A multi-year temporal and spatial evaluation of pyrethroid concentrations and biological effects in the lower American River

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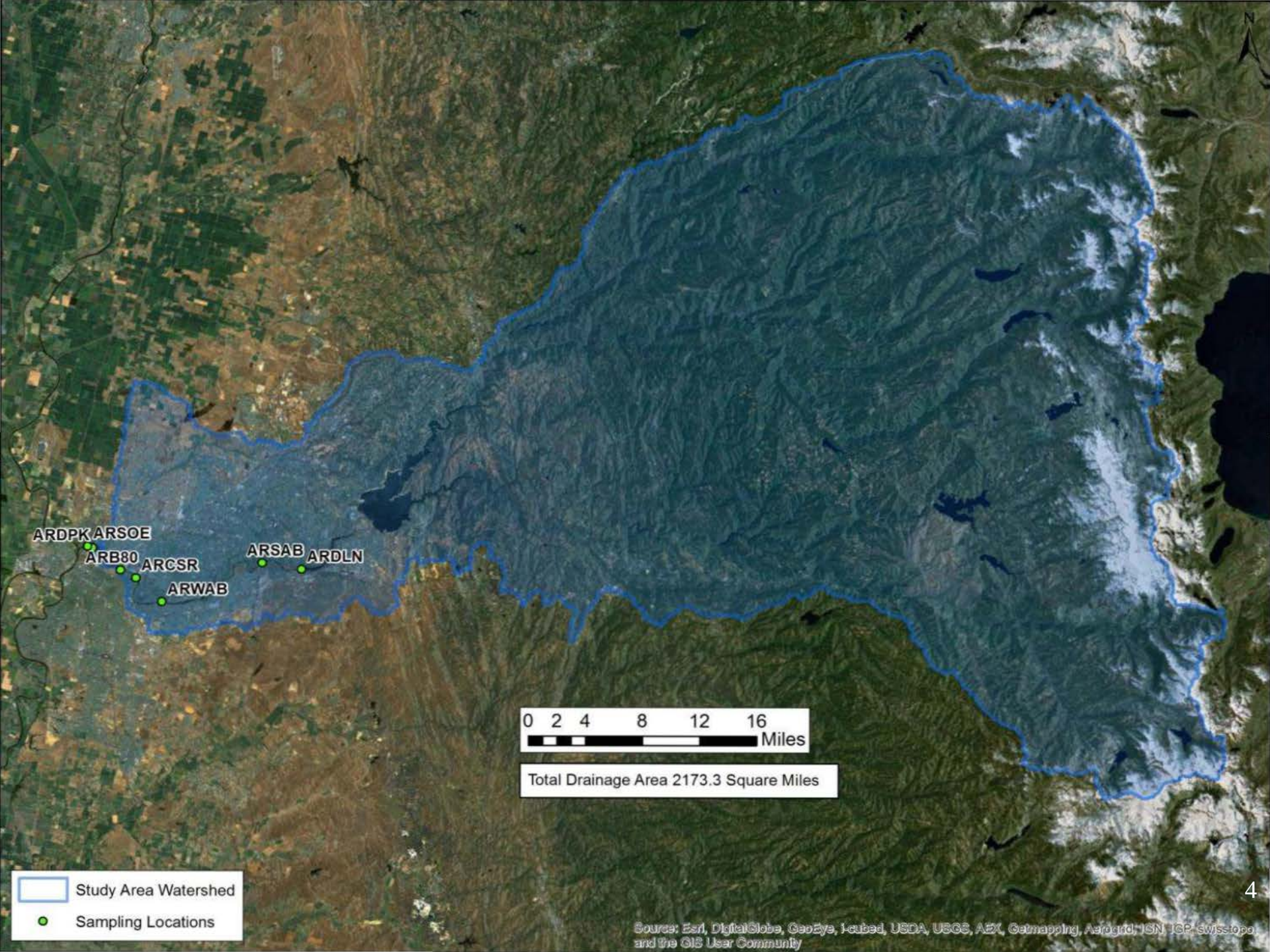
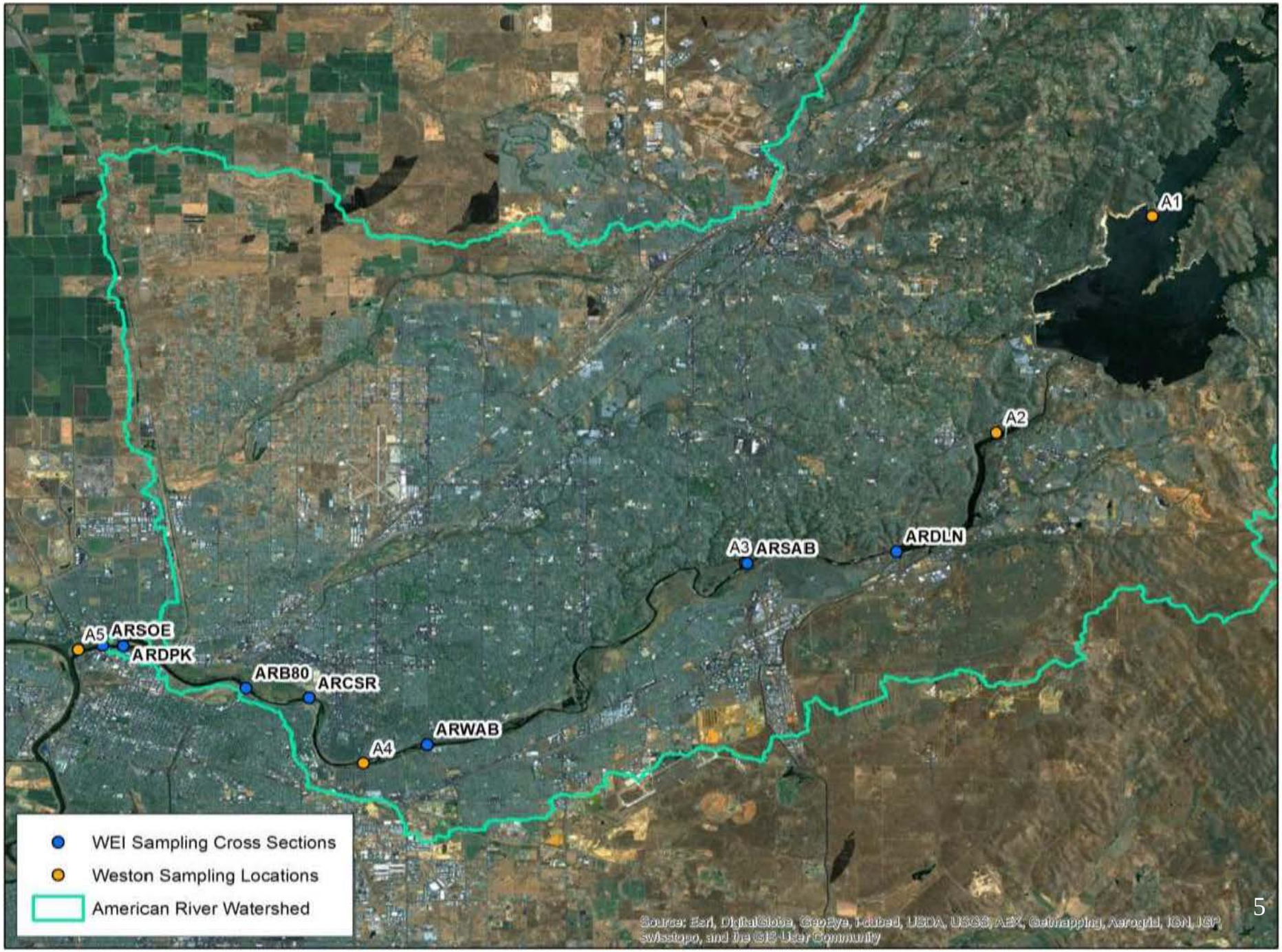
Presentation Overview

- Background/history
- Study objectives
- Study and sampling design updates
- Results to date
- Conclusions

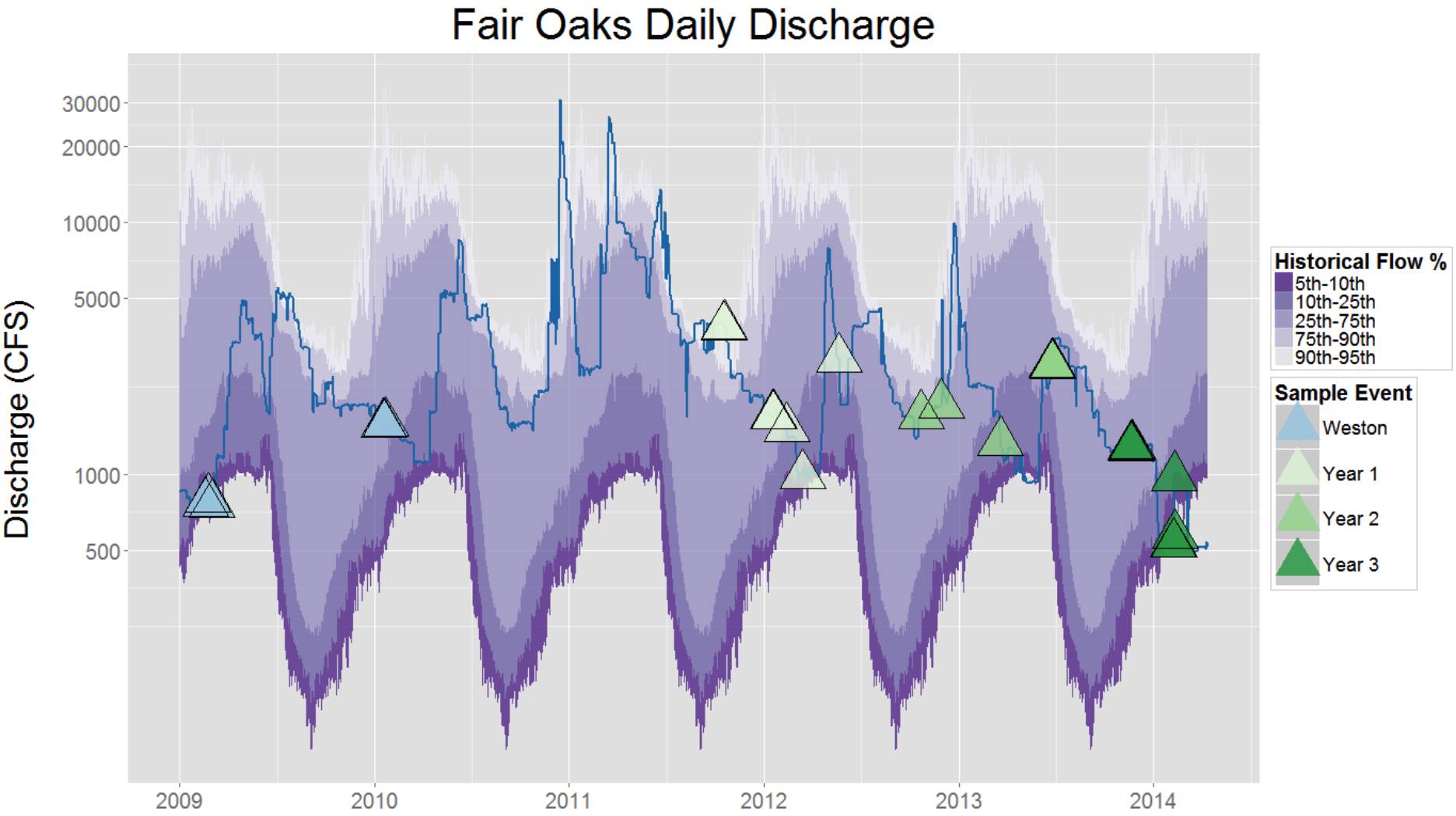
Pre 2012-2014 Monitoring Summary

- Weston and Lydy (2010 and 2012) indicated the presence of pyrethroid residues in grab samples and toxicity to *H. azteca* in lower 30 km reach
- Additional monitoring program started in 2011 by Pacific EcoRisk/Waterborne using multiple discrete depth transects to evaluate spatial and temporal aspects of magnitude and duration of any exposures
  - Dry-weather sampling yields non-detects
  - Rainfall-event sampling yields few sporadic detections without a discernible trend or pattern
    - Within a river transect
    - Generally from transect to transect on a day and through the season


N
ARDPK
ARSOE
ARB80
ARCSR
ARWAB
ARSAB
ARDLN
0 2 4 8 12 16
Miles
Total Drainage Area 2173.3 Square Miles
Study Area Watershed
Sampling Locations
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


A1
A2
A3
ARSAB
ARDLN
A5
ARSOE
ARDPK
ARB80
ARCSR
A4
ARWAB
WEI Sampling Cross Sections
Weston Sampling Locations
American River Watershed
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

2009-2014 Flow and Sampling Events



Study Objectives

- Supplement existing reported monitoring results
- Expand sampling protocols to provide more extensive and relevant characterization
- Adapt monitoring design for very large river systems
- Focus monitoring power on as many significant rainfall events as possible for at least two rainy seasons
- Compare the sensitivity of resident *H. azteca* to laboratory-reared *H. azteca* using both stormwater samples and cypermethrin as a representative pyrethroid
- Provide a robust picture of the American River system to the Pyrethroid Working Group (PWG), regulatory authorities, and others and give them a tool with which to make sound, scientifically-based decisions

Expanded Approach for 2012-2014

- Evaluate and contextualize rainfall patterns and flows within the watershed
- Focus only on rainfall event-driven sampling
  - Analysis of total concentrations for 8 pyrethroids at the reporting limit (RL: 15 ng/L permethrin, 3 ng/L deltamethrin and esfenvalerate, all others 1.5 ng/L)
- Transect sampling to utilize depth integrated samplers
- Revisit a transect multiple times in a day
- Follow a pulse of river water downstream to learn more about dilution
- Sample during multiple parts of an event lasting several days for both analytical and toxicity assessment
- Begin to understand river discharge patterns, what does the full body of sampling data tell us?

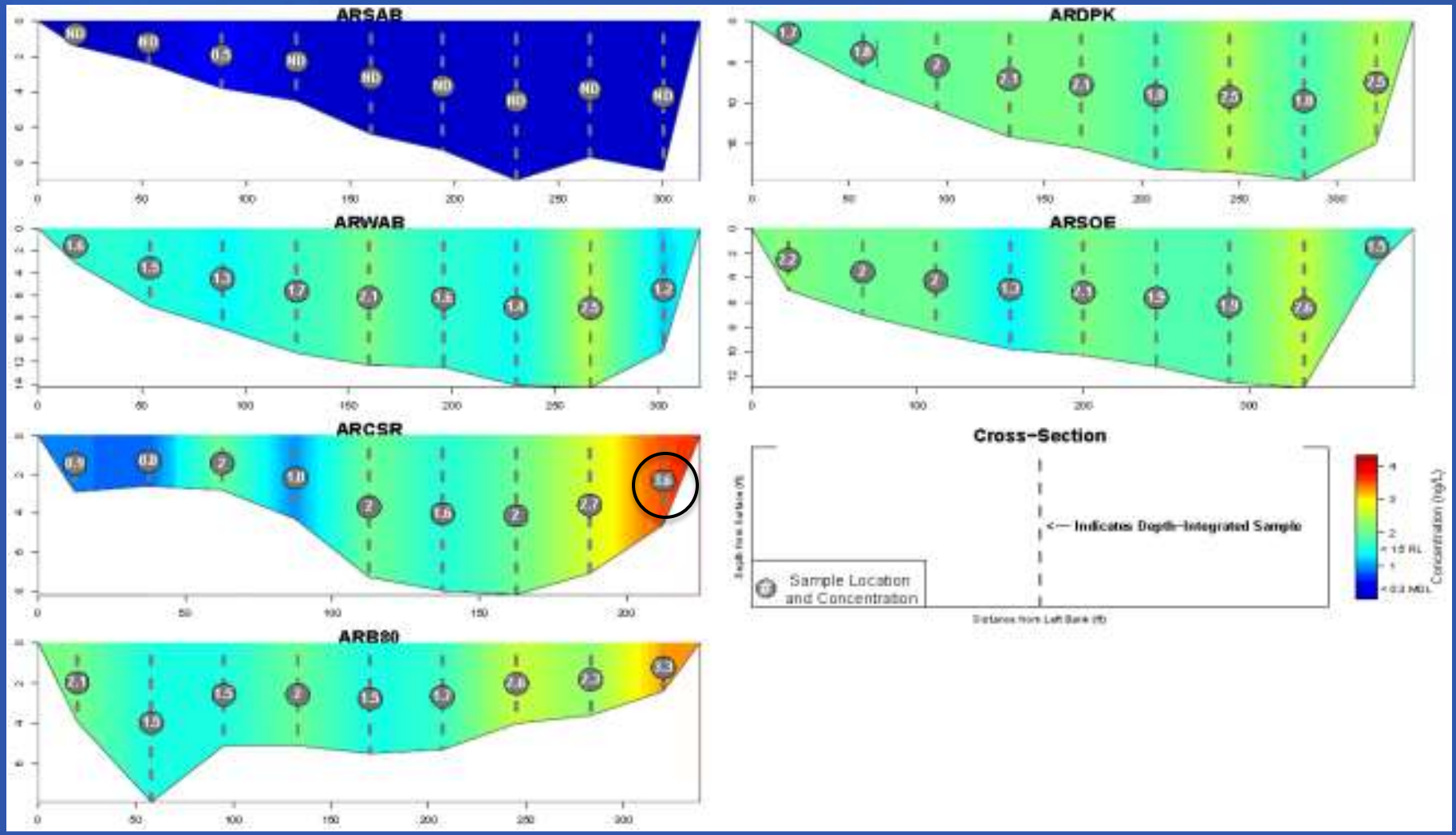
2012-2014 Season Transect Monitoring

Monitoring and Results

- Eight storm events that exceeded the threshold rainfall trigger (projected rainfall within 24 hours of >0.5 in)
  - Last event in (February 7-10, 2014)
- Detections again varied spatially and temporally (i.e. within individual transects, from transect to transect, and from event to event)

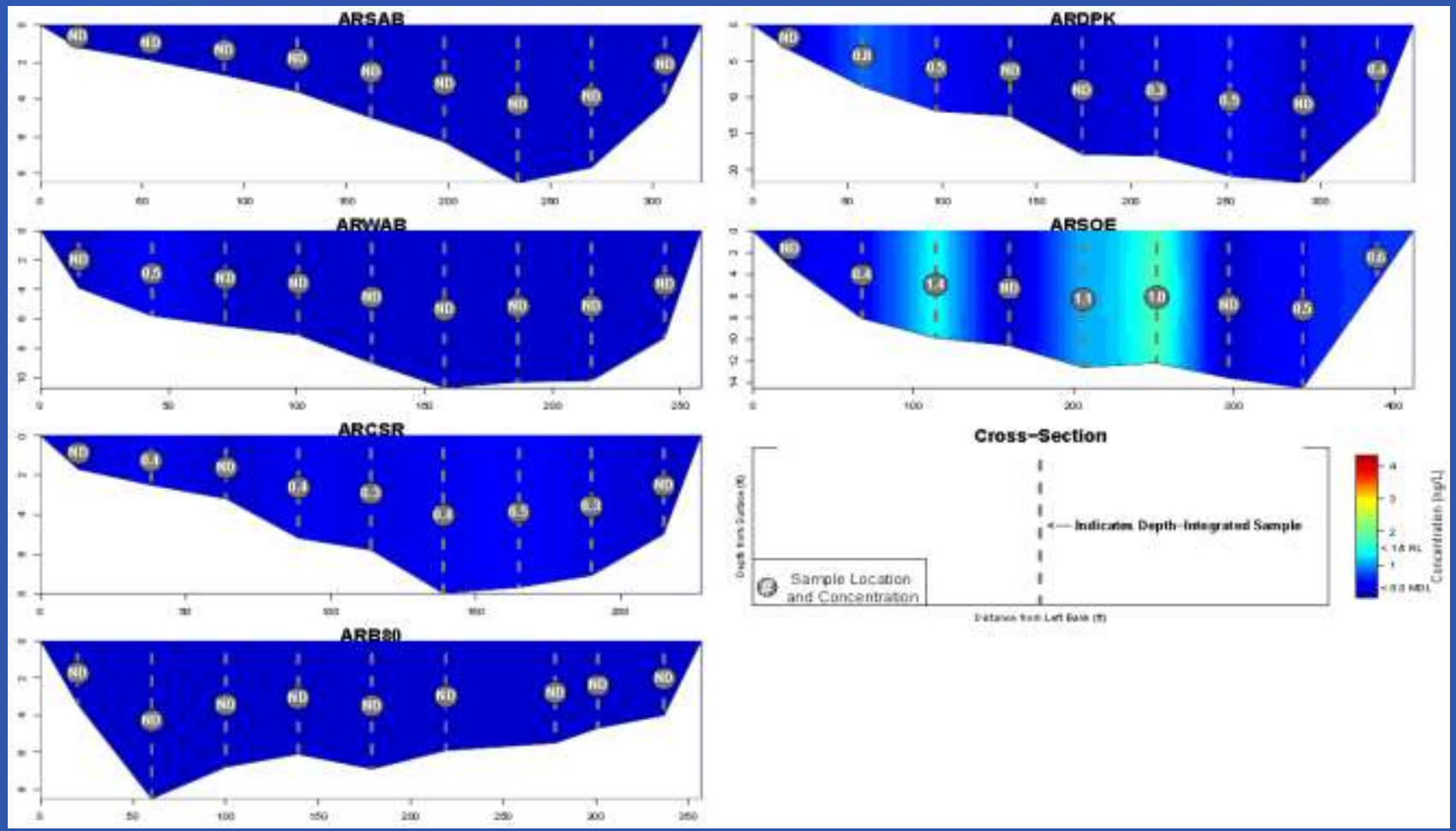
Concentrations below or slightly above RL; highest at bank near discharge

Example Comparison of Total Bifenthrin Concentrations 10/22/12



Concentrations below or slightly above RL – few detections

Example Comparison of Total Bifenthrin Concentrations 11/29/12

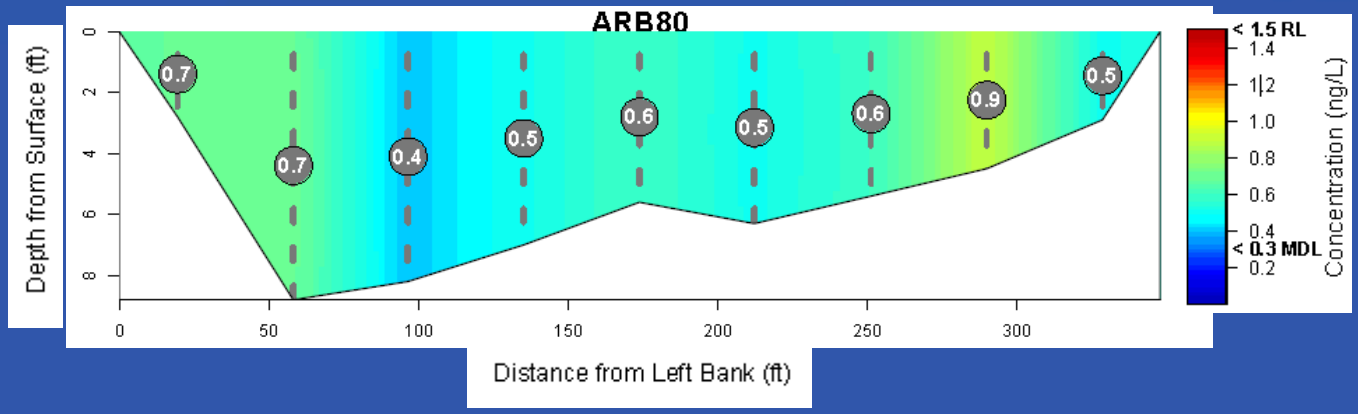


Revisit site – little difference (all <RL)

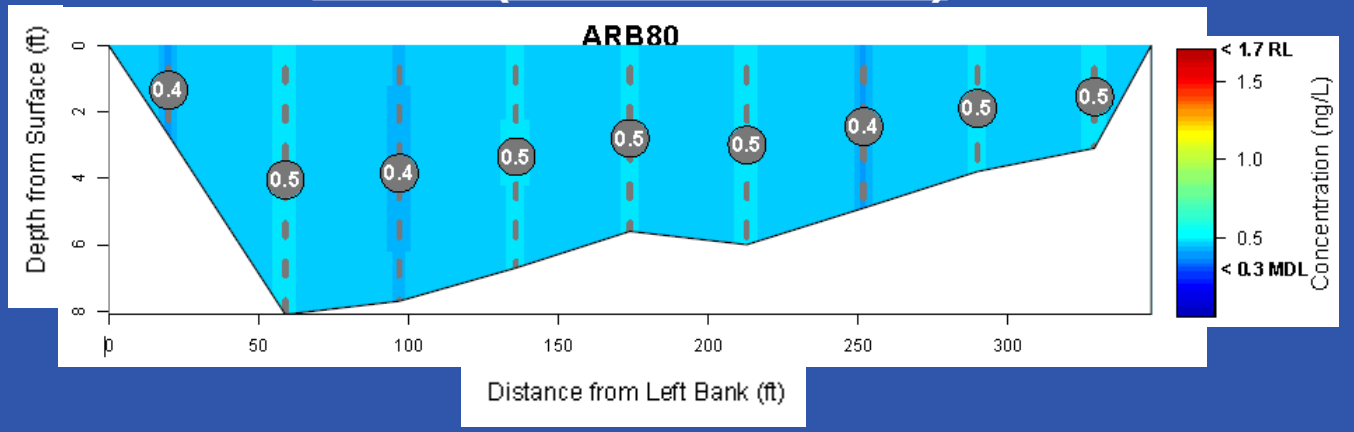
Differences	0.3	0.2	0.0	0.0	0.0	0.0	0.1	0.4	0.0

Temporal assessment of bifenthrin concentrations

PASS 1 (Mean Time - 16:42)



PASS 2 (Mean Time – 17:36)



Drift Event: bank near discharge with highest concentrations – where you sample matters

Lagrangian/Drift Sampling from ARCSR to ARB80– 3/20/13

Multi-day Sampling Events: short term, infrequent detections then back to "dry" conditions

Goal: Collect water samples before and during multi-day rainfall events, revisiting sampling transects multiple times over a period of 2-4 days. Grab samples at ARCSR and ARB80 on Days 1, 3, and 4 and depth integrated samples collected at up to six cross sections (9 samples at each) on Day 2.

Day 1 (6/24/13, 11/19/13, and 2/7/14):

- No target analytes (all 8 pyrethroids) detected on day 1.

Day 2 (6/25/13, 11/20/13, and 2/8/14):

- June 25 –only bifenthrin and cyfluthrin slightly above RL in one of 36 samples.
- November 20 –only bifenthrin and cyfluthrin slightly above RL in three and one of 54 samples, respectively.
- February 8 –only bifenthrin slightly above RL in ten of 54 samples.

Day 3 (6/25/13, 11/20/13, and 2/9/14):

- June 25 and November 20 - No target analytes (all 8 pyrethroids) detected.
- February 9 - only bifenthrin slightly above RL in both samples.

Day 4 (11/21/13, and 2/10/14):

- No target analytes (all 8 pyrethroids) detected on day 4

Single vs. Multi-sample Toxicity Results

- **No toxicity observed for both exposure protocols**

November 2013

Daily Renewal with Samples Collected Daily				Daily Renewal with Peak Flush Sample		
Water Sample	Organism Source			Organism Source		
	Chesapeake (%Survival)	Watt (%Survival)	Discovery Park (%Survival)	Chesapeake (%Survival)	Watt (%Survival)	Discovery Park (%Survival)
Lab Water	100%	100%	100%	100%	100%	96%
ARCSR	98%	100%	100%	96%	100%	100%
ARB80	96%	98%	96%	92%	98%	96%

- **Typical single sample stormwater collection overestimates toxicity for 96-hour *H. azteca* test; no toxicity when daily samples were used for testing**
- **Lab-reared organisms more sensitive than field collected organisms.**

February 2014

Daily Renewal with Samples Collected Daily				Daily Renewal with Peak Flush Sample		
Water Sample	Organism Source			Organism Source		
	Chesapeake (%Survival)	Watt (%Survival)	Discovery Park (%Survival)	Chesapeake (%Survival)	Watt (%Survival)	Discovery Park (%Survival)
Lab Water	100%	84%	58%	98%	84%	86%
ARCSR	94%	94%	80%	**46%***	88%	76%
ARB80	94%	92%	66%	**66%***	80%	74%

Resident *H. azteca*: 18x - >46x less sensitive than lab populations

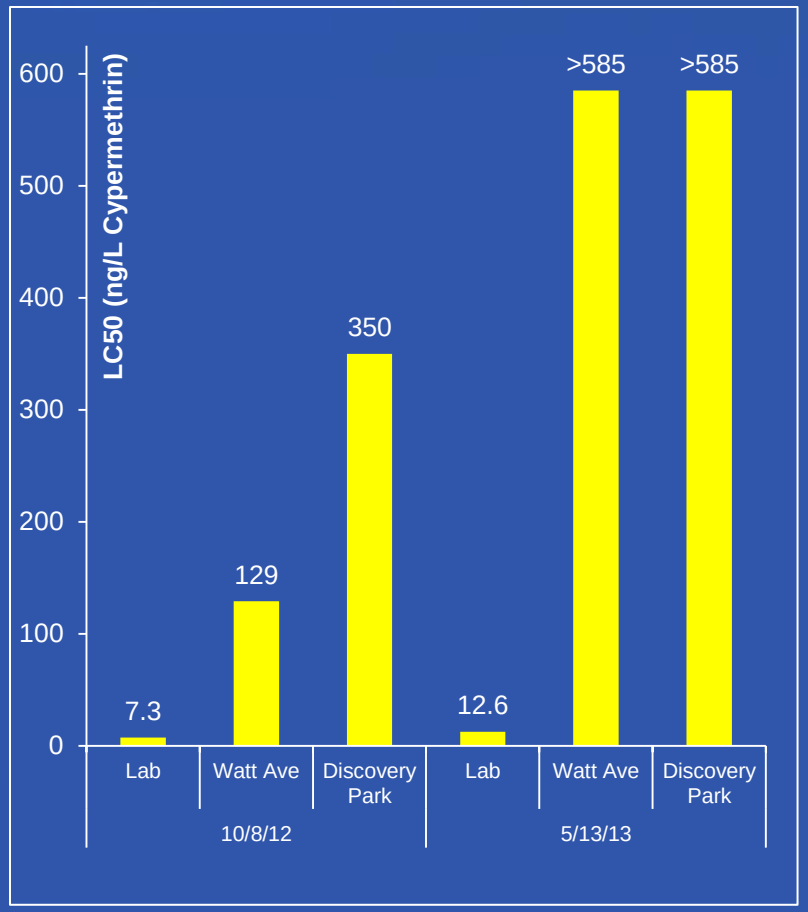
Goal: Compare the sensitivity of resident *H. azteca* to laboratory-reared *H. azteca* exposed to cypermethrin (a representative pyrethroid).

Study description:

- Resident organisms collected from Watt Avenue and at Discovery Park
- Laboratory-reared organisms ordered from Chesapeake Cultures
- All sources of organisms identified as *Hyalella azteca* species complex
- Exposed to cypermethrin for 96-hours in a water exposure

Conclusion:

- Resident *H. azteca* were from ~18 times to >46 times less sensitive than lab-reared *H. azteca*
- LC50s were >4.5x higher and >1.7x higher after the winter (seasonal change in sensitivity that correlates with stormwater discharge)



2011-2014 Approach Goals Achieved

- ✓ Evaluate and contextualize rainfall and flow patterns within the watershed
- ✓ Focus on rainfall event-driven sampling
- ✓ Expand sampling protocols to provide more extensive and relevant characterization
- ✓ Revise transect sampling to utilize depth integrated samplers
- ✓ Revisit a transect multiple times in a single day
- ✓ Follow a pulse of river water downstream
- ✓ Sample during multiple parts of the event over several days
- ✓ Evaluate sensitivity of resident *H. azteca* to pyrethroids

American River Study Conclusions

- Pyrethroids were not detected above the RL in samples collected during dry weather events
  - This is consistent with Weston and Lydy (2010 & 2012)
- During this study, pyrethroid concentrations in all sampling events were low (vast majority <RL) and would not have caused toxicity to even the most sensitive species within this 30 km section of the American River
  - No detections >RL for cypermethrin, esfenvalerate, and fenpropathrin.
  - Of the 732 samples collected, bifenthrin, cyfluthrin, deltamethrin, lambda-cyhalothrin, and permethrin were detected above the RL, and only in 13%, 2.2%, <1%, <1%, and <1%, respectively.
  - 19 samples (i.e,, 17 for bifenthrin and two for lambda cyhalothrin) were slightly above the most recent 96-hr *H. azteca* LC50 values submitted to EPA
  - Exposure duration (i.e., multi day) studies suggest that these short-term concentrations are insufficient to cause toxicity in the American River.

American River Study Conclusions

- When found, pyrethroid residues were seemingly transient and heterogeneous across any given transect.
- Typical single sample stormwater collection overestimates toxicity for 96-hour *H. azteca* test; no toxicity when daily samples were used for testing
- Resident *H. azteca* were from ~18 times to >46 times less sensitive than lab-reared *H. azteca*
- 30 km stretch of river *would not be toxic* to resident *H. azteca*

American River Study Conclusions

- Given the pulsed nature of storm water discharges and that pyrethroids are not detected during dry weather sampling, it has been demonstrated that any elevated pyrethroid concentrations in the lower American River are short lived and localized
- Temporal and spatial data indicate that sampling using depth-integrated transects provides greater resolution and completeness in describing the chemical status of the American River during run-off events than does grab sampling from the bank

Special Thanks

- 2-3 boat crews 14 hour days! Often in the rain!
- Caltest Analytical Laboratory – many samples to analyze over short period of time