initiated on Horsetooth Reservoir to assess spatial distribution of geosmin concentrations

2008 Horsetooth Reservoir Geosmin Sampling & Analysis



- Samples collected at top and bottom of reservoir
- Samples were unfiltered and analyzed for <u>total</u> geosmin concentration
- Analysis conducted on-site using solid phase microextraction (S.M.6040D (2005)) and gas chromatography/mass spectrometry
- Two-day turn around on results

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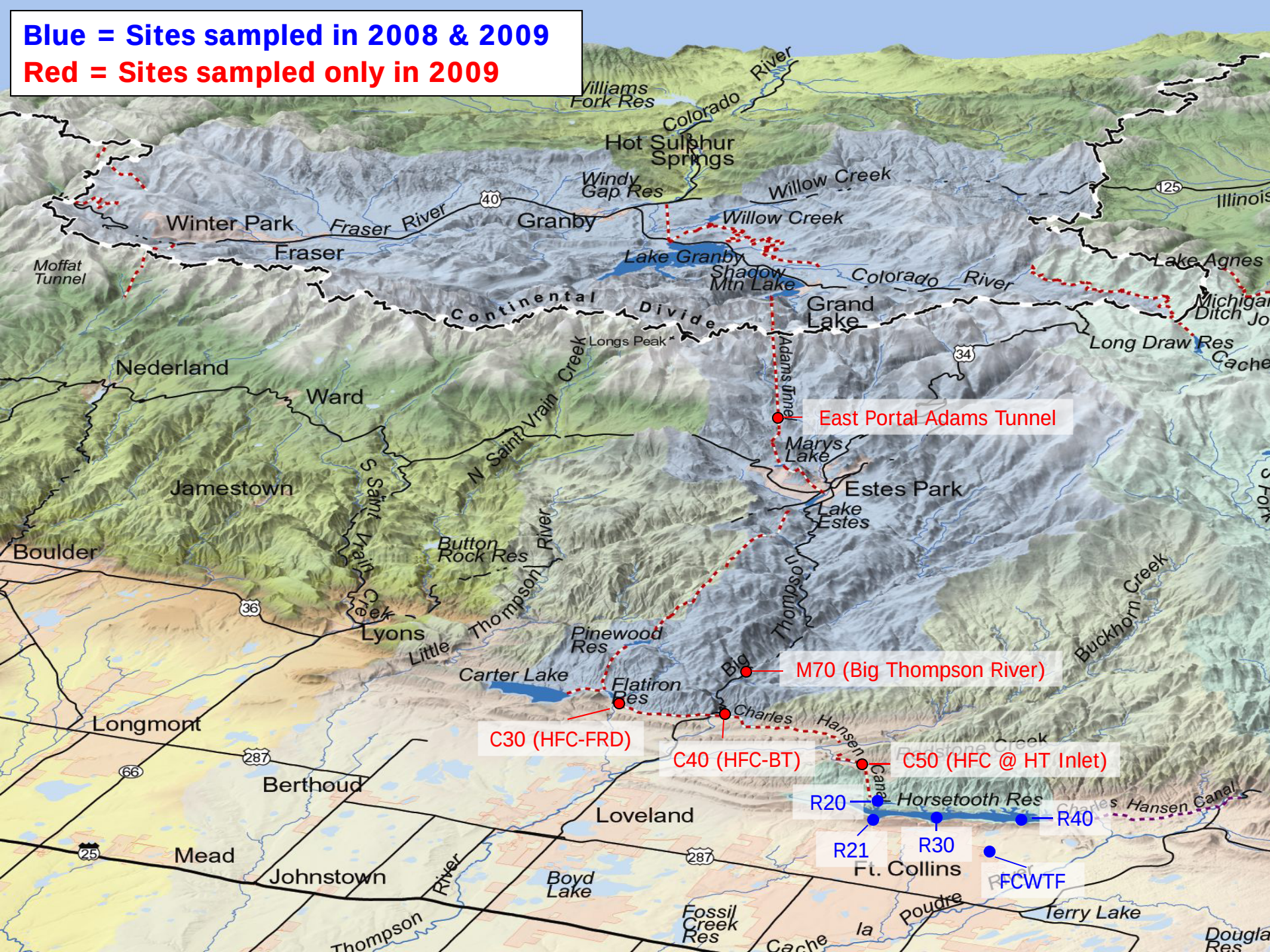
2009 Expanded Geosmin Monitoring Program

Objectives:

1. Better understand the spatial and temporal trends in geosmin

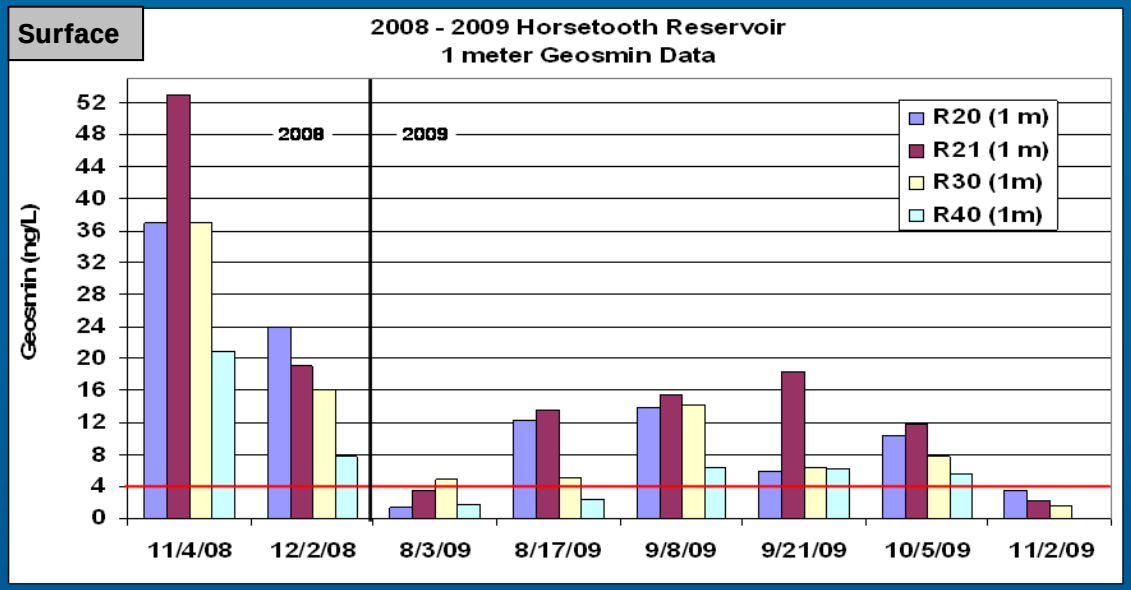
2. Improve early-warning capabilities
   - Sample earlier, more often and at more key sites

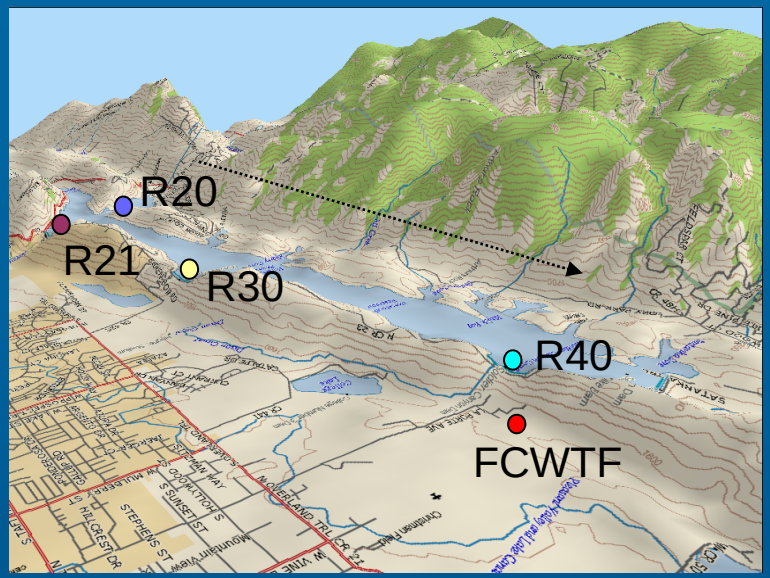
3. Evaluate the physical, chemical and biological factors affecting occurrence, transport and fate in Horsetooth Reservoir


Blue = Sites sampled in 2008 & 2009
Red = Sites sampled only in 2009
East Portal Adams Tunnel
M70 (Big Thompson River)
C30 (HFC-FRD)
C40 (HFC-BT)
C50 (HFC @ HT Inlet)
R20
R21
R30
R40
FCWTF
Hot Sulphur Springs
Winter Park
Fraser
Granby
Grand Lake
Estes Park
Nederland
Ward
Jamestown
Boulder
Lyons
Longmont
Berthoud
Loveland
Mead
Johnstown
Ft. Collins
Continental Divide
Longs Peak
Adams Tunnel
Marys Lake
Lake Estes
Lake Granby
Shadow Mtn Lake
Willow Creek
Windy Gap Res
Williams Fork Res
Colorado River
Fraser River
Moffat Tunnel
Lake Agnes
Long Draw Res
Buckhorn Creek
Button Rock Res
Pinewood Res
Carter Lake
Flatiron Res
Big Thompson
Charles Hansen Canal
Horsetooth Res
Boyd Lake
Fossil Creek Res
Terry Lake
Little Thompson River
N Saint Vrain Creek
S Saint Vrain Creek
Thompson River
Poudre River

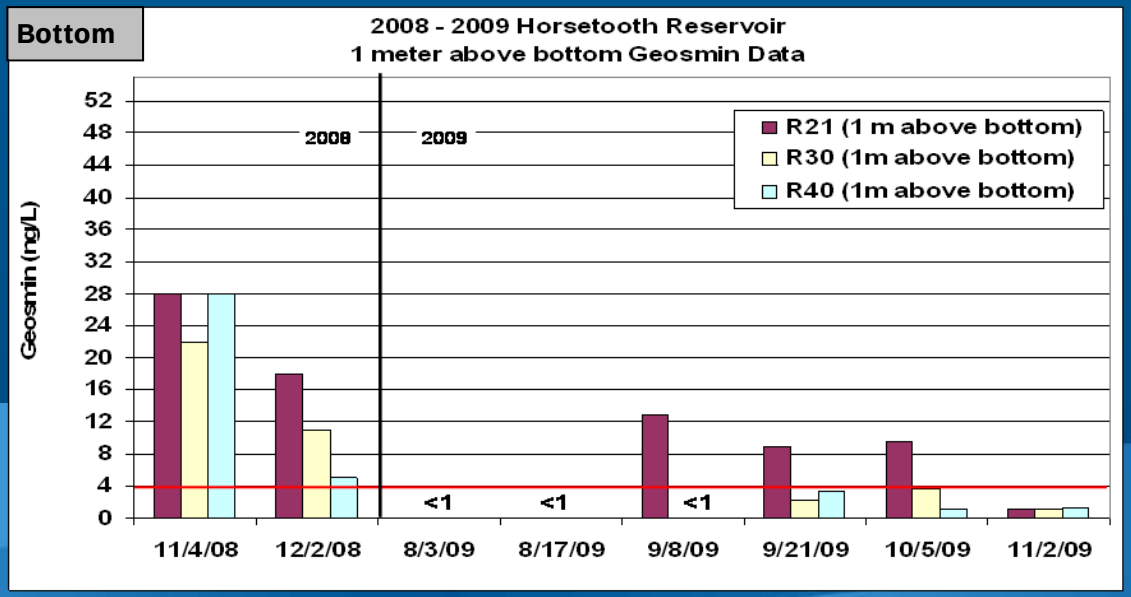
Horsetooth Reservoir Results

Surface





Bottom



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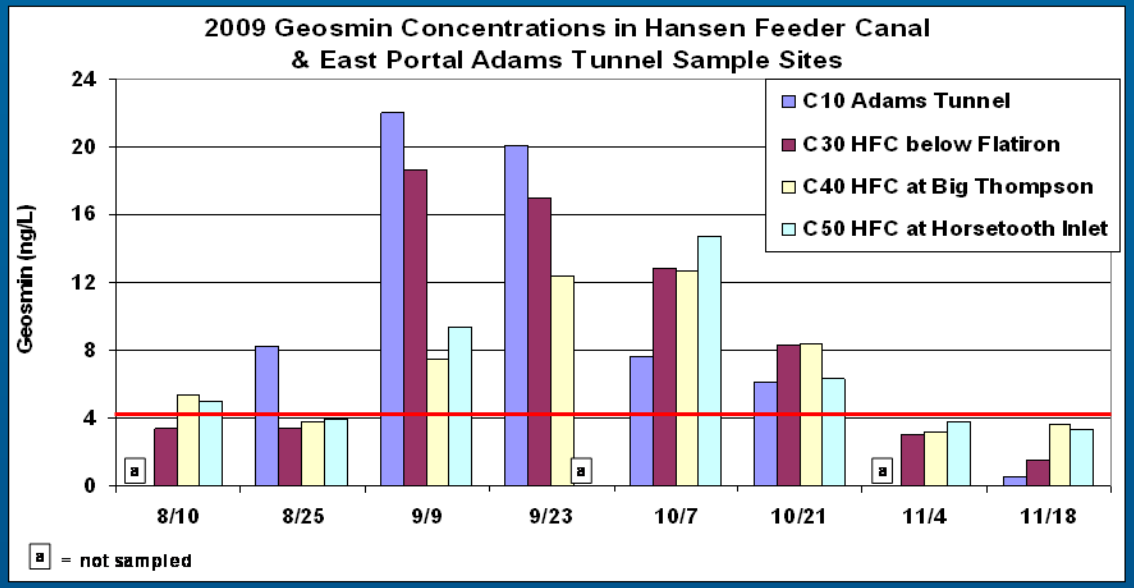
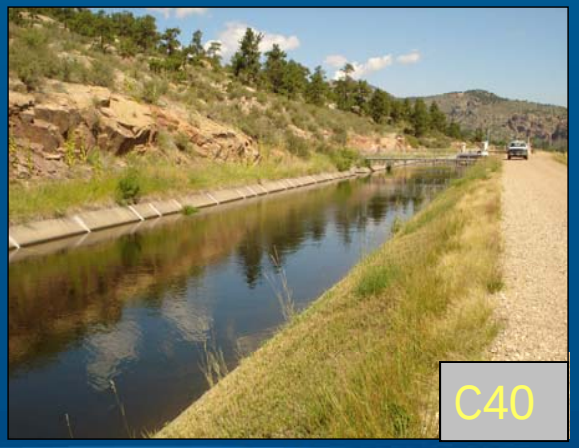
Hansen Feeder Canal & East Portal Adams Tunnel Sample Sites





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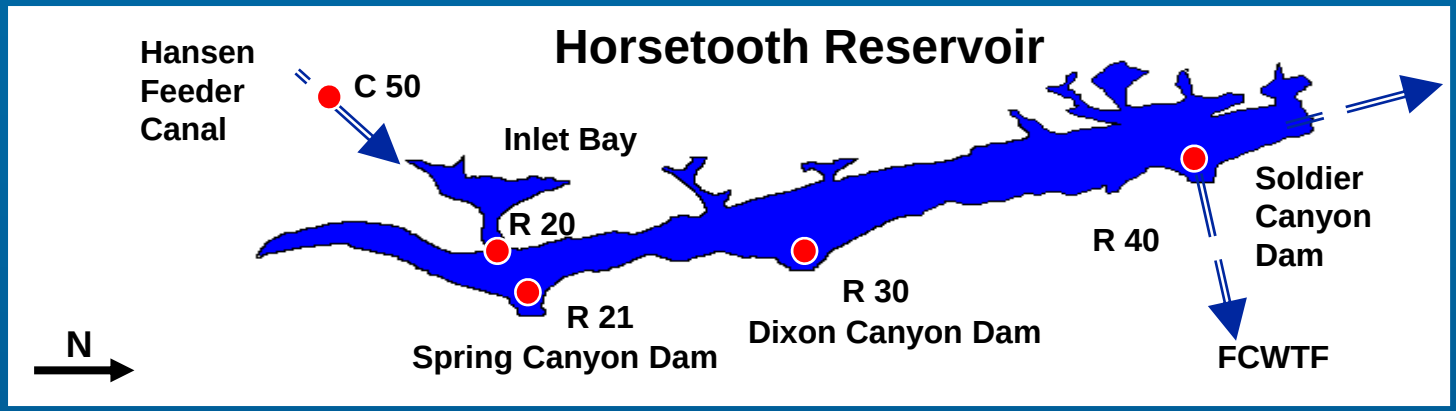
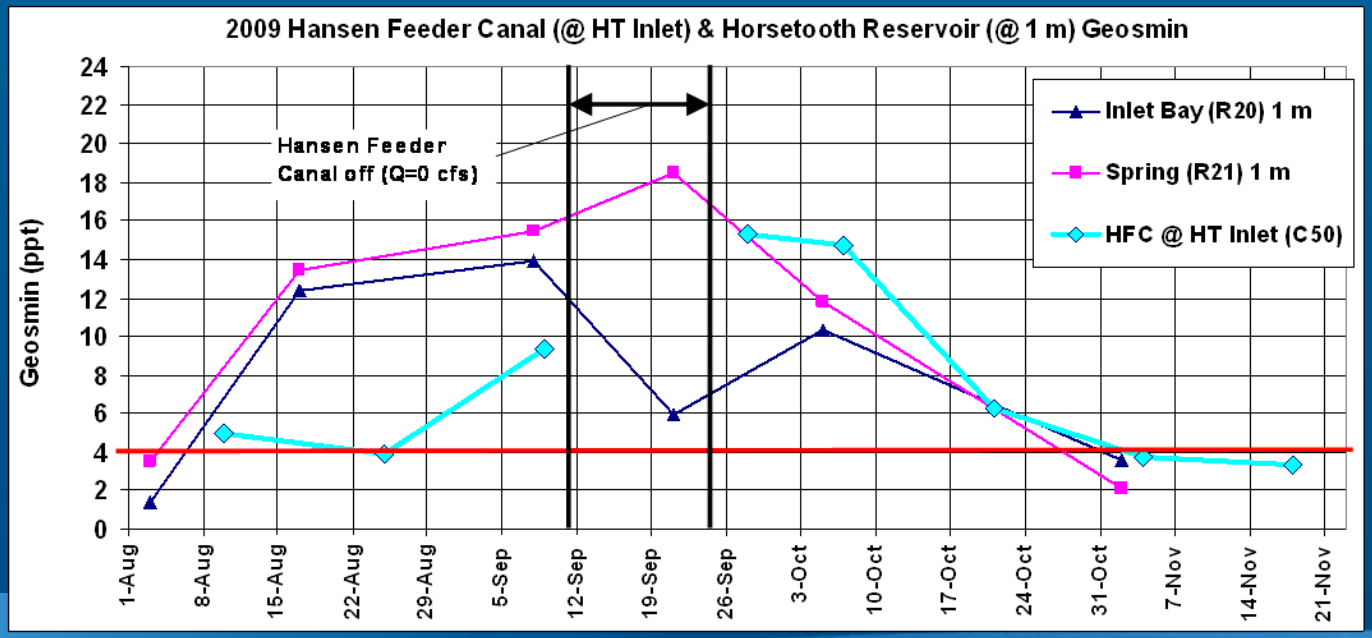
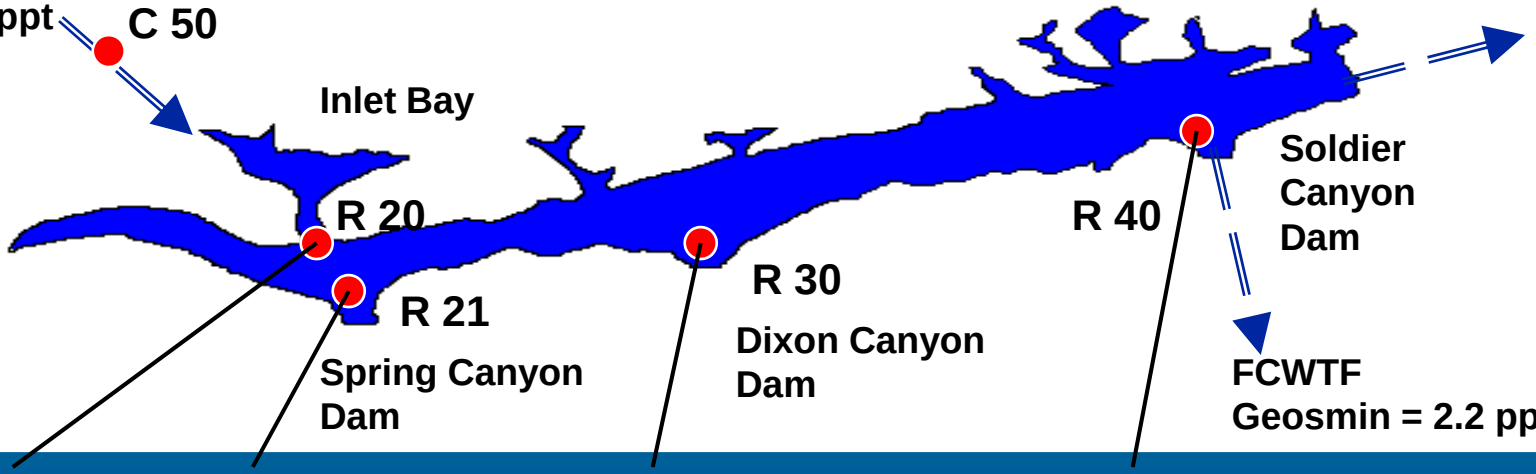
HFC-Inlet Canal (C50) & Horsetooth Reservoir

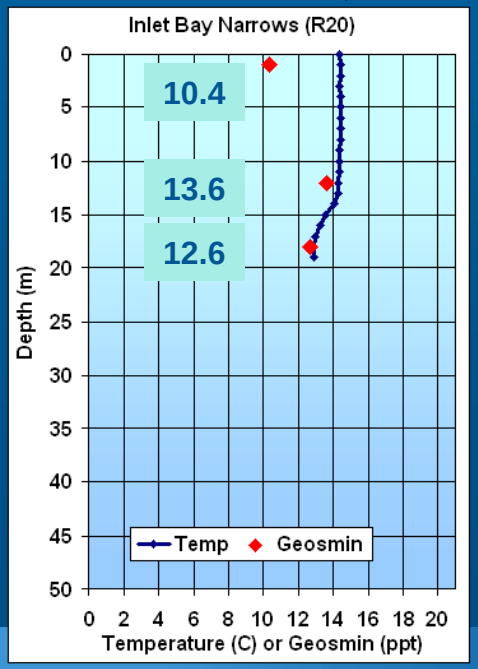


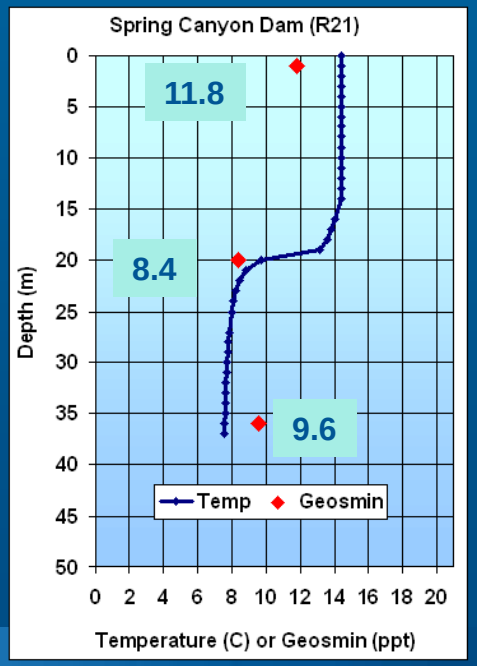


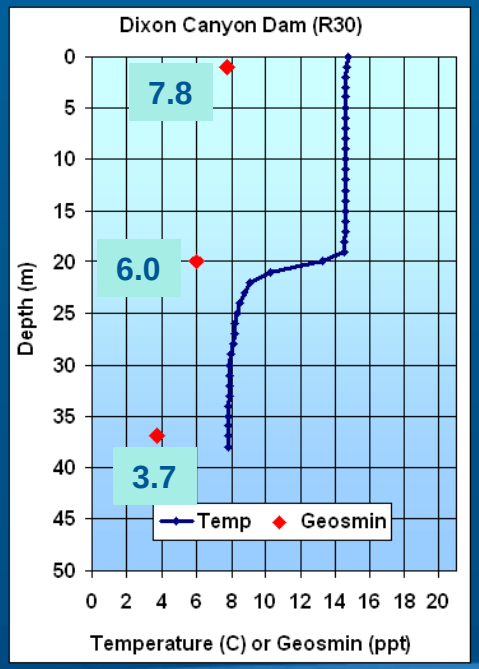
Horsetooth Reservoir

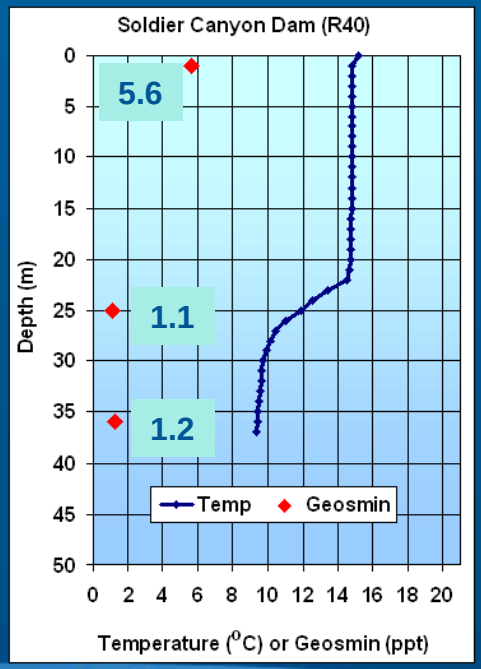
Hansen Feeder Canal
Geosmin = 14.8 ppt
Q = 89 cfs
T = 10 °C
10/7/2009











Profiles and reservoir geosmin data from October 5, 2009

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Key Findings

- Significant spatial variation in geosmin within the reservoir and upstream water bodies.
- Significant geosmin concentrations can exist at the bottom of the reservoir even when the reservoir is stably stratified.
- Data suggest that geosmin is both transported into the reservoir via the Hansen Feeder Canal and produced within Horsetooth Reservoir.
- No correlation exists between geosmin and chlorophyll-a concentrations or the algal cell density of the potential geosmin producing genera.
- Understanding geosmin transport and fate will require separate analysis of the dissolved and cell-bound fractions.
- Numerical modeling is needed to fully understand flow patterns in Horsetooth Reservoir and the impact of Hansen Feeder Canal interflow on geosmin transport.

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Conclusions

- For drinking water utilities, early warning system for geosmin is critical for protecting the aesthetic quality of the water.
- Key elements for geosmin monitoring success were:
  1) high quality data
  2) short turn-around times
  3) scheduling flexibility provided by analytical laboratory
- Control strategies depend on understanding the temporal and spatial variability, concentrations, production sites, transport and fate of geosmin within source watersheds.
- Several years of monitoring will be required to more fully understand the temporal and spatial dynamics of geosmin production and fate in Horsetooth Reservoir.

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