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Effects of Drought on Water Quality of Lake Powell and Glen Canyon Dam Releases

William S. Vernieu
Grand Canyon Monitoring and Research Center
Flagstaff, AZ
bvernieu@usgs.gov

Colorado River Commission of Nevada
Implications of Lower Lake Levels
April 21, 2010

U.S. Department of the Interior
U.S. Geological Survey

Topics

- GCMRC Water Quality Monitoring Program
- Recent Drought Hydrology – Powell & Mead
- Lake Powell Limnology
- Results of Reservoir Drawdown
  - Temperature
  - Dissolved Oxygen
  - Rechannelization

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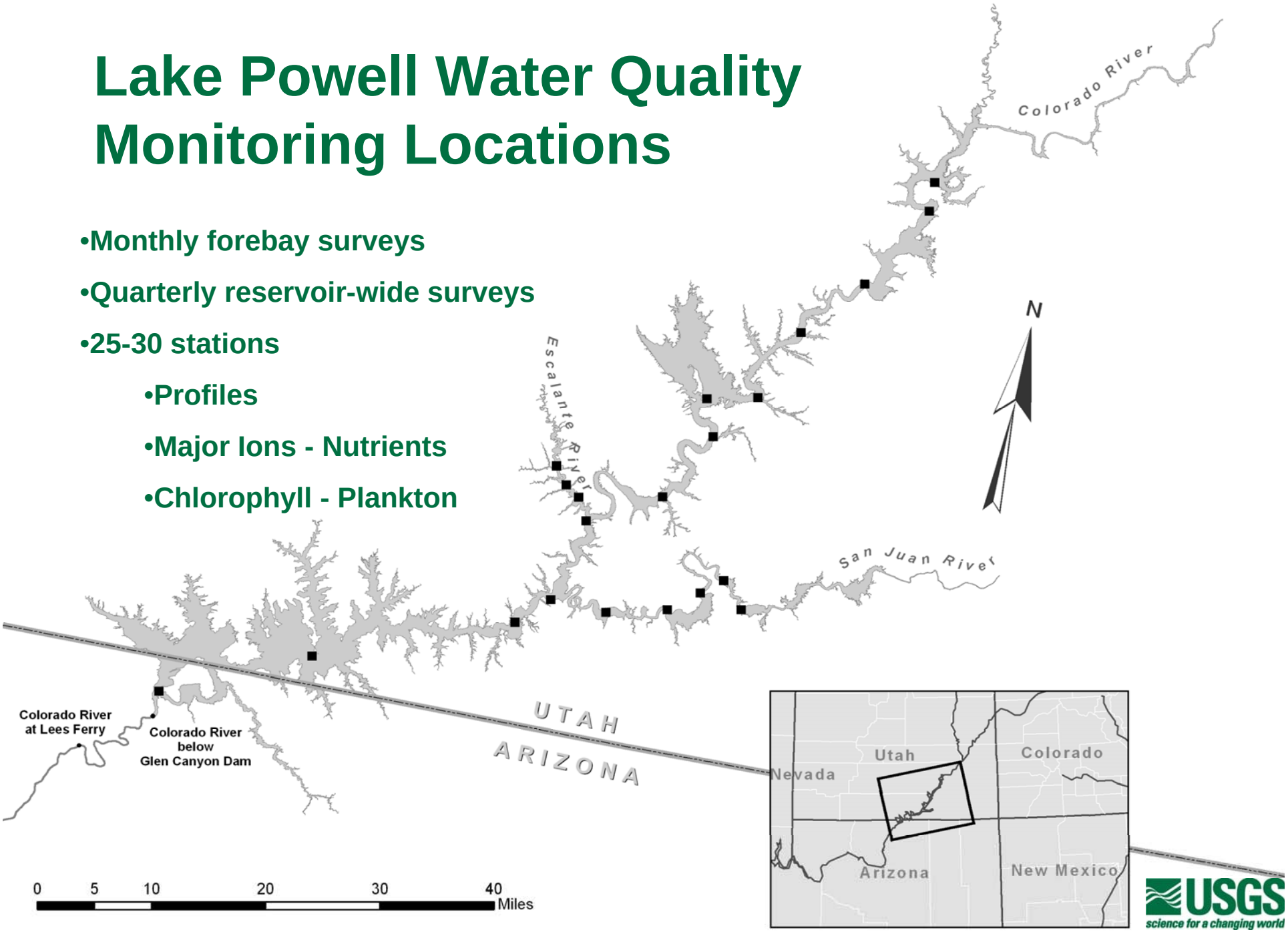
Lake Powell Water Quality Monitoring Locations

- Monthly forebay surveys
- Quarterly reservoir-wide surveys
- 25-30 stations
  - Profiles
  - Major Ions - Nutrients
  - Chlorophyll - Plankton



Parameters of Interest

- Temperature
  - Affects density and fate of inflow currents
  - Affects aquatic life in downstream environment
  - Effects for endangered fish
- Dissolved oxygen
  - Supports aquatic life in downstream ecosystem
  - Affected by organic material and respiration
  - Affected by primary productivity

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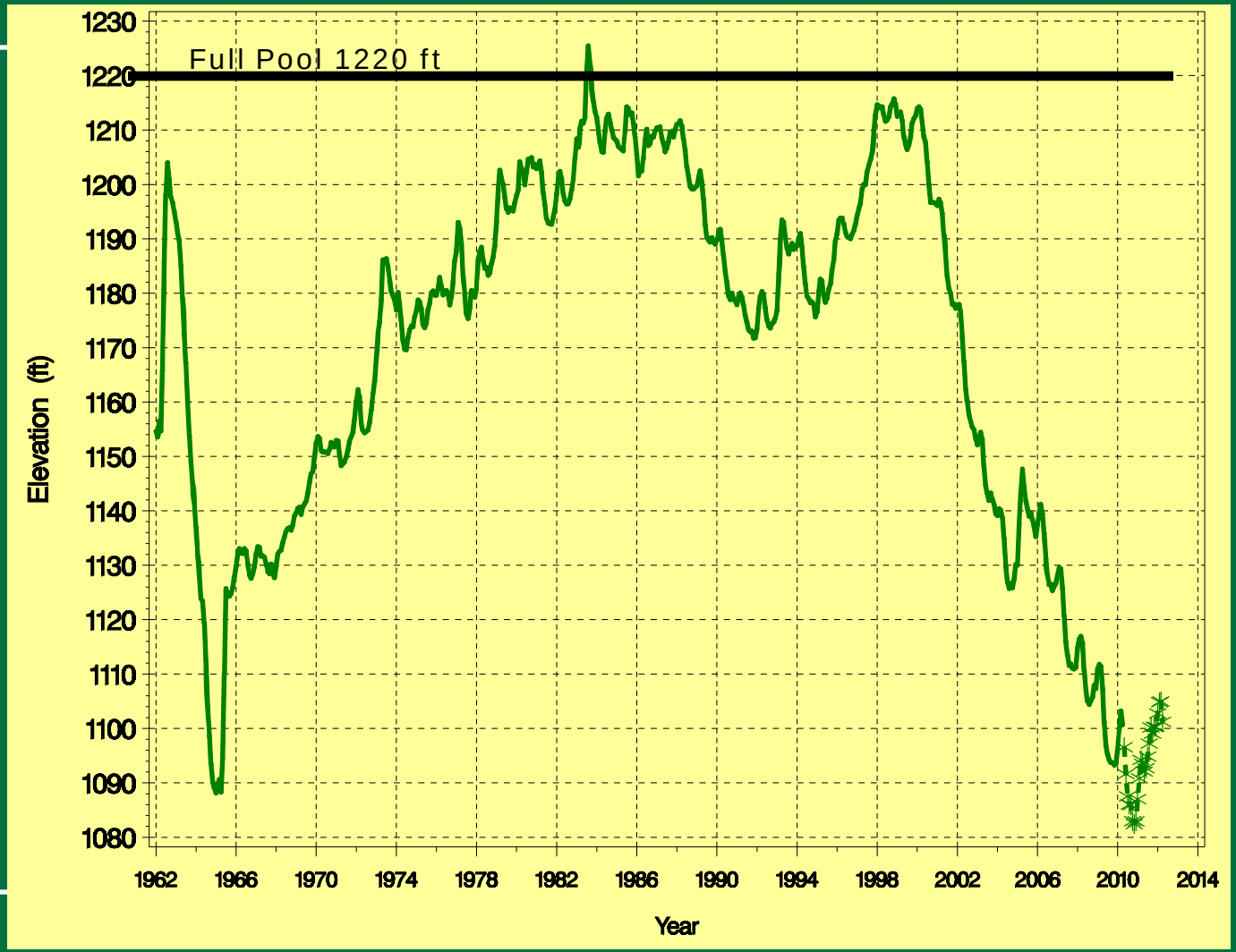
Lake Mead History – 1962 to present

- Glen Canyon Dam completed in 1963
- Lowest level 1083.6 ft Mar 1956
- Current level 1099.0 ft
- Projected low 1082.5 Nov 2010



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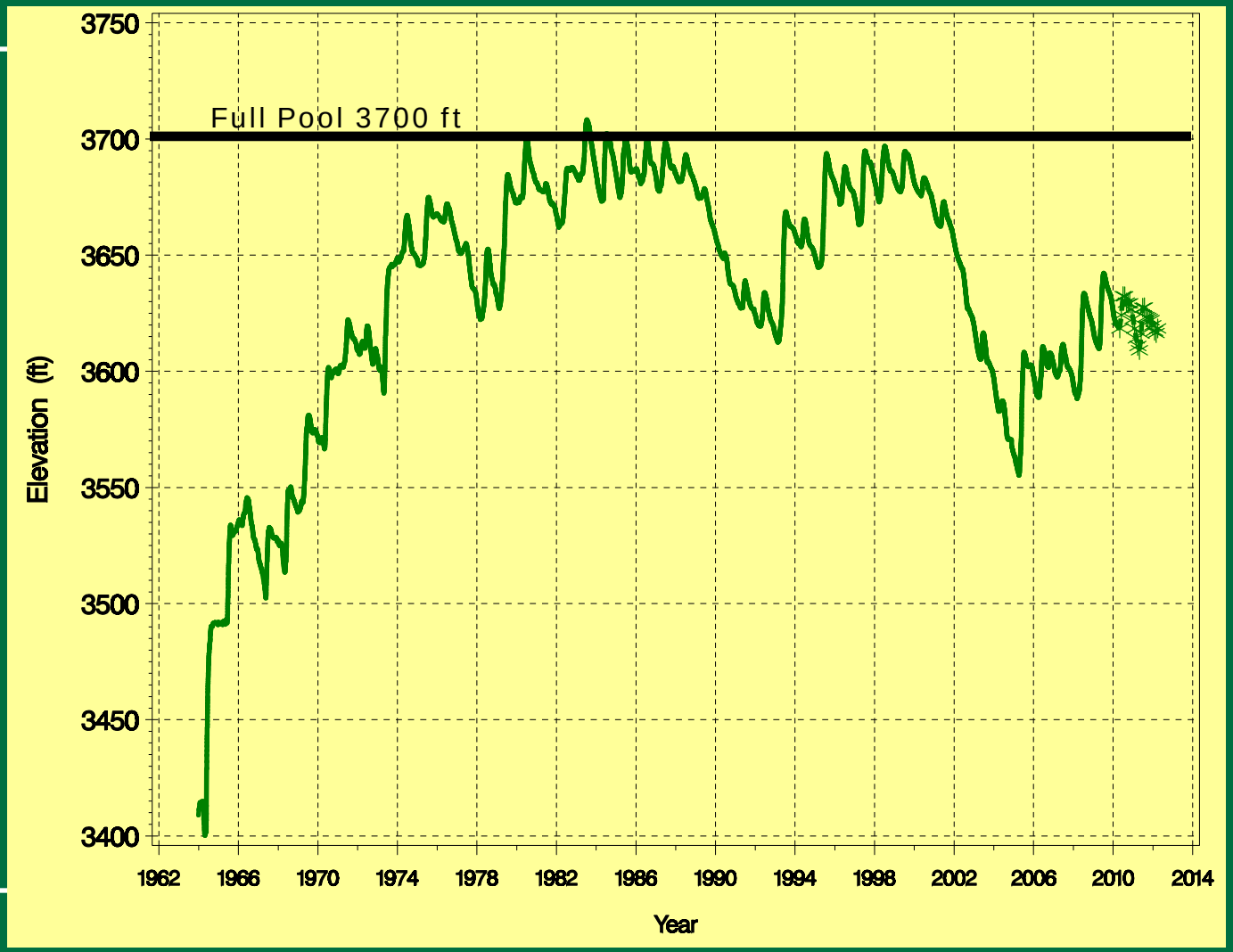
Lake Powell History – 1963 to Present

- Glen Canyon Dam completed in 1963
- Full pool in 1980
- Droughts in late 1970s, early 1990s, and 2000-2010



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Recent Inflows to Lake Powell

- 2000 – 62%
- 2001 – 59%
- 2002 – 25%
- 2003 – 51%
- 2004 – 49%
- 2005 – 105%
- 2006 – 73%
- 2007 – 68%
- 2008 – 101%
- 2009 – 95%

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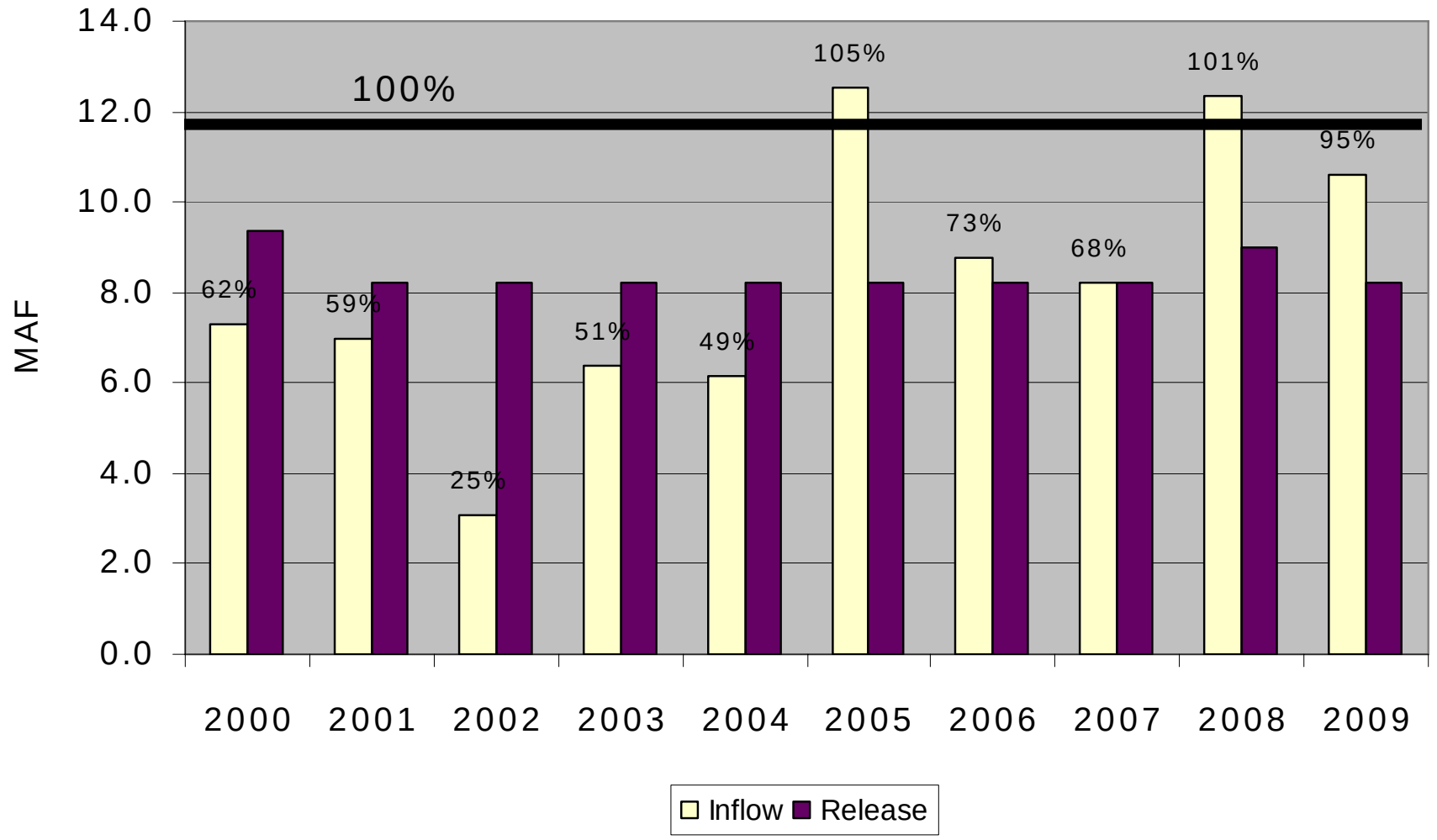
Lake Powell Inflows and Releases



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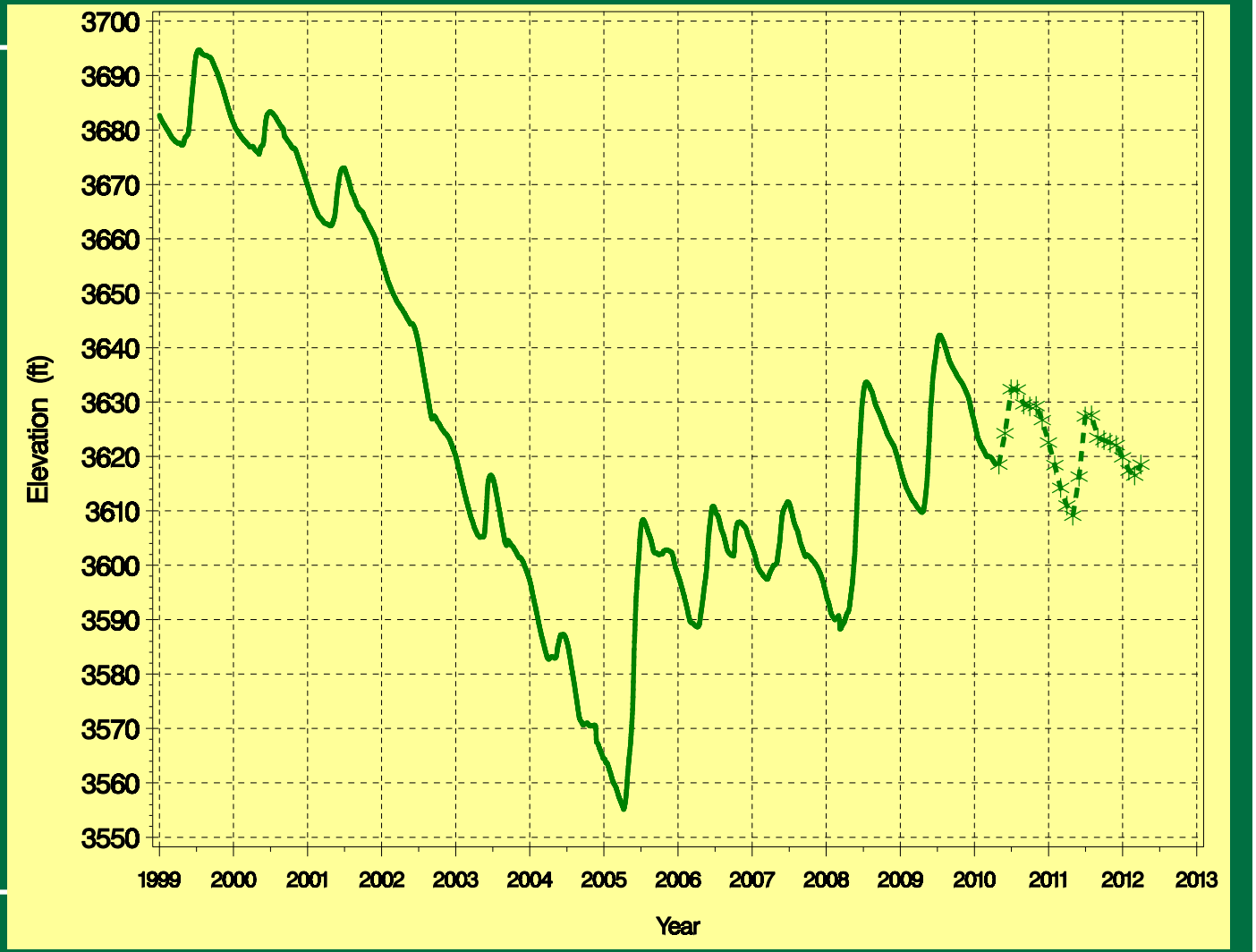
Lake Powell History – 1999 to Present

- 1999
  97% capacity
  3695 ft
- Below average inflow in 8 of past 10 years
- 2005
  37% capacity
  3555 ft



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Lake Mead History – 1999 to Present

- 8.23 MAF from Glen Canyon Dam except in 2000 and 2008
- Near capacity in 2000
- Projected low 1082.5 Nov 2010

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2005 Glen Canyon Dam Releases

Two Unusual Events

- **Highest Release Temperature Since 1971**
  - 16°C (61°F) on October 8, 2005
- **Lowest Dissolved Oxygen on Record**
  - 3.3 mg/L on October 8, 2005 from draft tubes
    - **(Data since 1990 – no evidence of prior hypoxia)**

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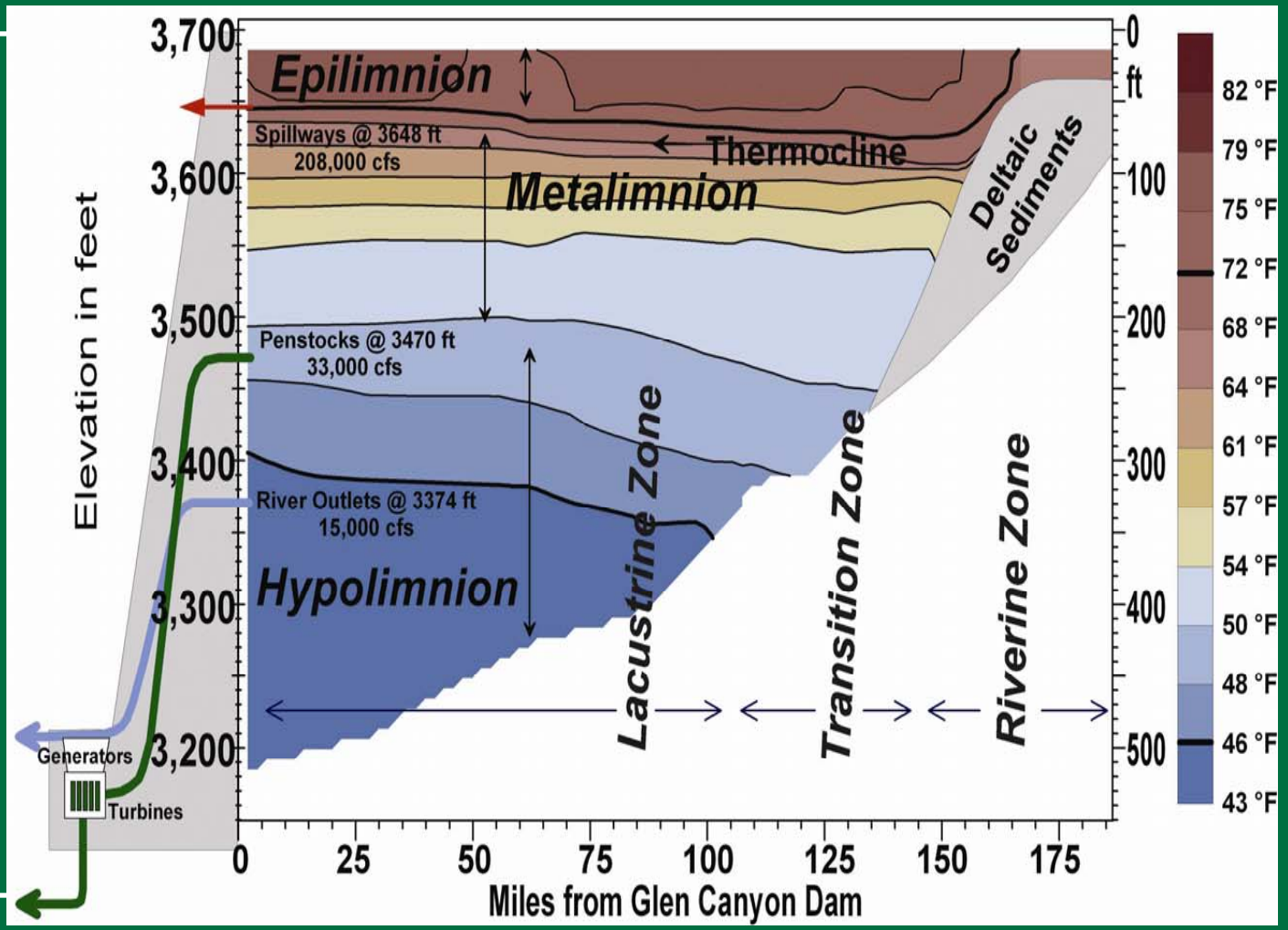
Lake Powell and Glen Canyon Dam

- 3 Discharge structures
- Reservoir stratified by density
- Longitudinal zonation



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Fate of Inflows

- Destination depth determined by density
  - Temperaure
  - Salinity
  - Sedimnentj
- Lake Powell
  - Seasonal overflow
- Lake Mead
  - Constant underflow

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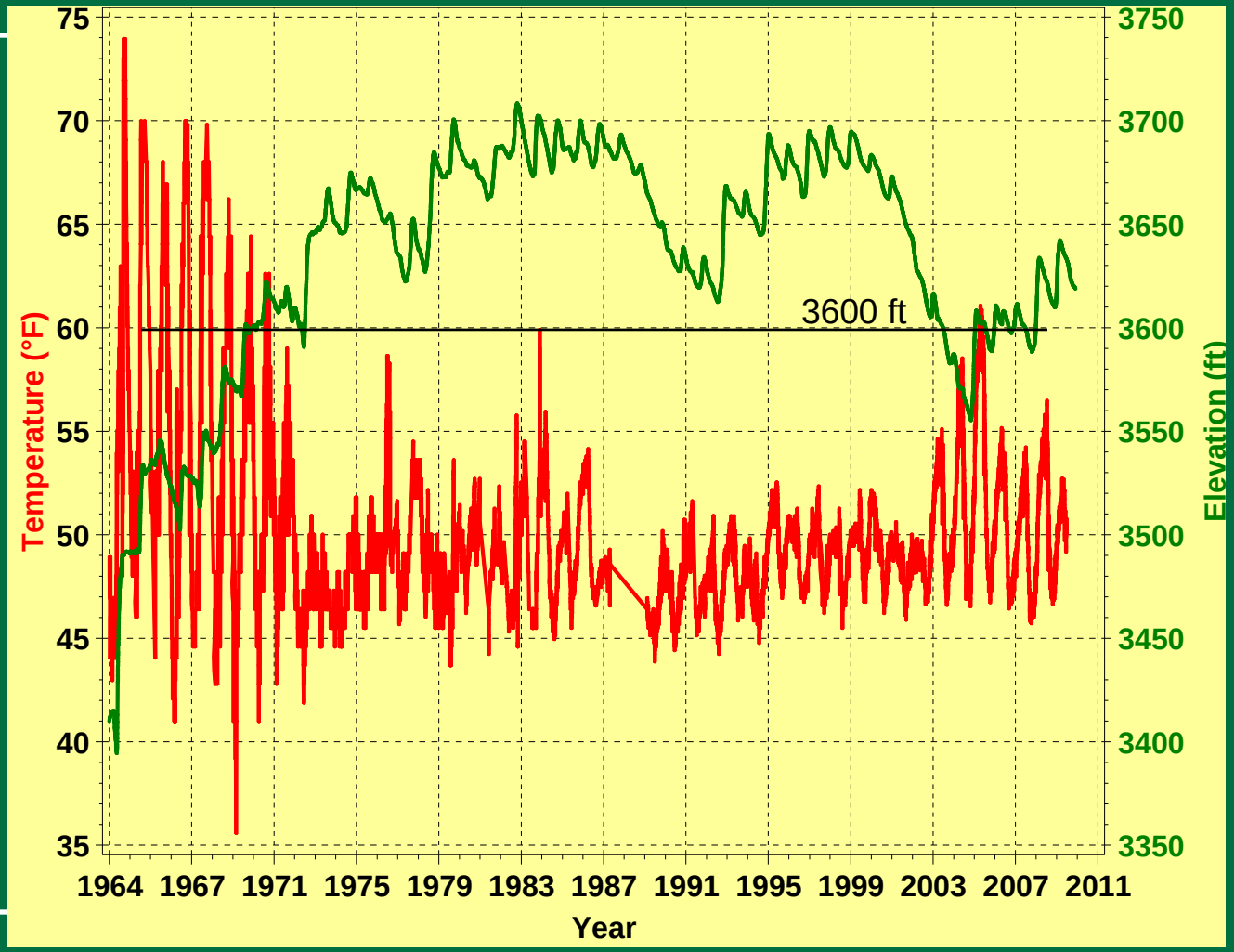
Glen Canyon Dam Release Temperature

- Temperature fluctuations confined at higher reservoir levels
- Warmest temperature in winter from reservoir mixing
- Recent release temperatures highest since 1971
- Max 2005 temperature 61 °F



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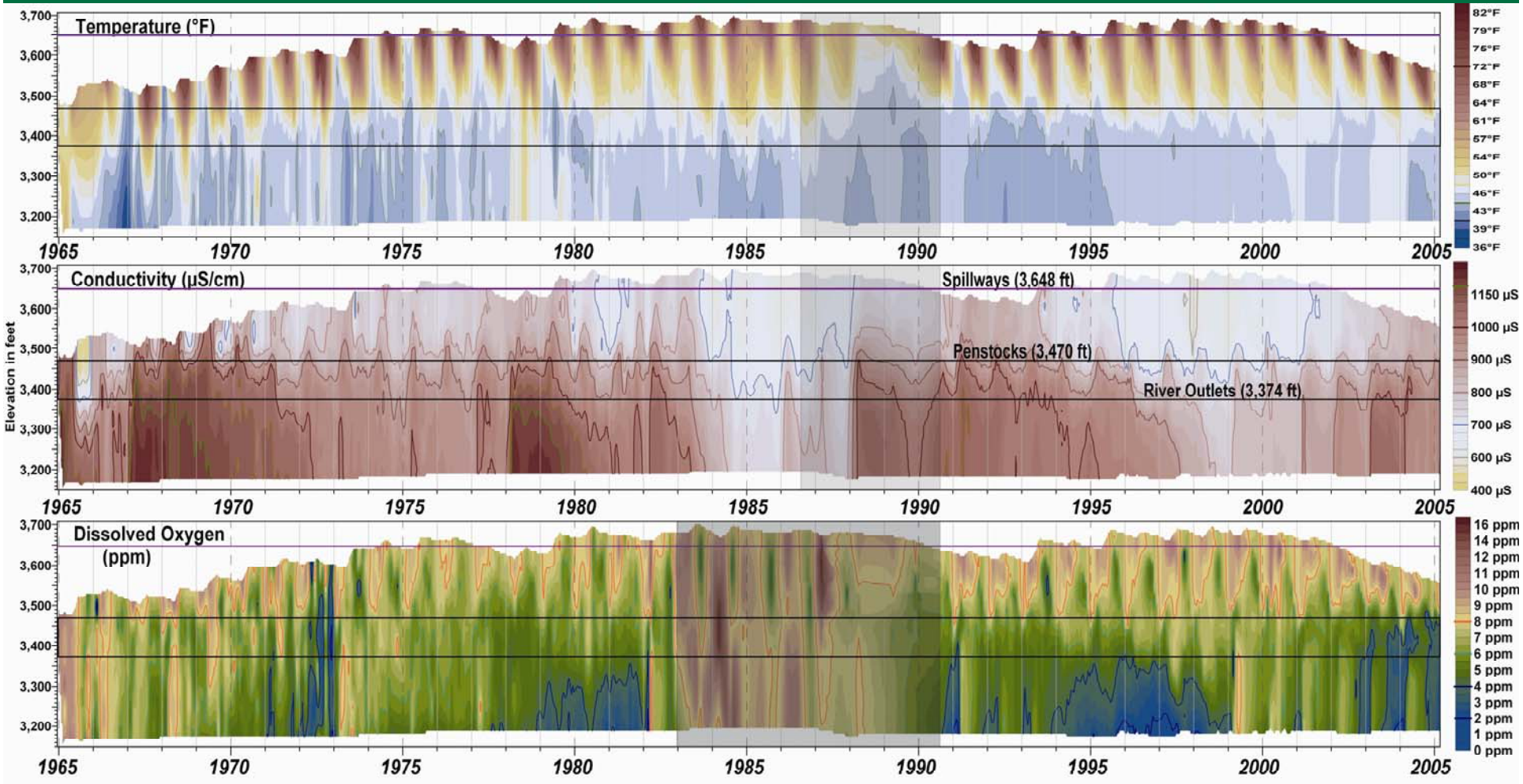
Lake Powell Water Quality History



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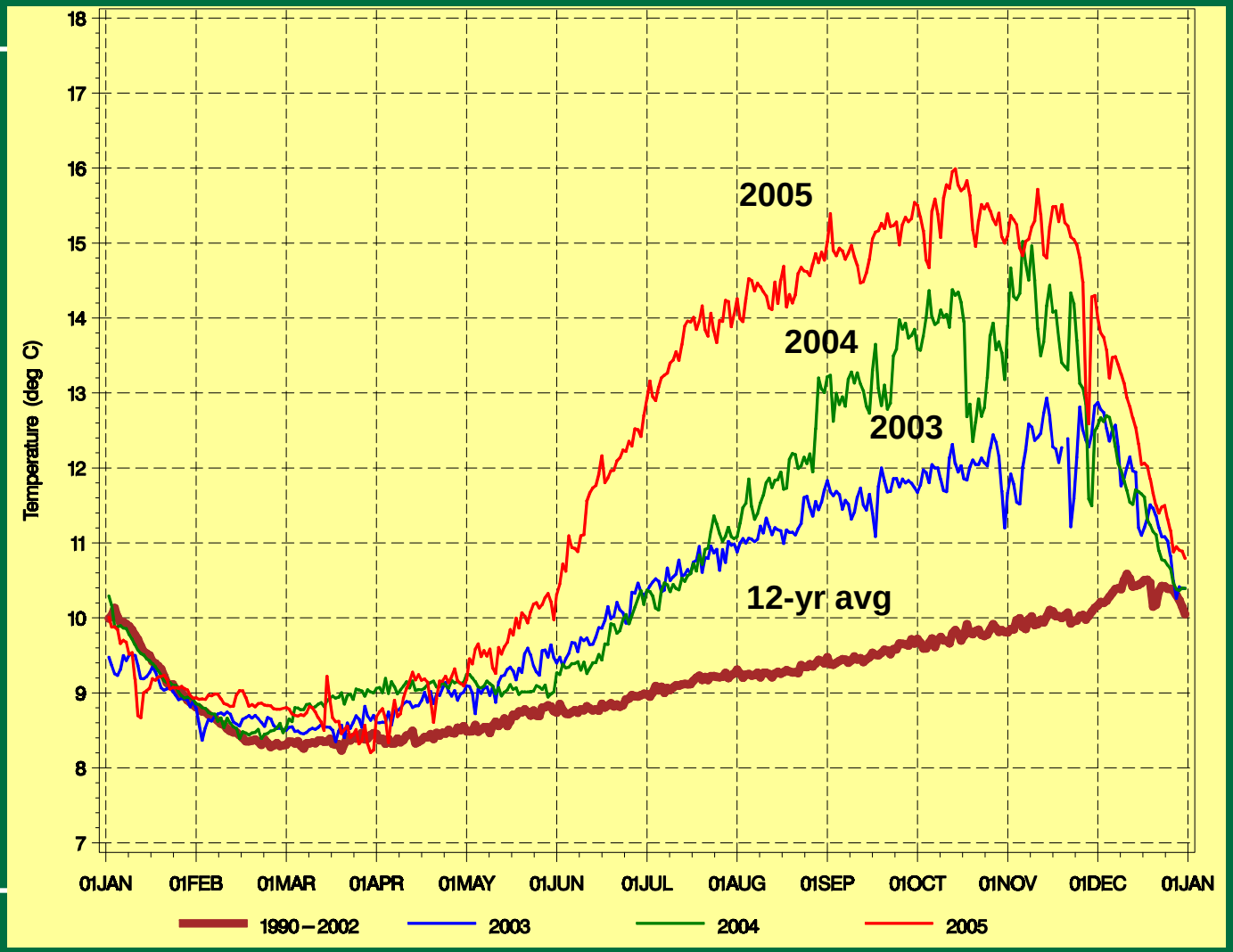
Glen Canyon Dam Release Temperature

- Warmest releases since 1971
- 16°C (61°F) October 2005
- 6°C above 12-yr average (1990-2002)
- Low reservoir brings warm surface water closer to penstocks



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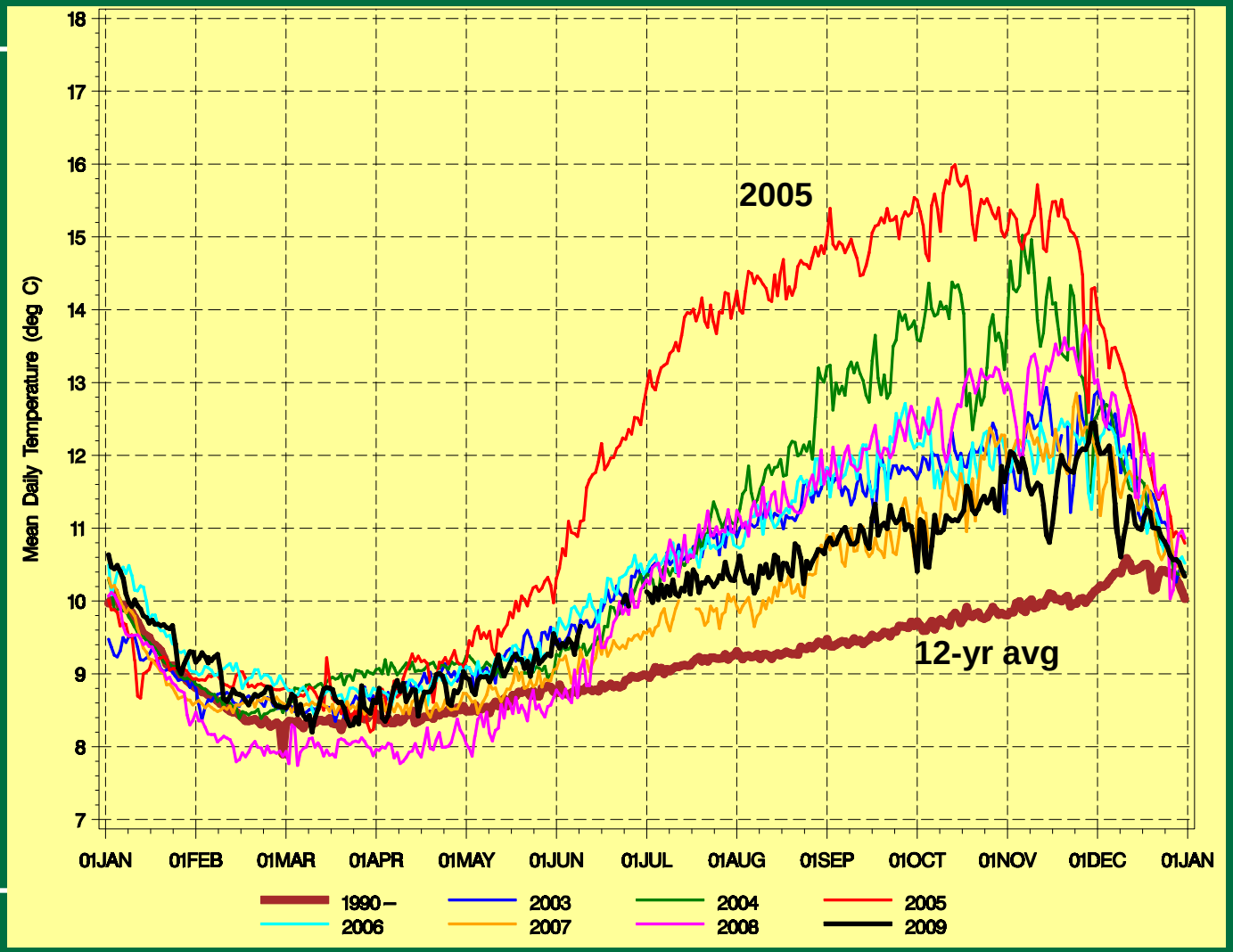

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Formation of Delta Deposits

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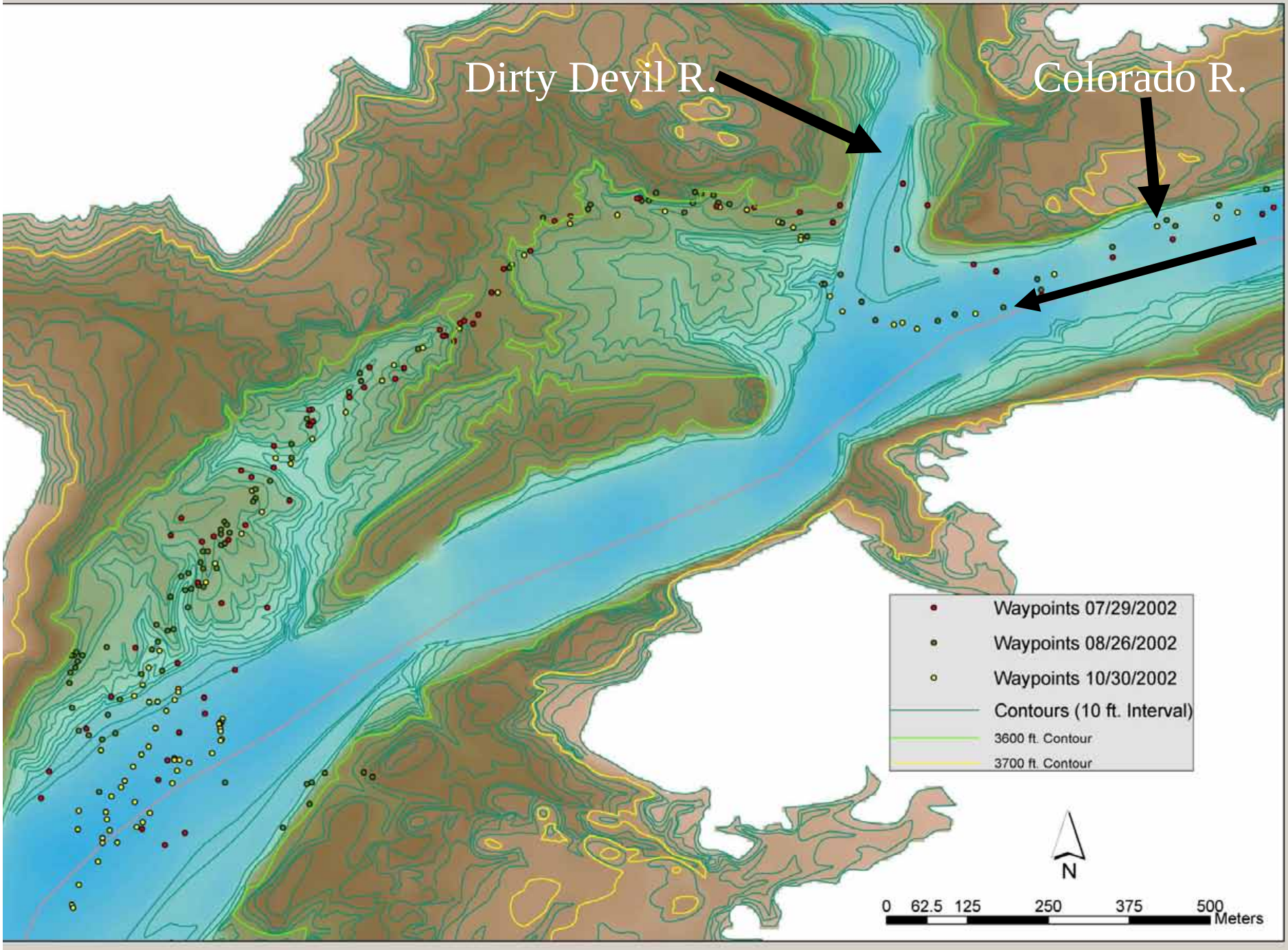
Lake Powell
~1973


Dirty Devil R.
Colorado R.
Waypoints 07/29/2002
Waypoints 08/26/2002
Waypoints 10/30/2002
Contours (10 ft. Interval)
3600 ft. Contour
3700 ft. Contour
N
0 62.5 125 250 375 500
Meters


Hite Bay looking upstream
Full Pool Elevation


Lake Powell
7/26/2002


Lake Powell
03/09/2003


Lake Powell
09/18/2003


Lake Powell
03/01/2004


Lake Powell
12/23/2004

Lake Powell Hydrology - 2005

- Pre-Runoff Conditions
  - Surface elevation - 3555 ft on April 8, 2005
  - Lowest elevation since May 1969
  - 38 % of total capacity
- 2005 Runoff
  - Apr-Jul 2005 unreg. inflow - 111% of normal
  - Surface elevation - 3608 ft on July 13, 2005
  - Runoff increased elevation by 53 ft in 2005
  - 55% total capacity

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2005 Inflow to Lake Powell

- Above average inflows caused head cutting of deltaic sediments
- Resuspension of large amount of sediment from inflow areas
- Resulted in low dissolved oxygen levels in inflow plume as it traveled through reservoir

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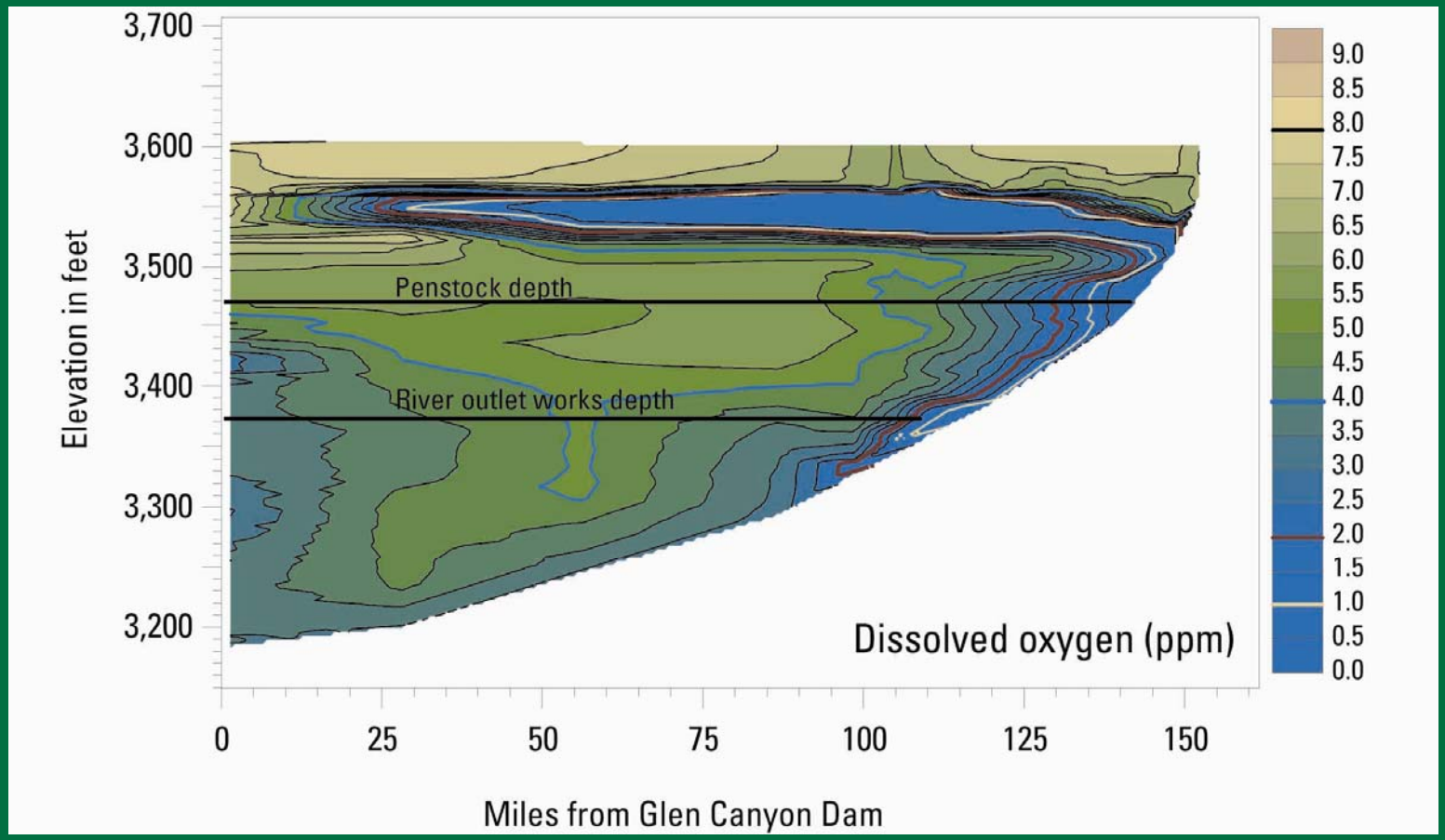
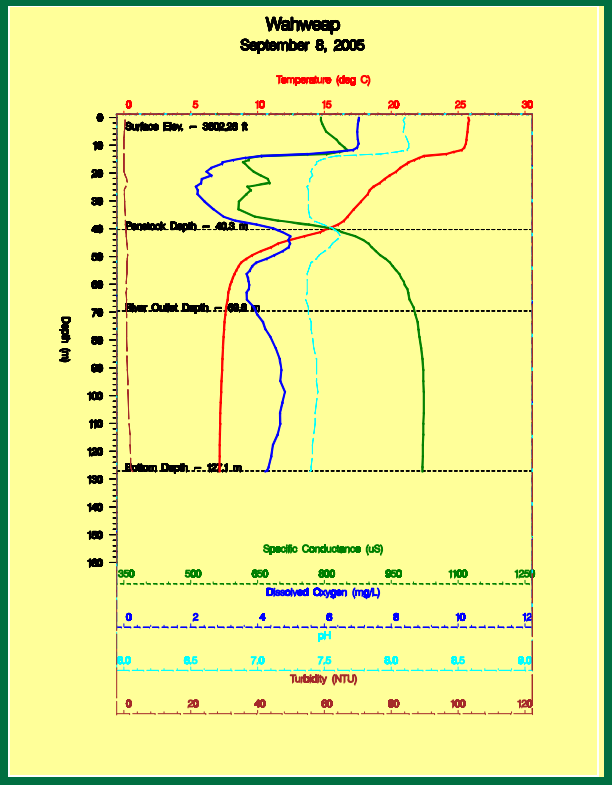
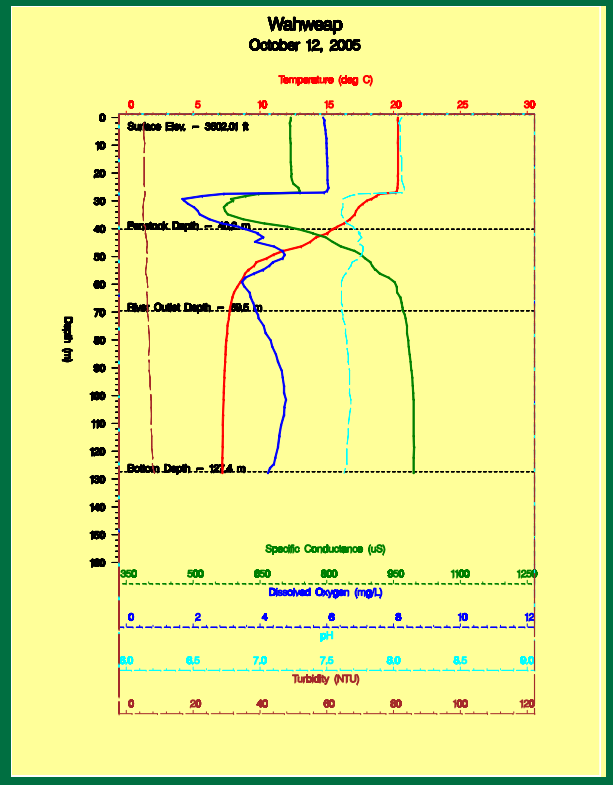
Effects of Sediment Resuspension

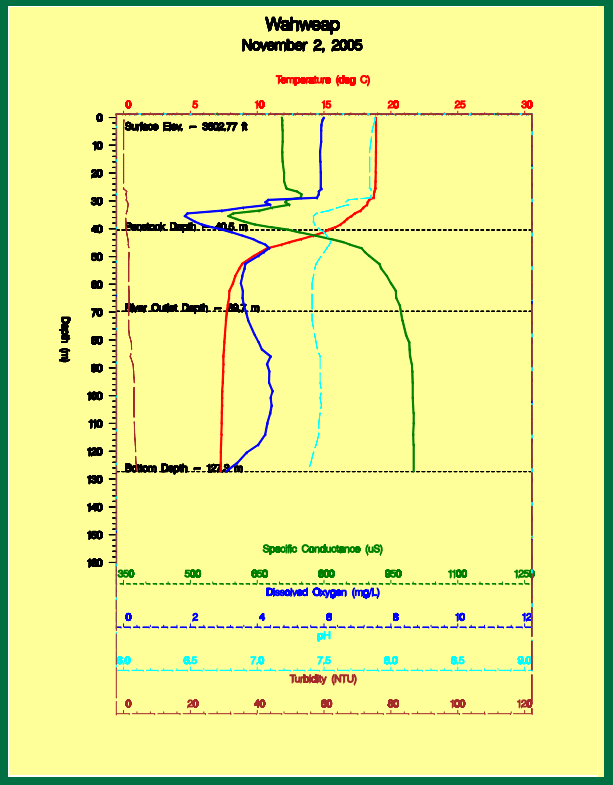


USGS Lake Powell Dissolved Oxygen – September 2003

Result of Hypoxic Inflow 2005







9/8/05 | **10/12/05** | **11/2/05**

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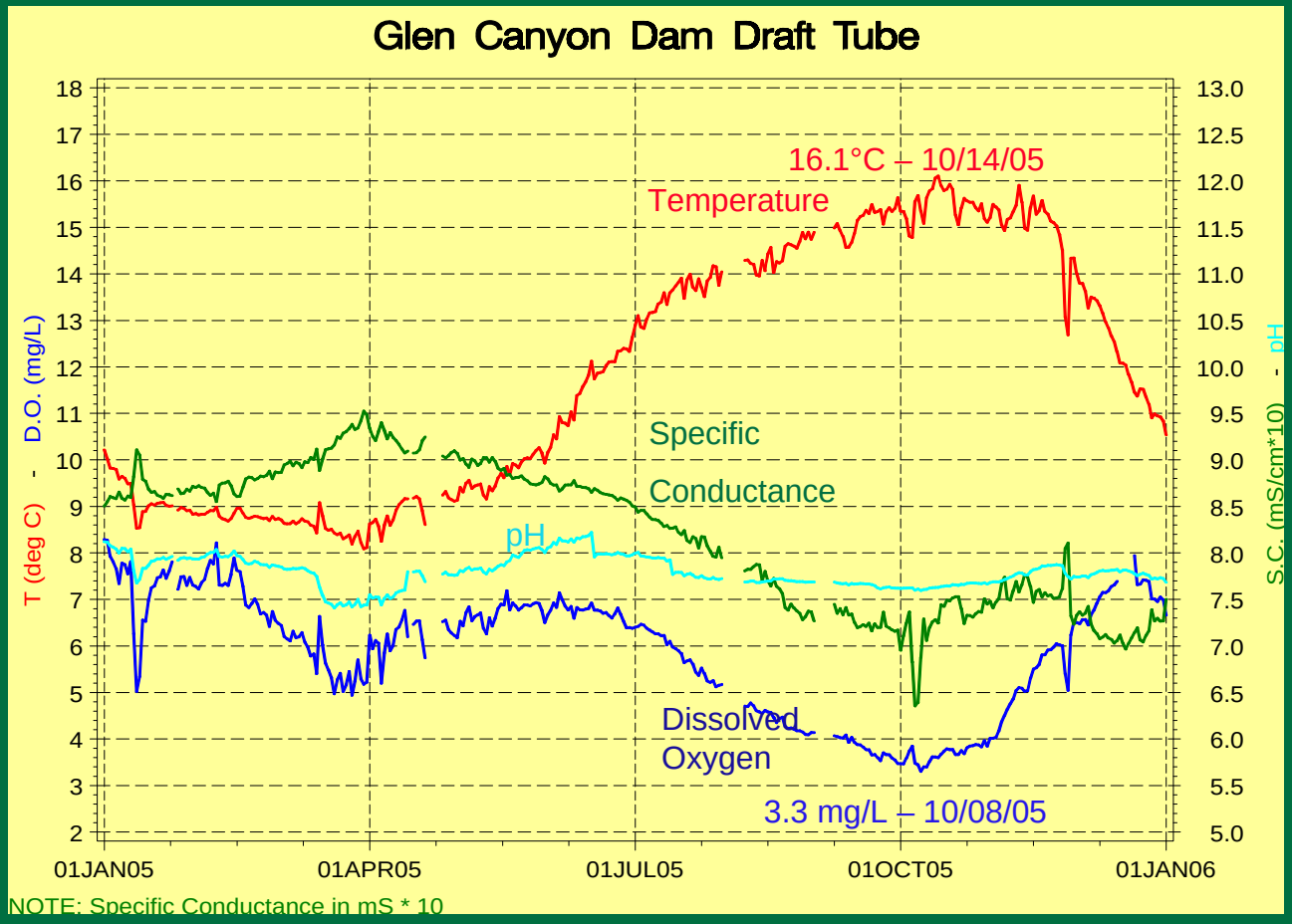
Glen Canyon Dam Releases 2005

Mean daily values

- Lowest dissolved oxygen on record (since 1990)
- 3.3 mg/L on October 8, 2005 from draft tubes
- Hypoxia dissipated by reservoir surface mixing
- Data since 1992 – no evidence of prior hypoxia



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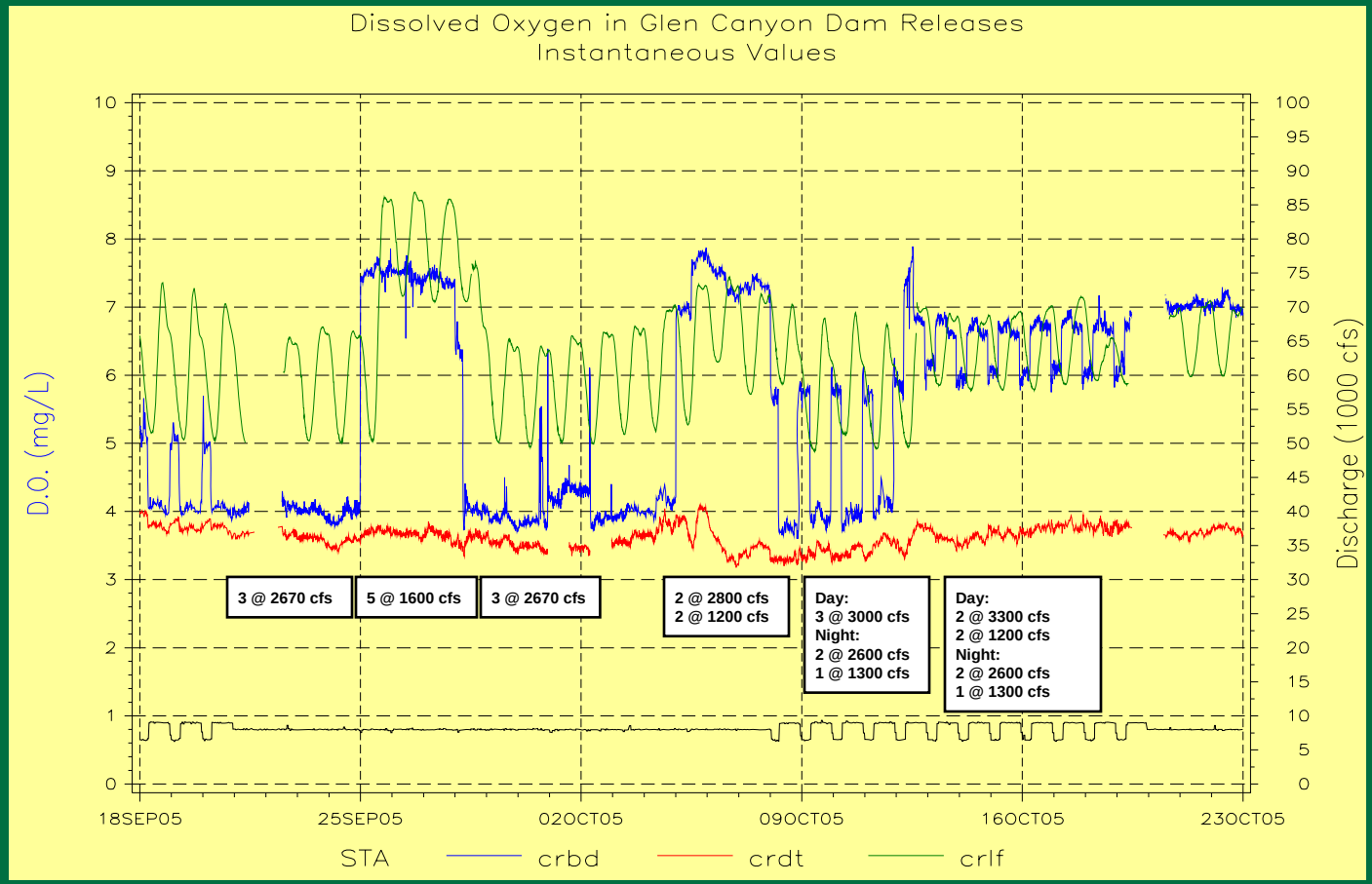
Reaeration Experiment

Long-term monitoring at three locations:

- CRDT (red) GCD Draft Tube
- CRBD (blue) GCD tailwater
- CRLF (green) Lees Ferry



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Applicability to Lake Mead

- Quality of inflows
  - Determines density and depth of inflow
- Quantity of inflows
  - Determines amount of sediment resuspension
- Sediment quality
  - Basin characteristics
- Controls to deltaic erosion
- Withdrawal elevation and intended use

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(928) 556-7051 bvernieu@usgs.gov

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