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Water Quality Monitoring Design Issues for Central Valley, California Streams

Salmonid Restoration Federation
Salmon Enhancement Workshop
March 18, 2004; Davis, CA

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U.S. Geological Survey

Outline for talk

Emphasis will be on monitoring design with respect to data needed for interpretation and not on monitoring protocols (for USGS protocols see http://water.usgs.gov/owq/FieldManual/)

- **Important factors in designing an appropriate monitoring program**
- **Case I – Stable hydrologic conditions (example on pesticide transport during irrigation season)**
- **Case II – Unstable hydrologic conditions (example of pesticide transport during storms and the use of ancillary data in interpretation)**
- **Examples of inappropriate designs**

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Factors Involved in Designing an Appropriate Monitoring Program

- **Goals of data interpretation (i.e., Questions to be answered with data)**
  - **affects entire program (fixed-interval, storm hydrograph, and/or Lagrangian sampling)**
  - **time series of concentrations; peak concentrations; loads; spatial versus temporal variability?**
  - **available ancillary data?**
- **Hydrologic Conditions**
  - **stable versus unstable?**
  - **affects sampling frequency**

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Factors Involved in Designing an Appropriate Monitoring Program (cont'd)

- **Constituents of concern**

  - dissolved vs. suspended material?

  - affects sampling method (grab vs. integrated; manual vs. autosampler; continuous probe vs. discrete samples)

- **Concentrations of concern**

  - affects required detection limits

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Factors Involved in Designing an Appropriate Monitoring Program (cont'd)

- **Location of streamflow and rain gages**
  - real-time?
  - affects location of sampling sites
  - affects ability to design sampling and interpret data
- **Travel times in hydrologic system**
  - affects timing of sampling
- **Size of streams**
  - wading vs. boat
  - affects personnel and equipment needs

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Flow measurement on Feather River with ADCP

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Flow measurement on Bear River with ADCP

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Factors Involved in Designing an Appropriate Monitoring Program (cont'd)

- **QA/QC**
  - **blanks (contamination?)**
  - **replicates (variability?)**
  - **spikes (recovery in sample matrix?)**
  - **required to assure quality of data collected**
- **Available resources for sampling**
  - **personnel**
  - **equipment**
  - **vehicles**

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Case I – Stable Hydrologic Conditions

Example – irrigation season loads of the herbicide metolachlor in SJB

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Stable Hydrologic Conditions

- **Streamflow:** Agricultural drainage and reservoir releases [minor fluctuations except during prolonged reservoir releases for fish movement]
- **Chemical occurrence:** f(application/source and agricultural drainage)
- **Sampling design:** Fixed-interval plus Lagrangian sampling

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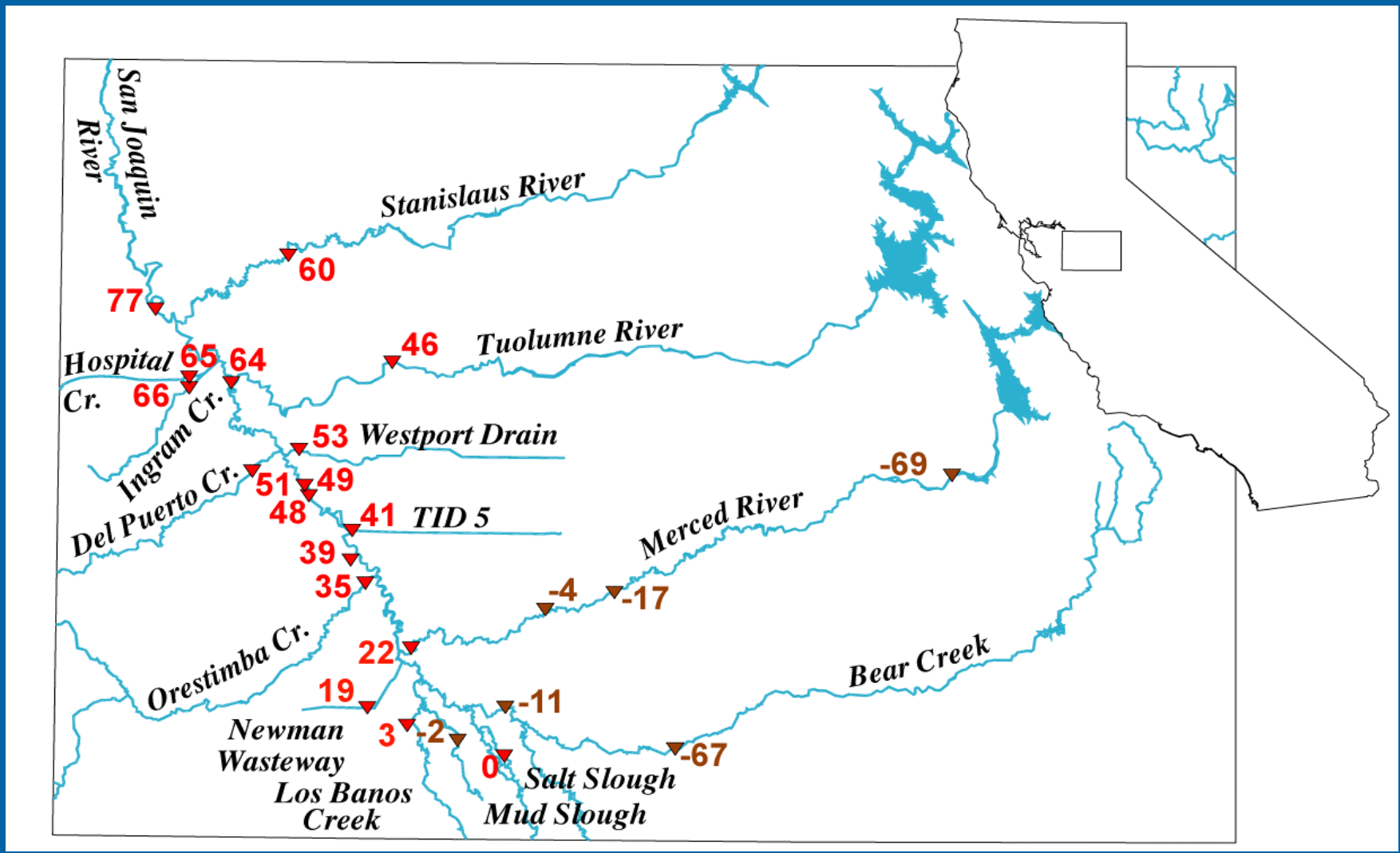
Lagrangian Sampling Design for SJB during Stable Hydrologic Conditions



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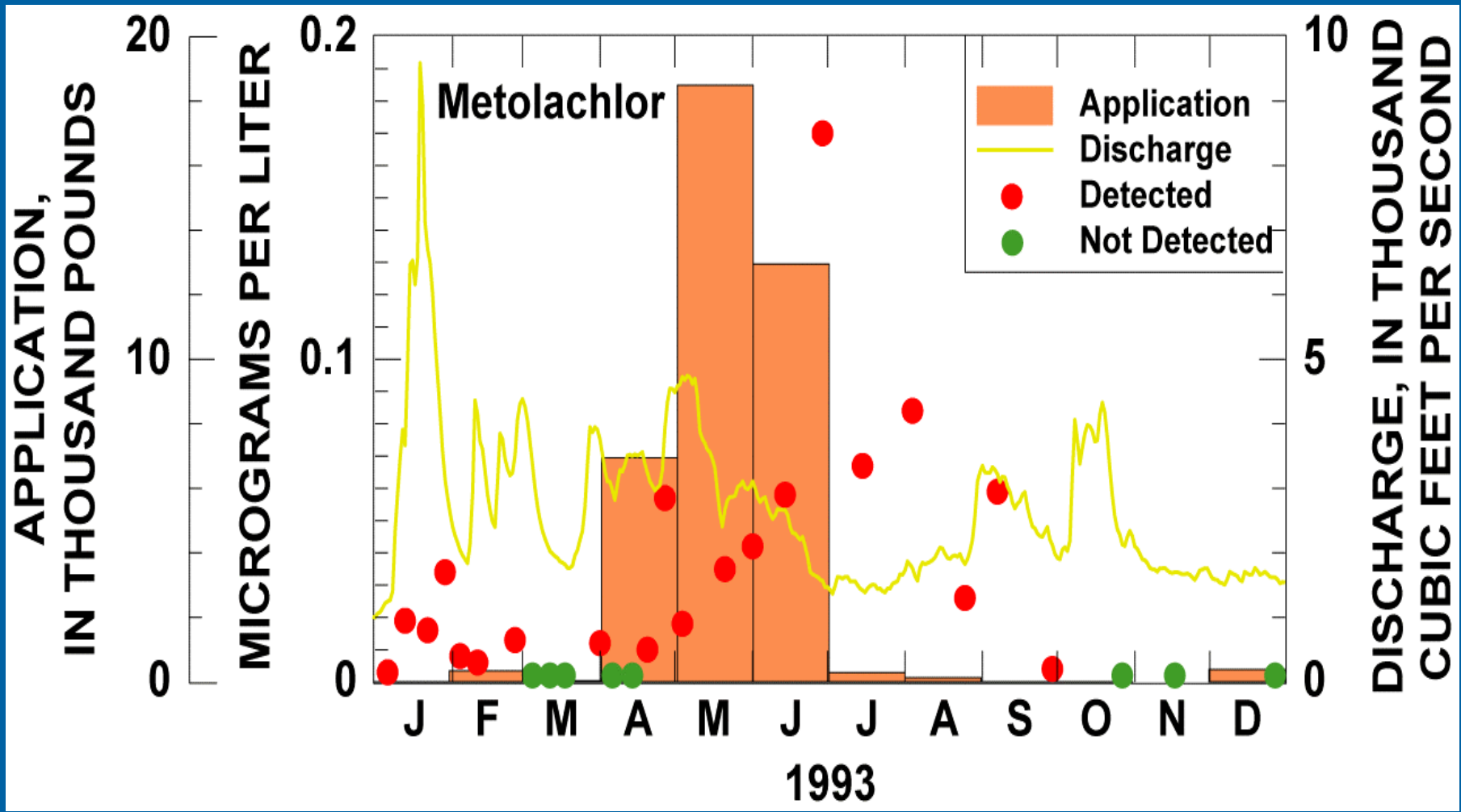
Application and Occurrence of Metolachlor in SJB



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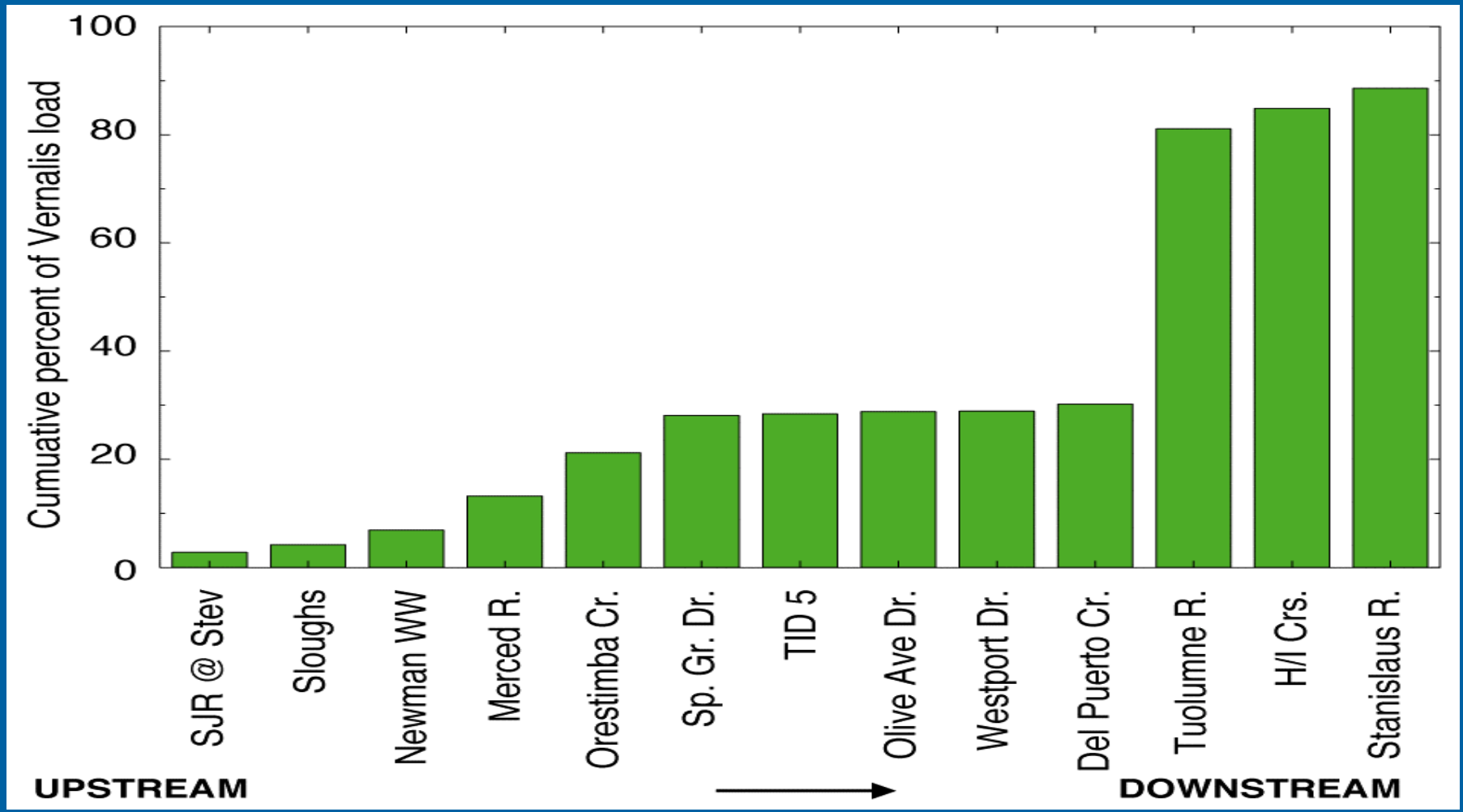
Sources of Metolachlor in SJB on 6/24/94 based on Lagrangian Sampling



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Case II – Unstable Hydrologic Conditions

Example – diazinon concentrations and loads during storms

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Unstable Hydrologic Conditions

- **Streamflow:** Storm runoff and reservoir releases [major fluctuations during storms; can become prolonged high flow after storms if reservoir is into flood control storage space]
- **Chemical occurrence:** f(application/source and storm runoff)
- **Sampling design:** Fixed-interval between storms plus storm hydrograph sampling

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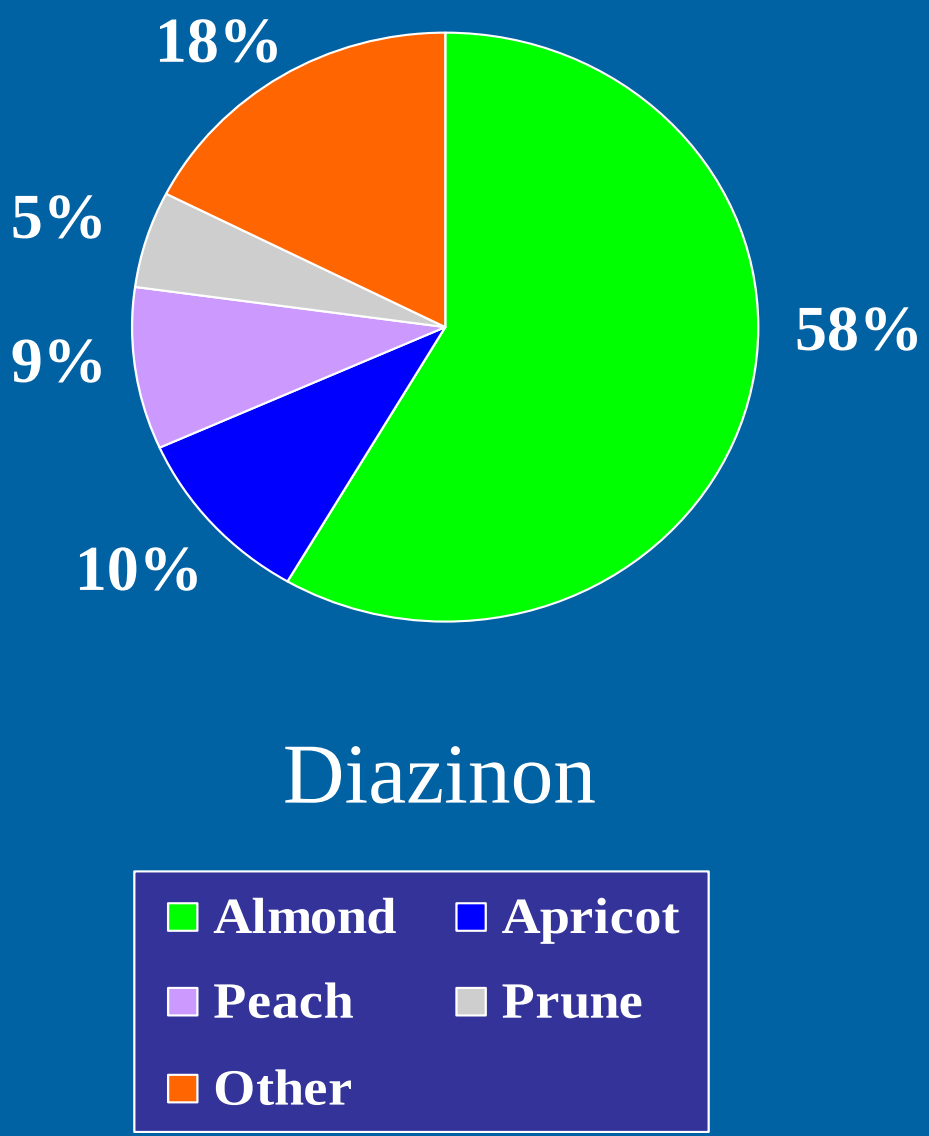
Main Agricultural Uses of Diazinon in SJB, 1995-99



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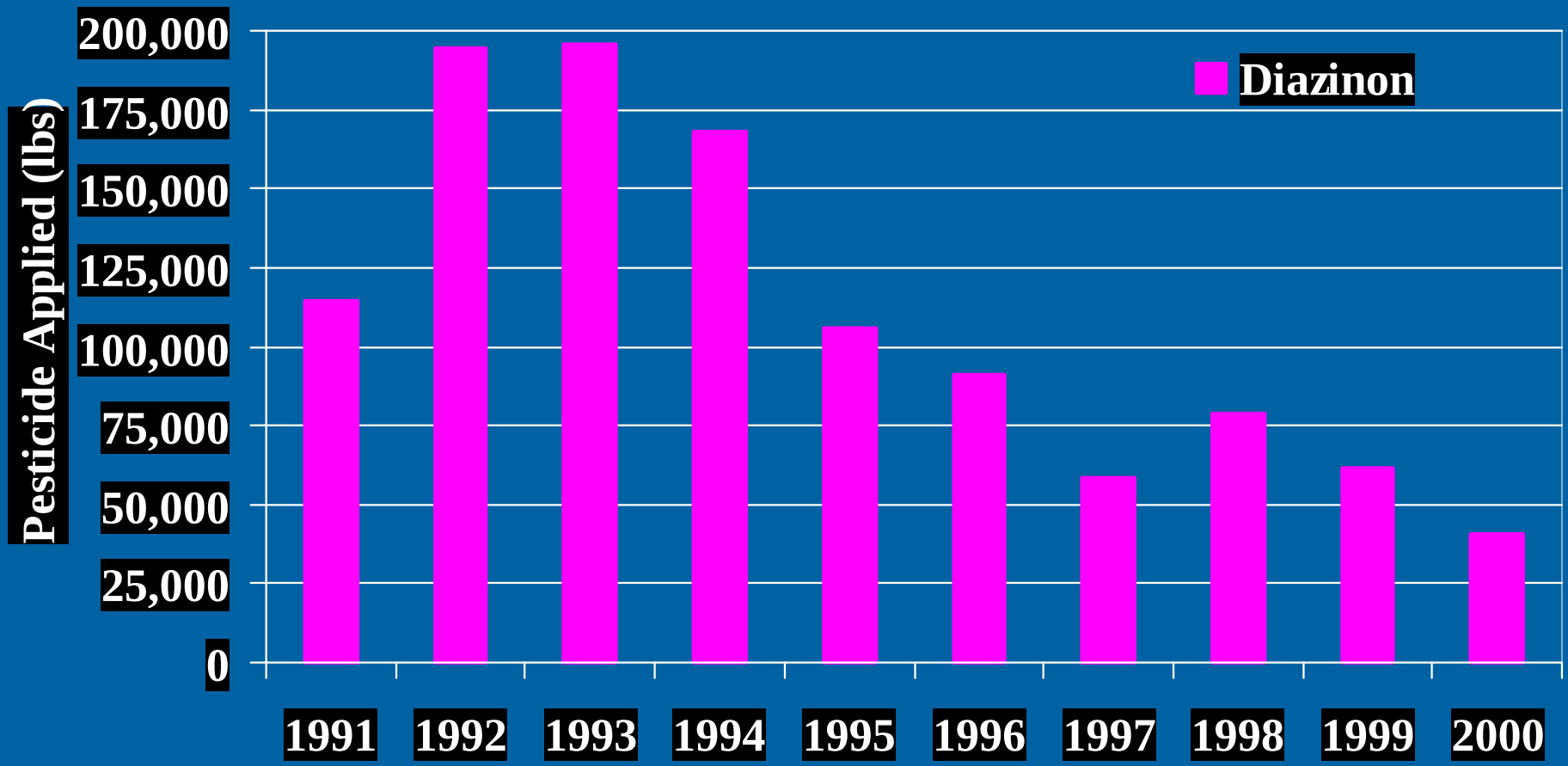
Diazinon Application in SJB, 1991-2000



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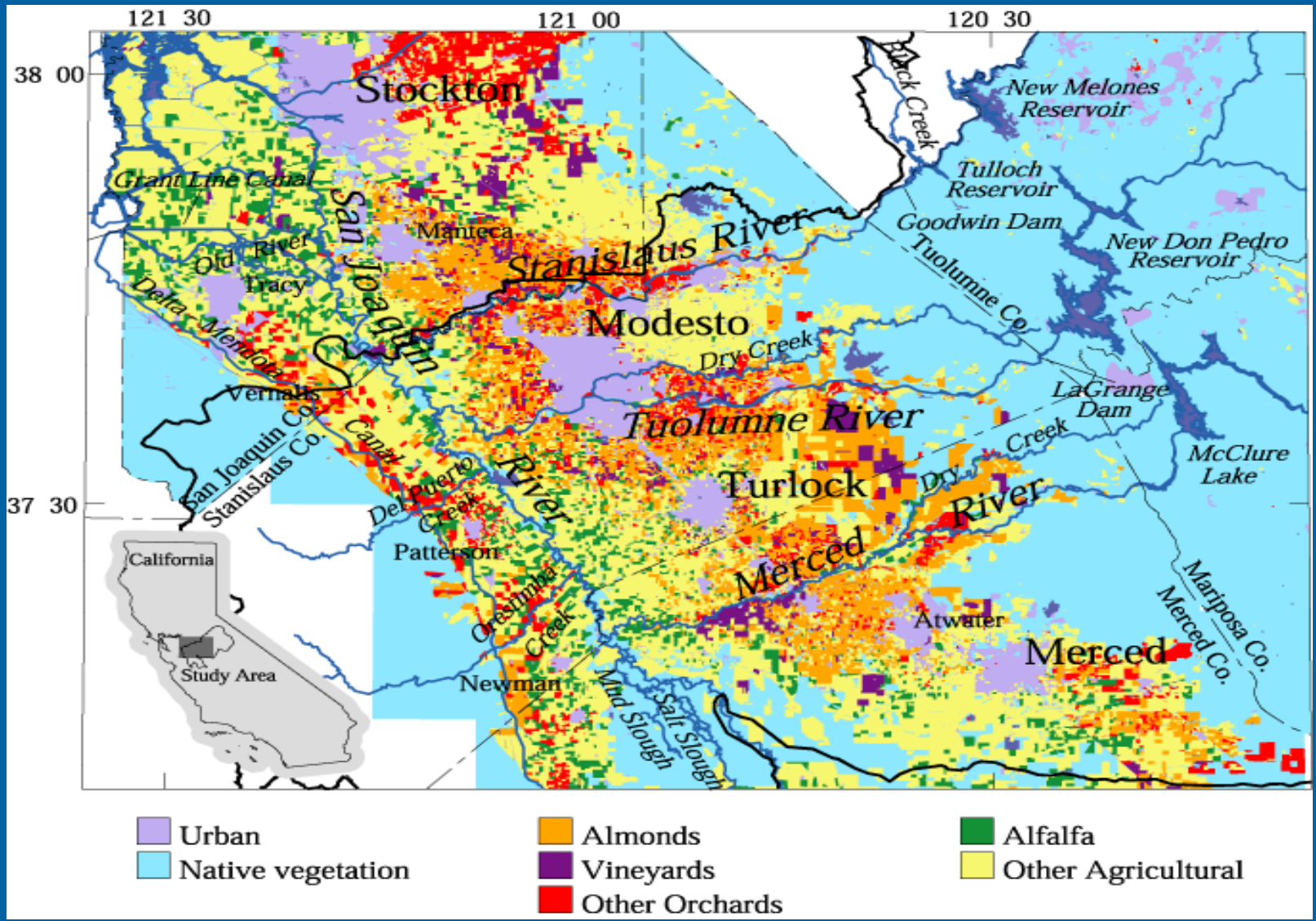
Ancillary Data – Land Use in SJB



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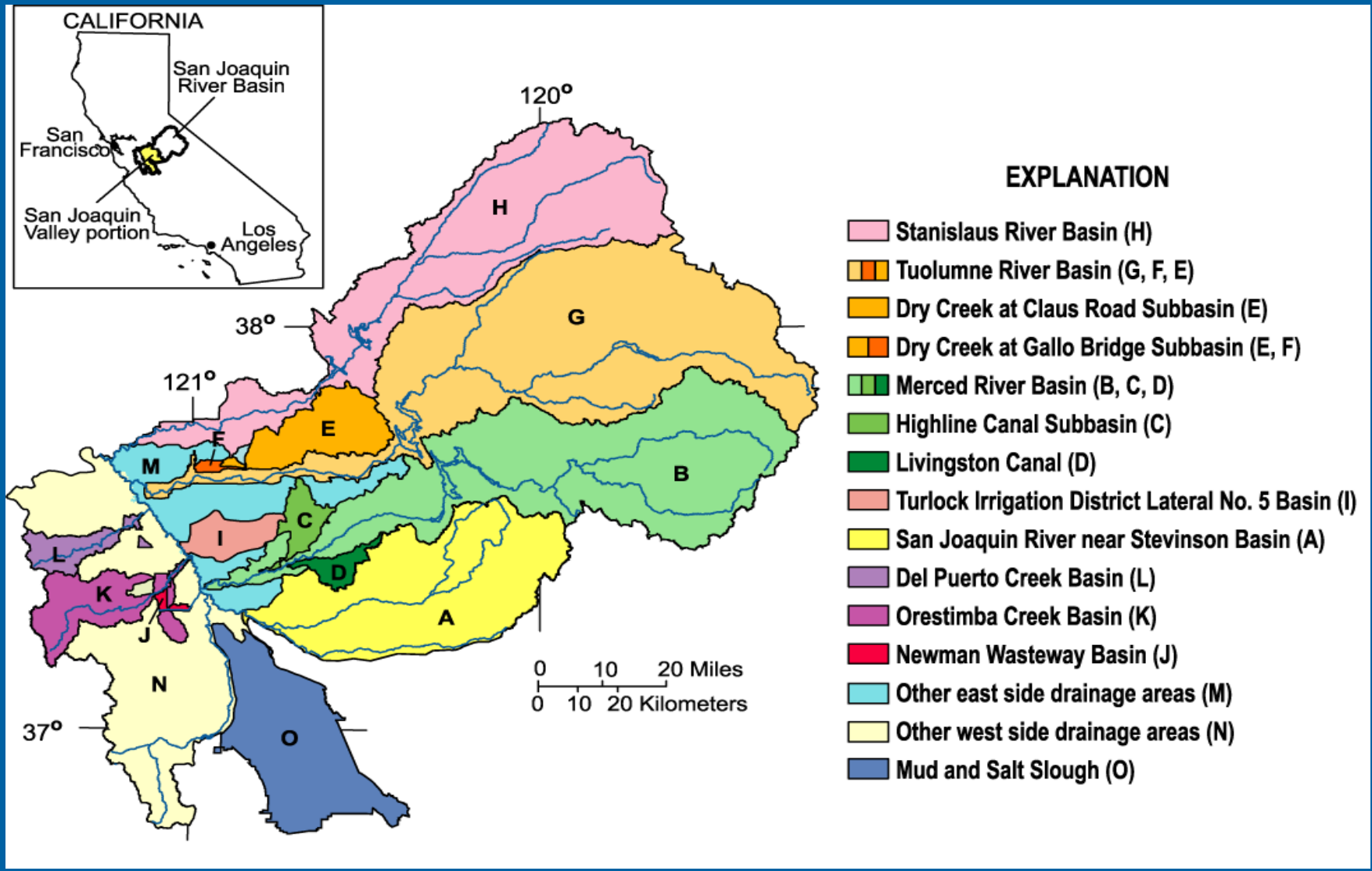
Ancillary Data – Drainage Basins in SJB



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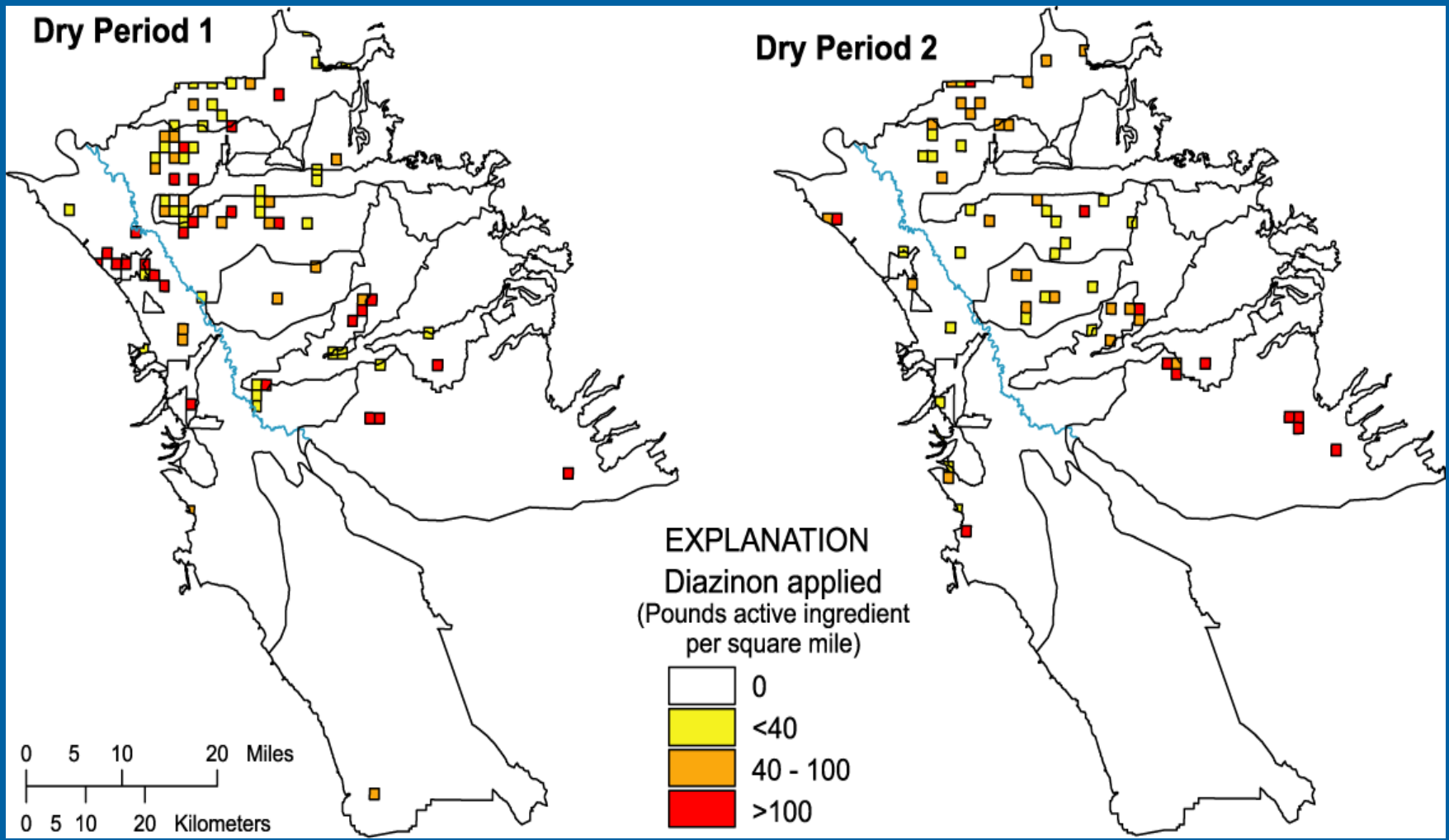
Ancillary Data – Diazinon Application in SJB, 12/99 – 2/00



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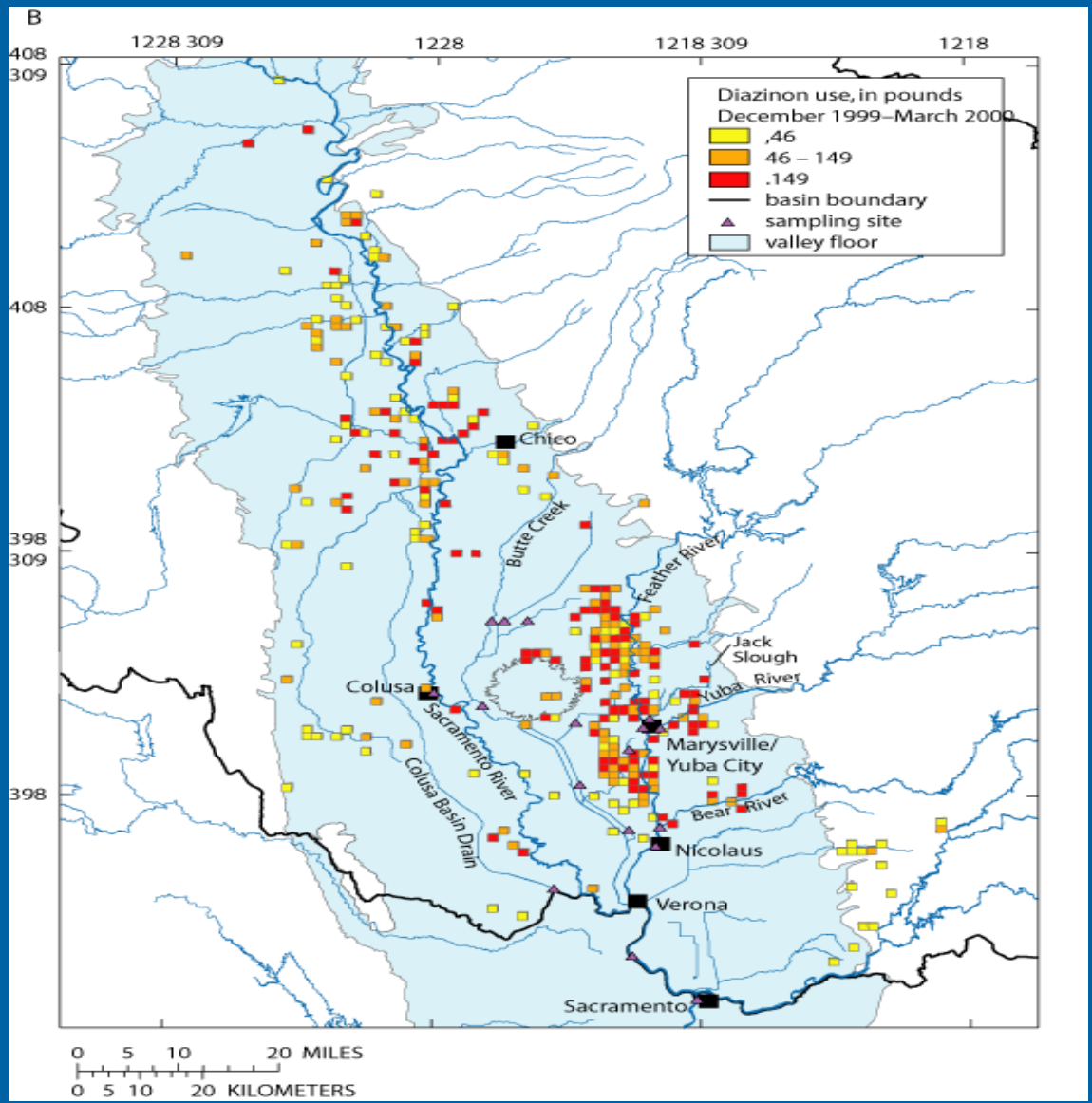
Ancillary Data – Diazinon Application in Sac Basin, 12/99 – 3/00



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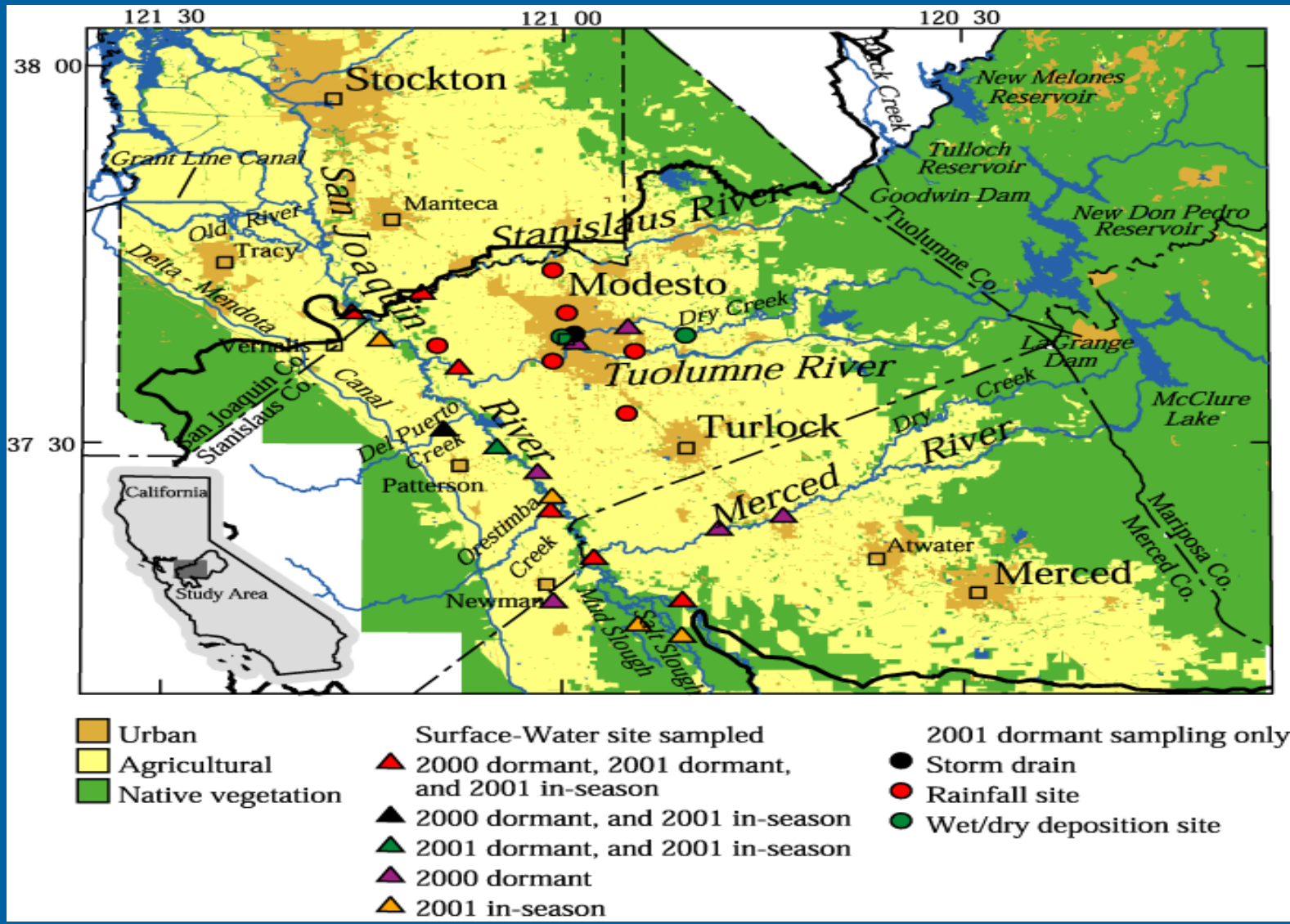
Monitoring Sites in SJB, 1/00 – 8/01



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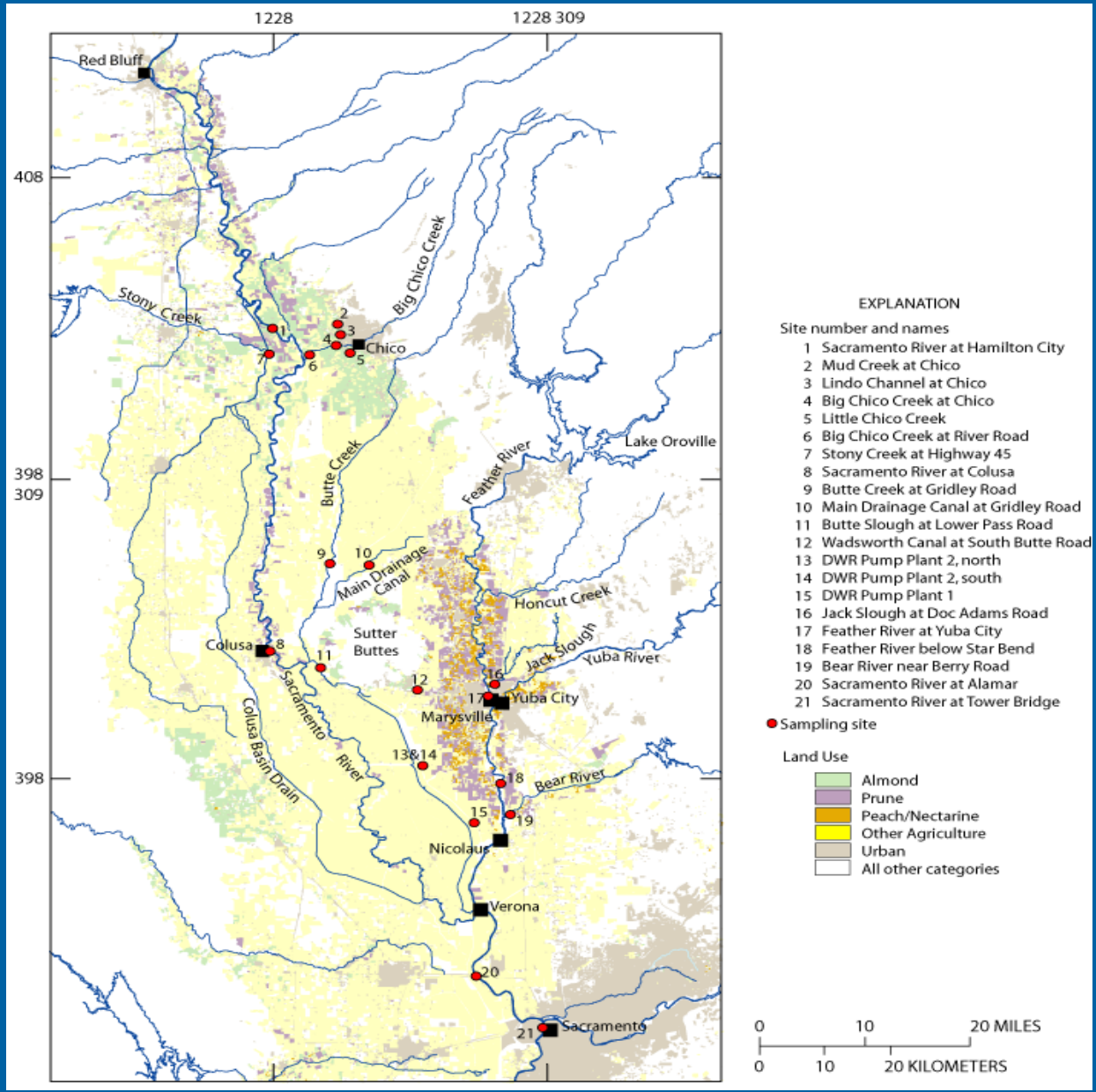
Monitoring Sites in Sac Basin, 1/01 – 2/01



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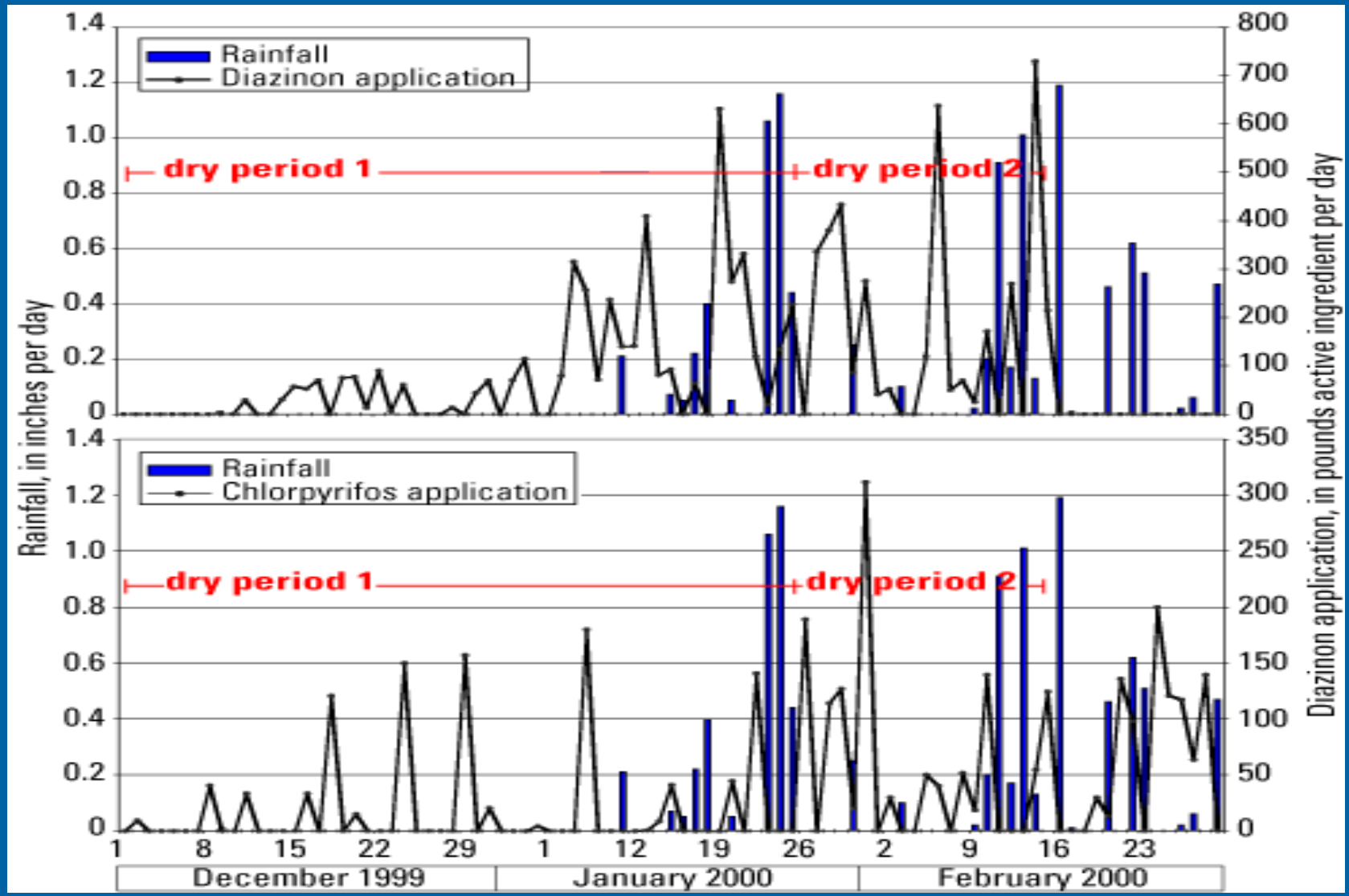
Monitoring Design – Application & Rainfall in SJB, 12/99 – 2/00



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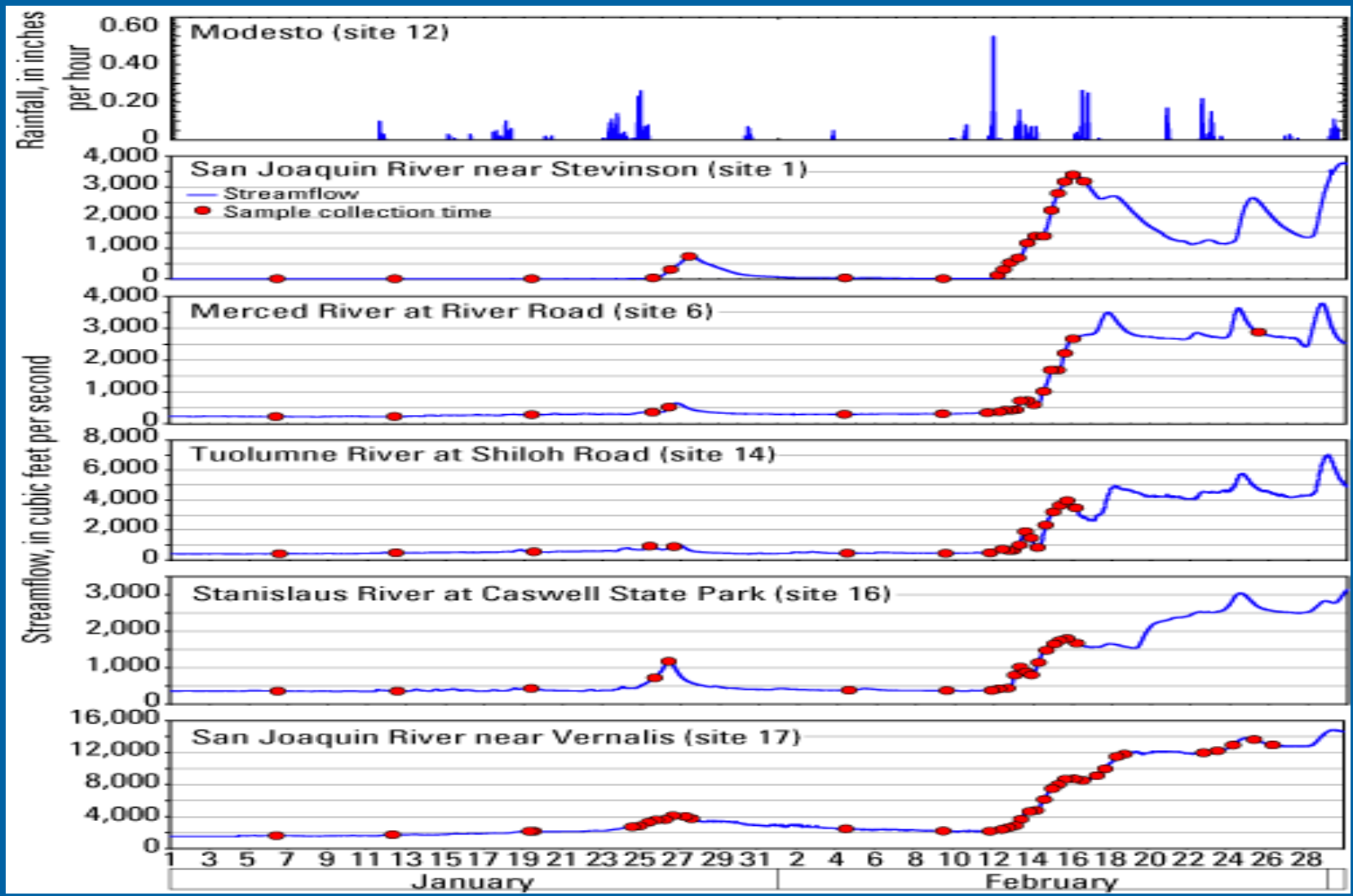
Monitoring Design – Sample Collection in SJB, 1/00 – 2/00



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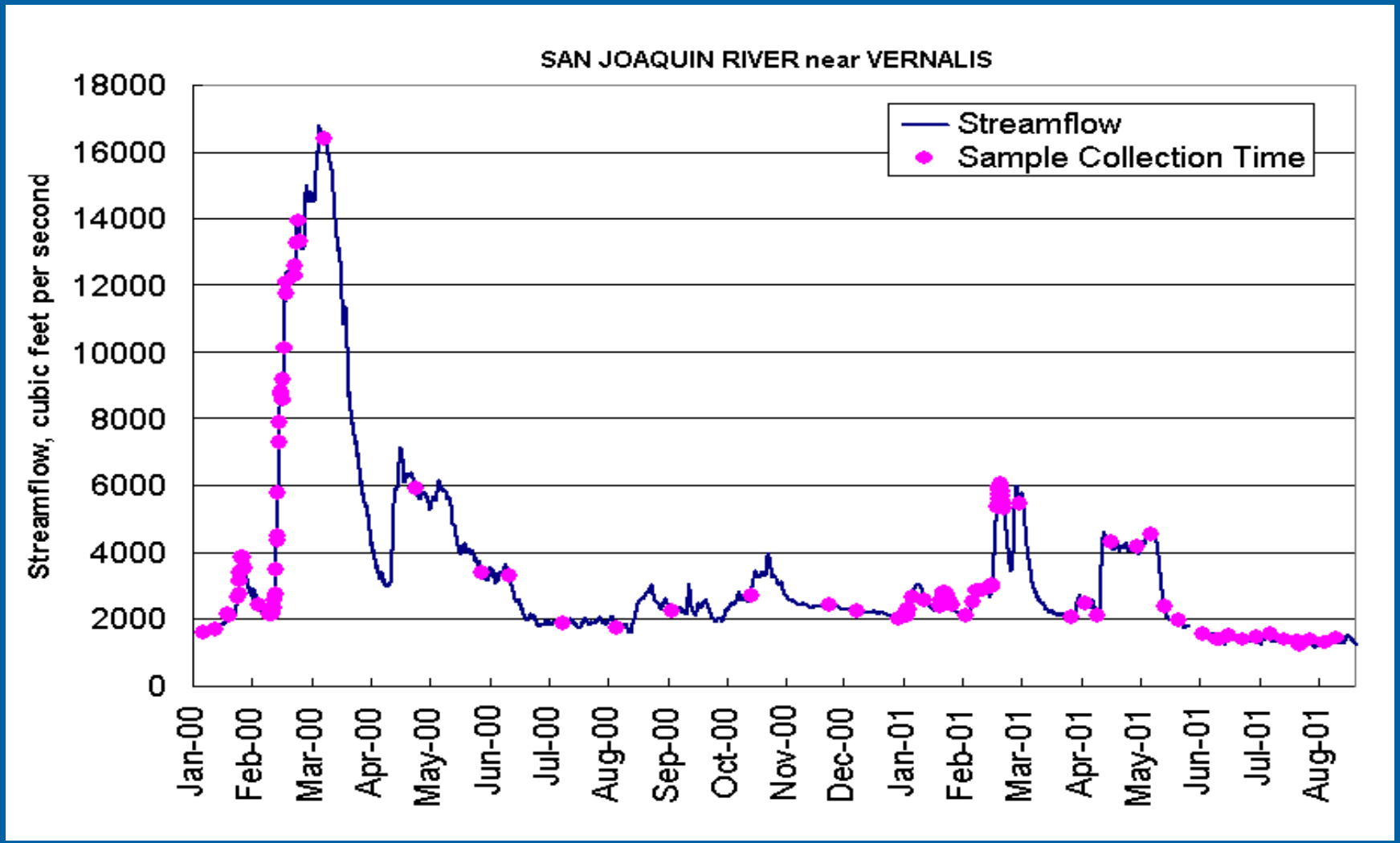
Monitoring Design – Sample Collection in SJB, 1/00 – 8/01



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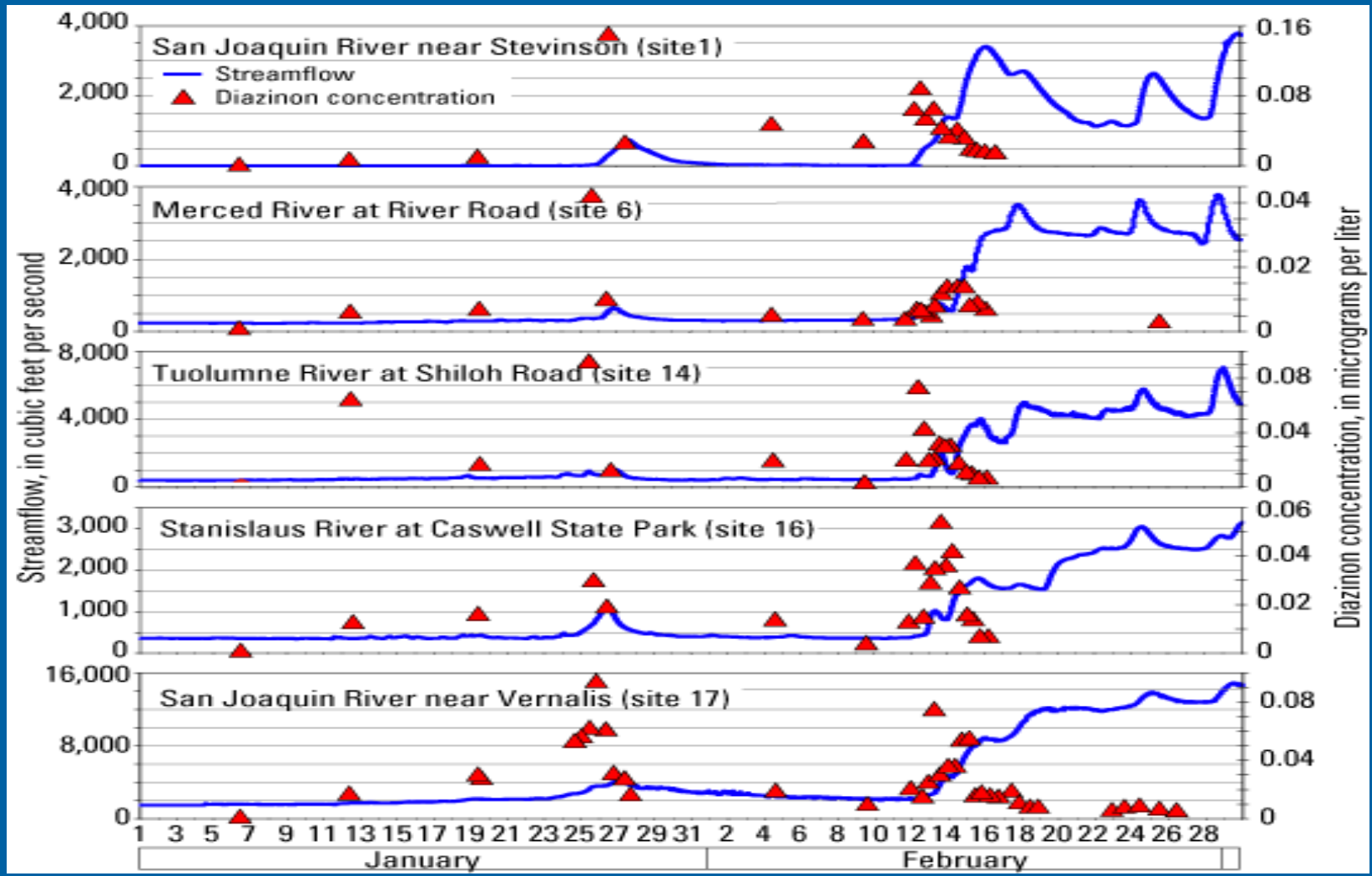
Diazinon Concentrations in SJB, 1/00 – 2/00



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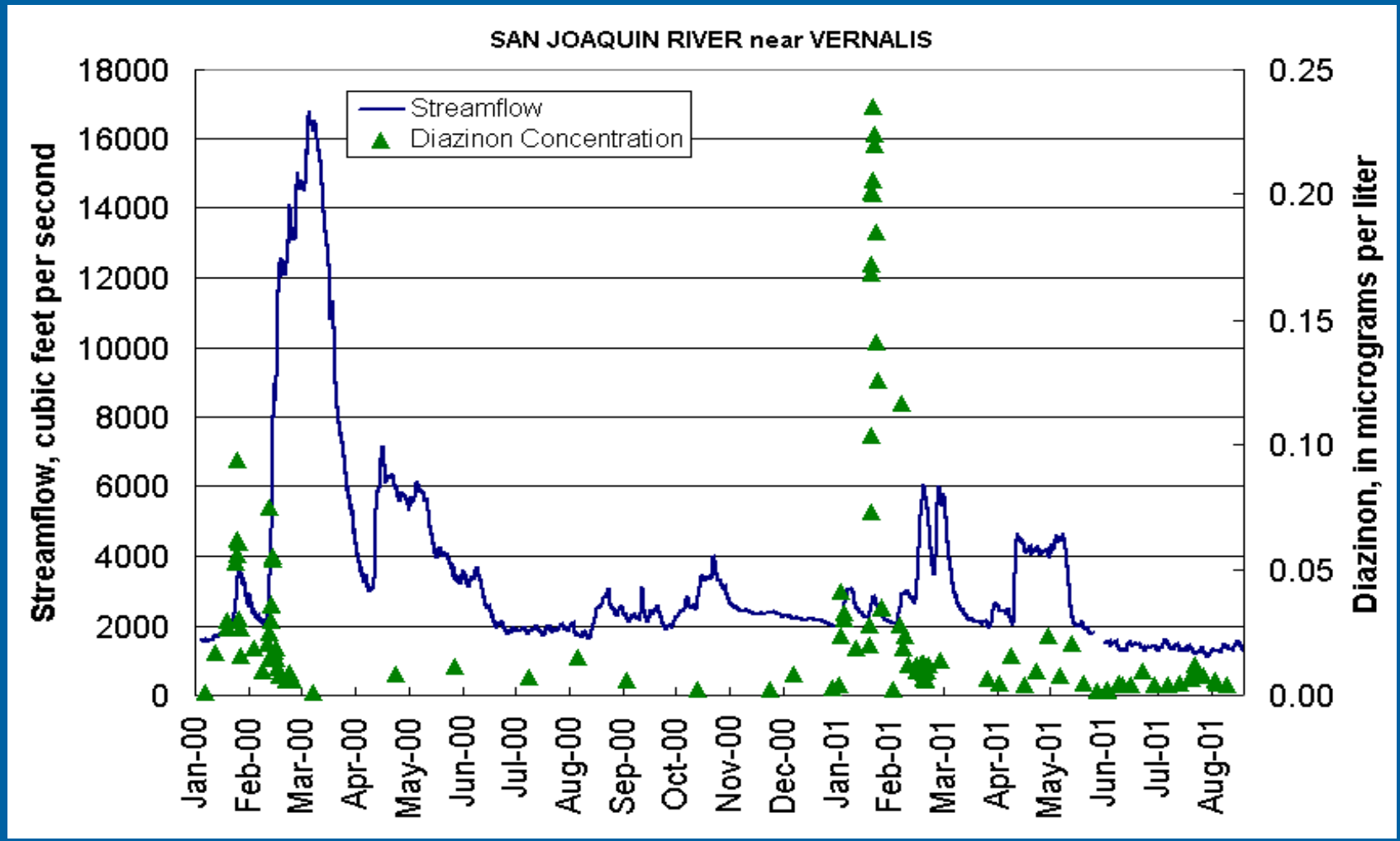
Diazinon Concentrations in SJB, 1/00 – 8/01



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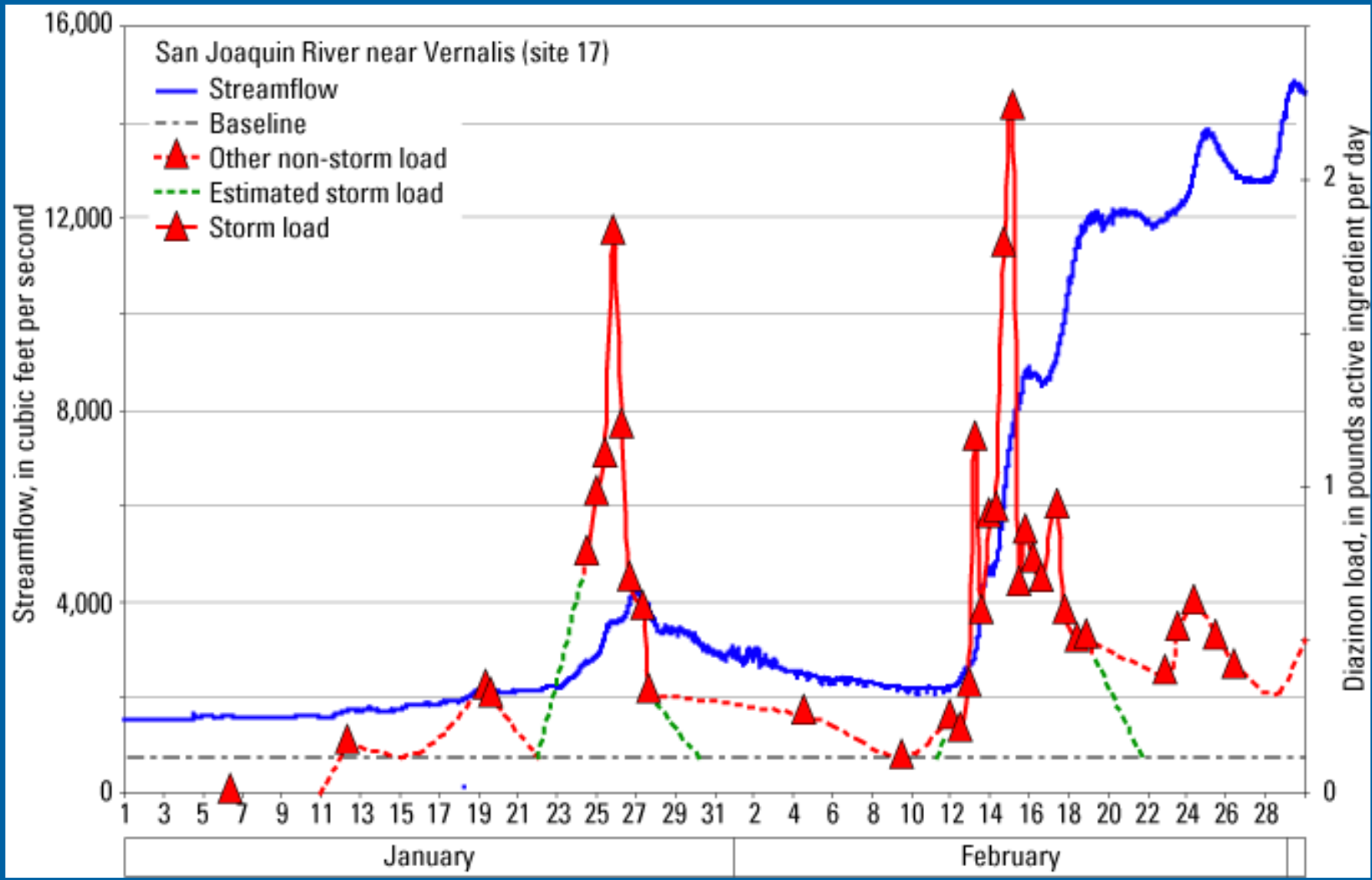
Diazinon Loads in SJB, 1/00 – 2/00



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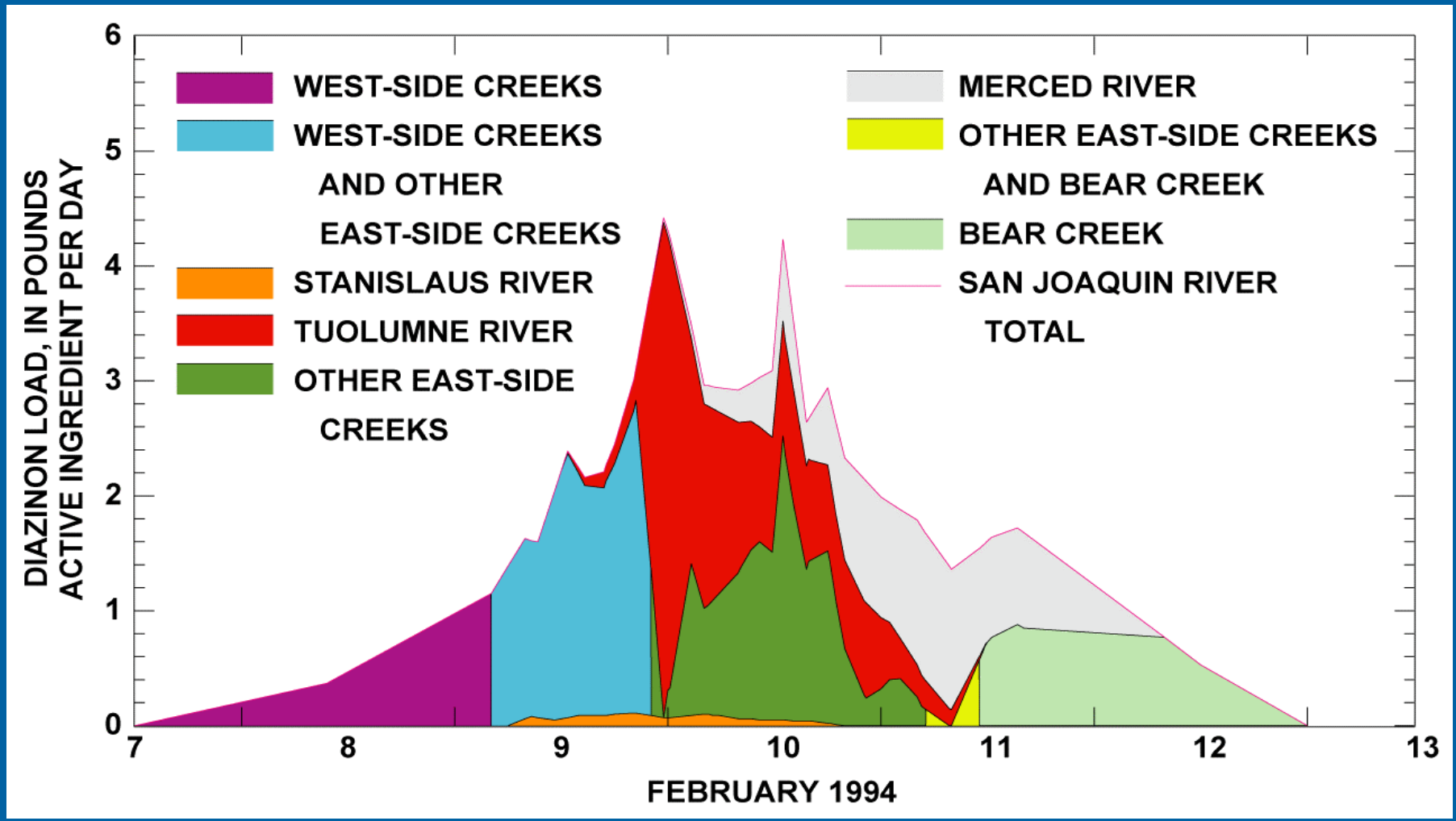
Contributions to Diazinon Load in SJB, 2/94



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Data Interpretations Possible

- Concentrations
- Instantaneous loads
- Total storm and nonstorm loads
- Load as % of application by subbasin
- Yield per contributing subbasin area

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Examples of Inappropriate Designs

- **Insufficient sampling frequency during unstable hydrologic conditions**

  - will miss a significant transport mechanism for most chemical constituents

- **Conducting Lagrangian sampling during unstable hydrologic conditions**

  - will likely misinterpret chemical source areas

- **Analyzing samples with higher detection limits**

  - will make load calculations less defendable

- **Short-term vs. long-term sampling**

  - short-term data will not represent the hydrologic variability in Central Valley

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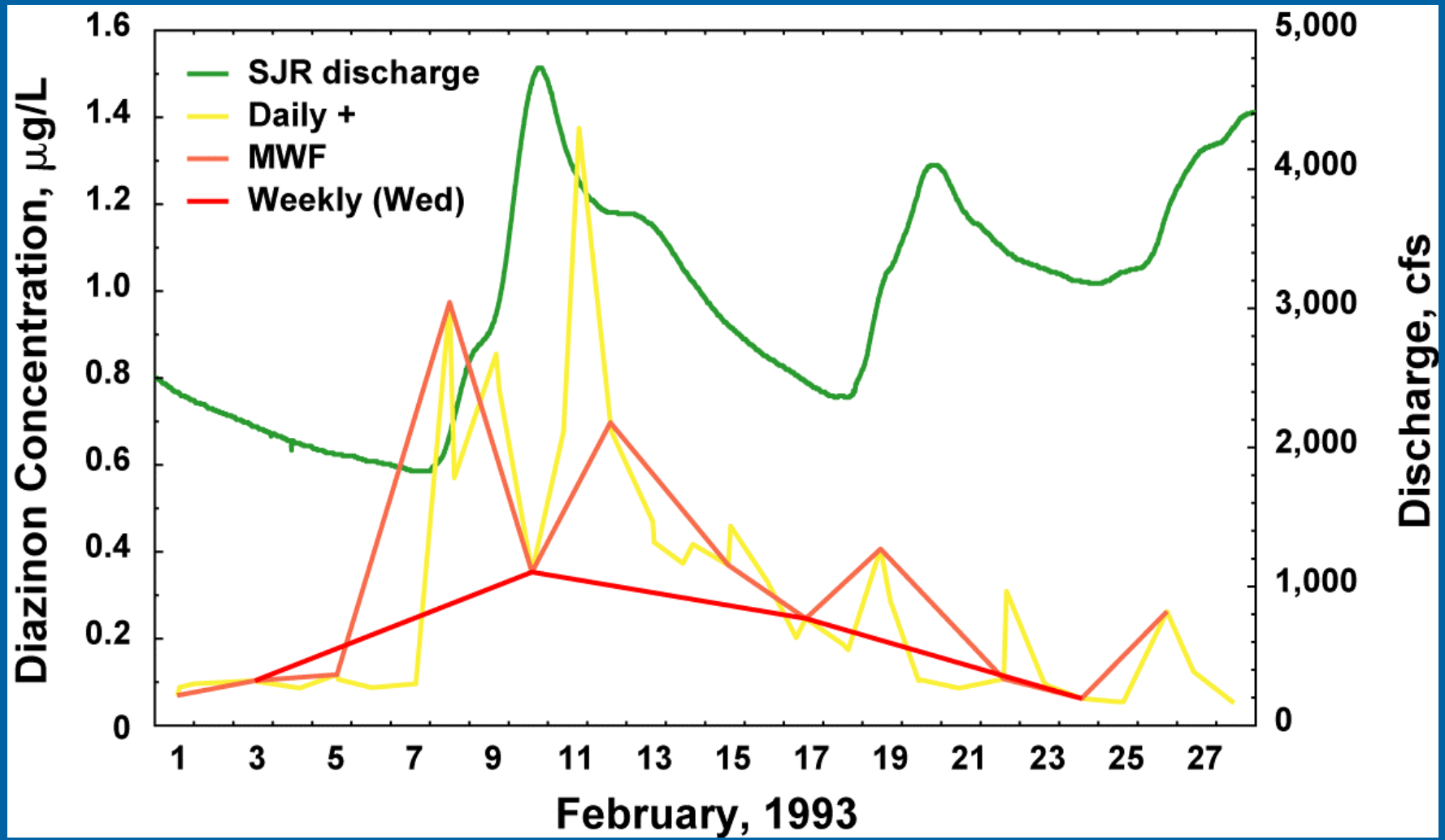
Examples of Inappropriate Designs (sampling frequency)



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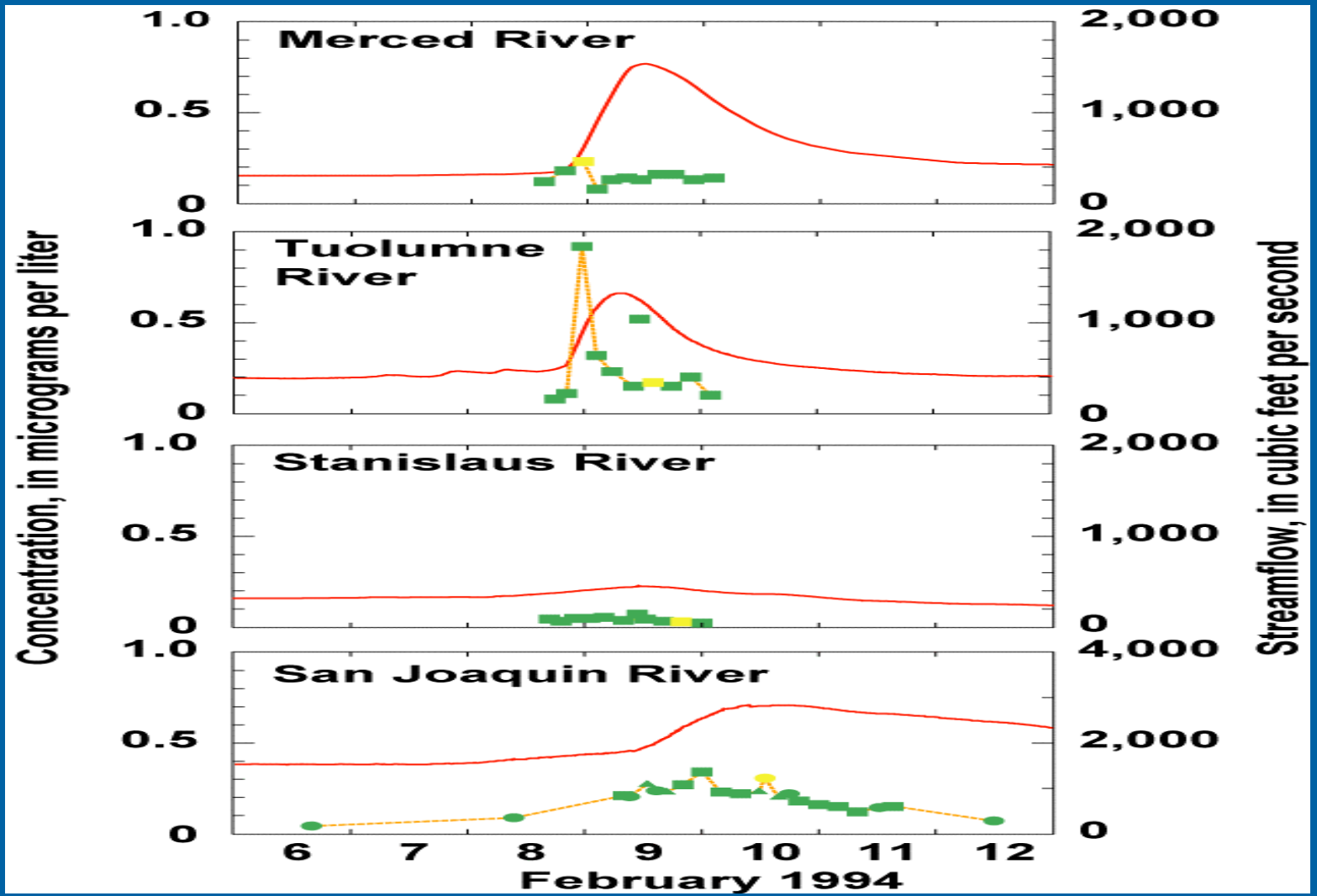
Examples of Inappropriate Designs (Lagrangian sampling during storm)



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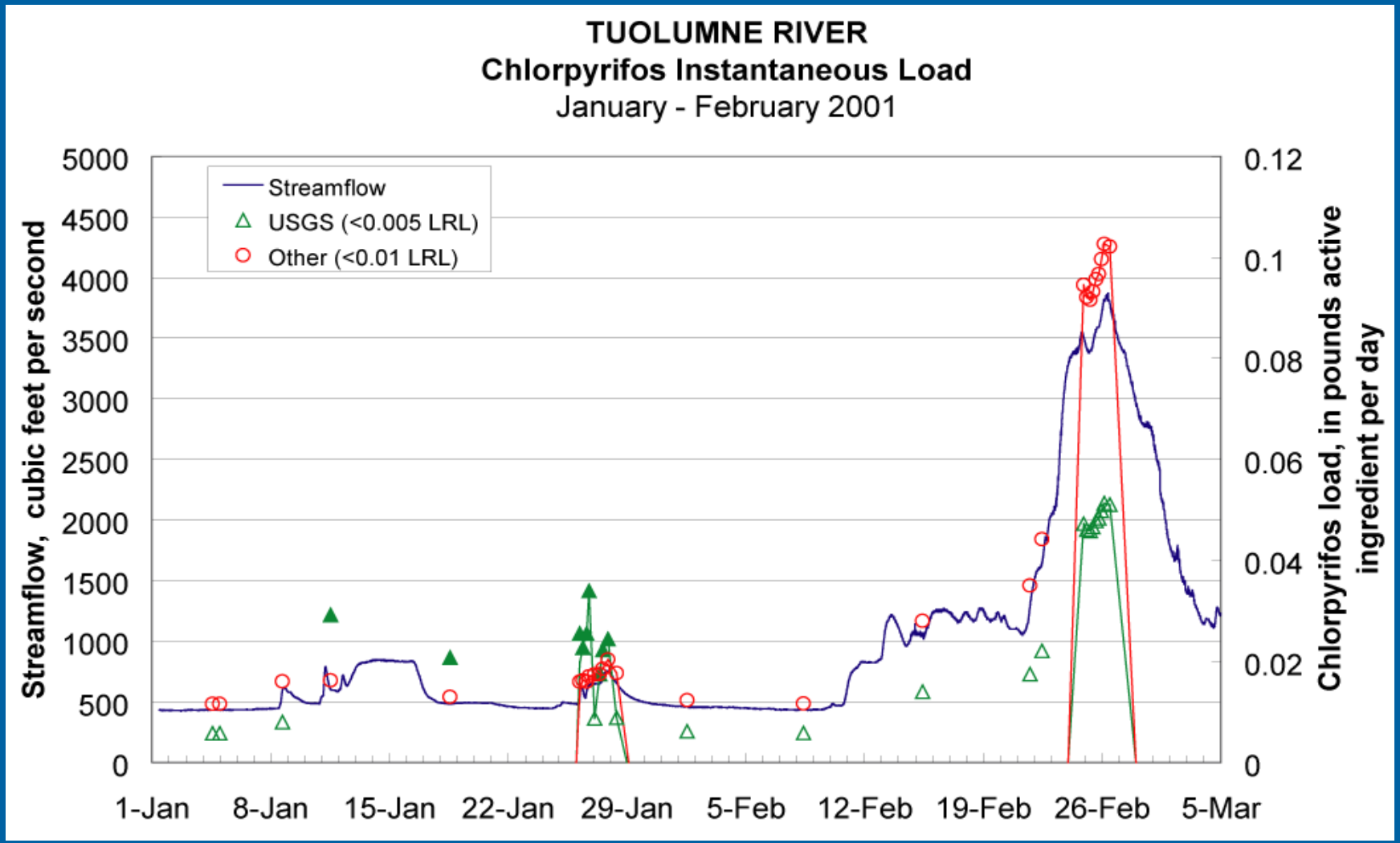
Examples of Inappropriate Designs (detection limits)



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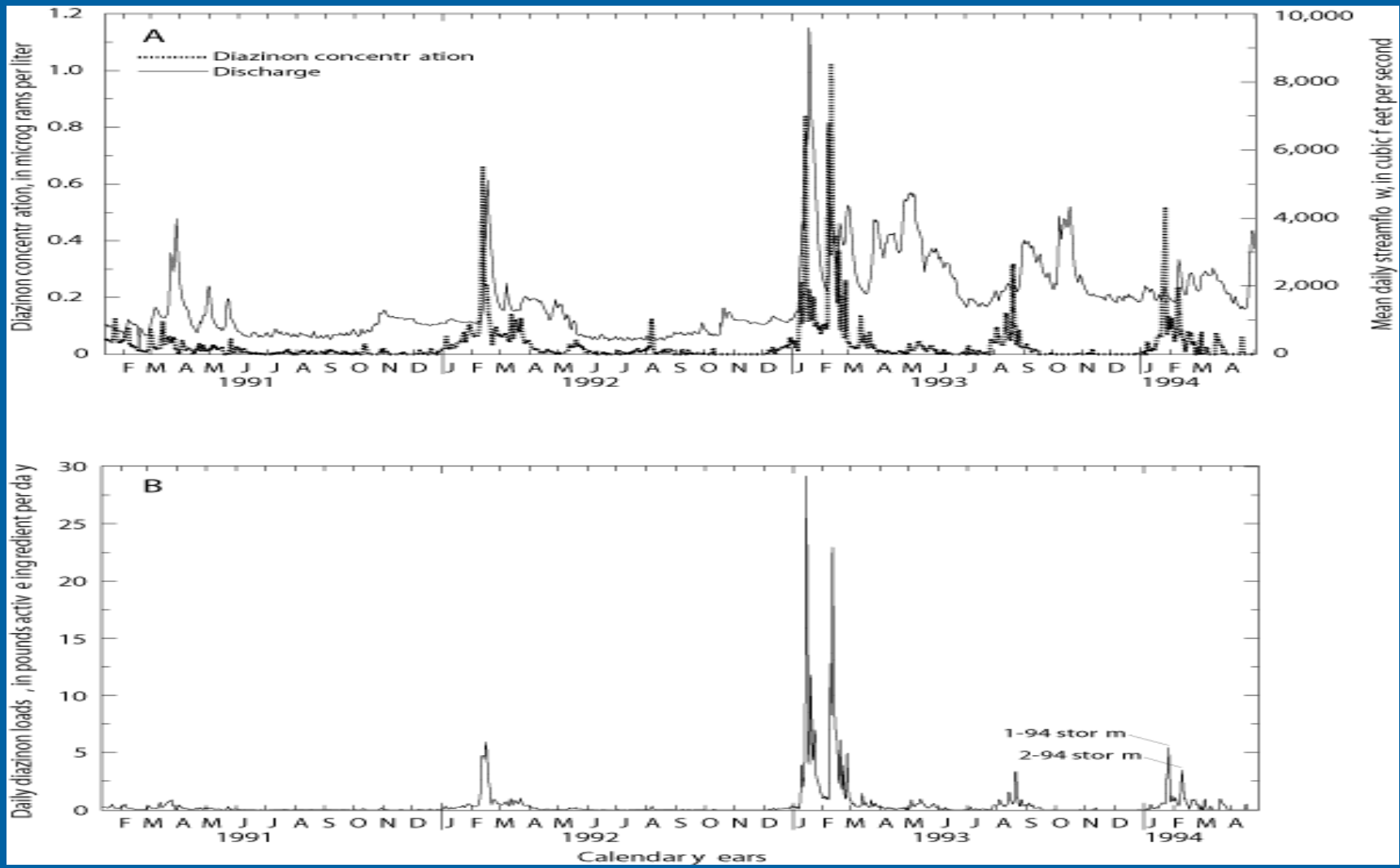
Examples of Inappropriate Designs (short-term vs. long-term sampling)



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How do we measure the success of a water-quality monitoring program?

- Collecting adequate data to calculate loads and/or evaluate trends in water quality
- Loads – need enough data to comfortably integrate under the curve (usually done for storms) or to use a multiple regression load calculation program (ESTIMATOR)
- Trends – need enough data to do a LOWESS flow-adjustment to the data and a seasonal Kendall trend analysis on the flow-adjusted dataset

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Conclusions

- Sampling frequency is determined by chemical application/sources and hydrology
- Real-time hydrologic information is essential to storm sampling
- Ancillary data is very useful for site selection and data interpretation
- Low detection limits are essential to load calculations
- Long-term sampling is essential in the Central Valley to represent hydrologic variability
- Streamflow data is essential to a successful water quality sampling program

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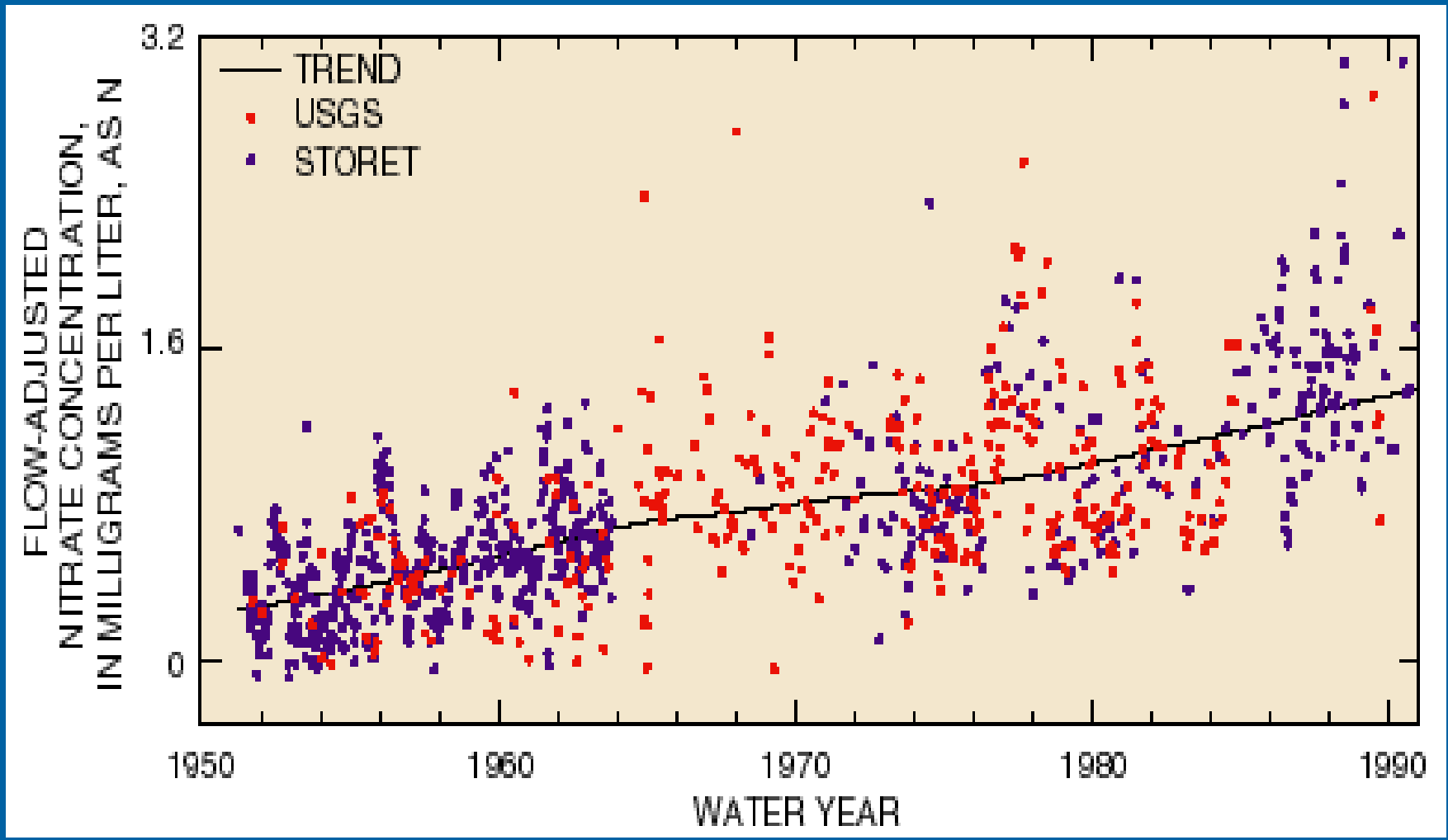
Example of a GREAT dataset – Nitrate trend in SJB, 1951-2004



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General Sampling Recommendations for Central Valley Streams

Stable Hydrologic Conditions:

- Fixed-interval sampling at small number of "representative" sites for evaluating temporal and spatial variability
- Lagrangian sampling at several sites for evaluating additional spatial variability

Unstable Hydrologic Conditions:

- Fixed-interval sampling at small number of "representative" sites for evaluating temporal and spatial variability (between storms)
- Storm hydrograph sampling at "representative" sites during storm runoff to evaluate temporal variability

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