Proposed

LBNL Subsurface Science SFA

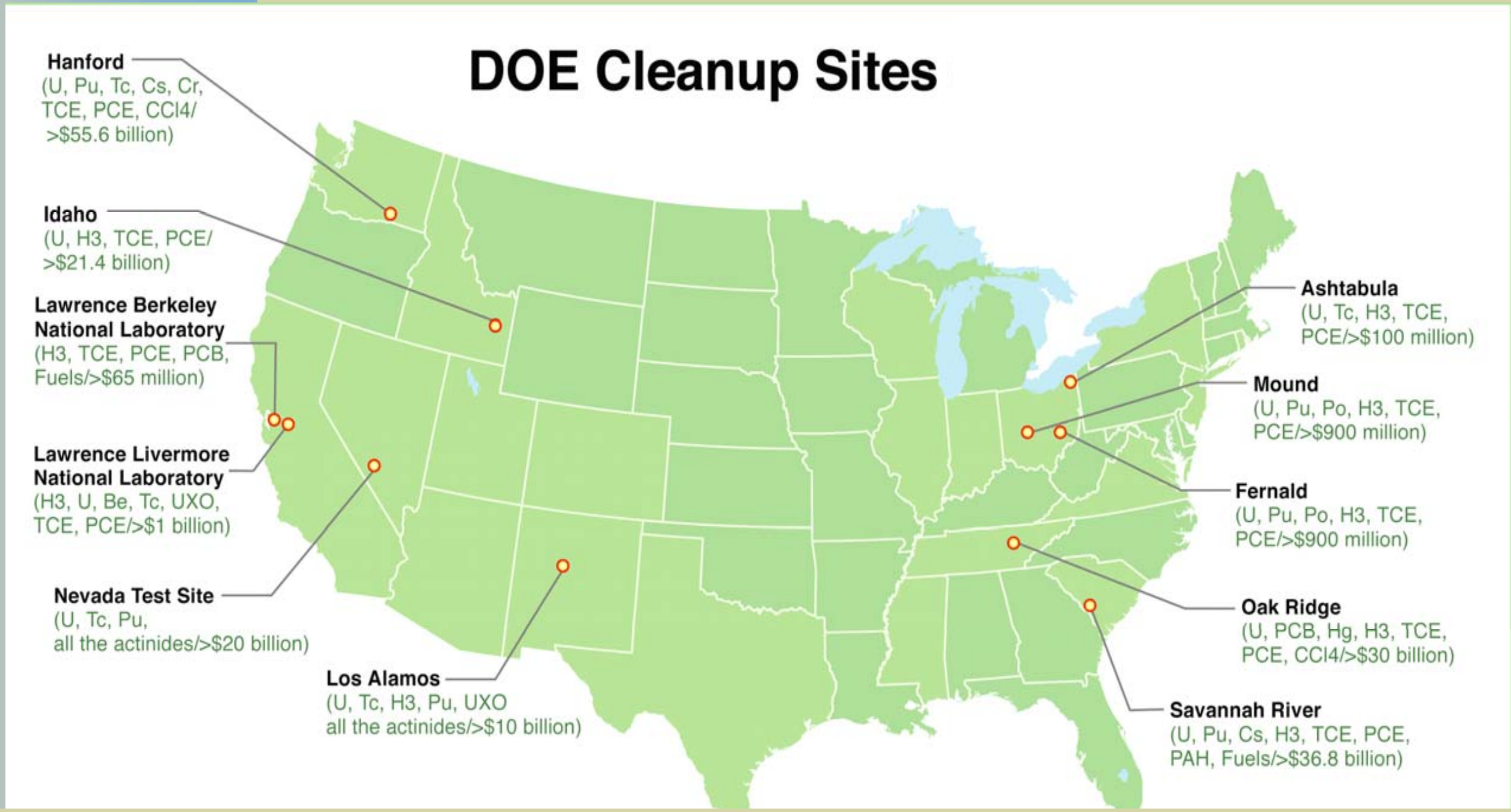
- Motivation & Critical Challenges
- SFA Structure
- Scientific Research Areas
  - Area 1 Sustainable Systems Biogeochemistry
  - Area 2 Integrated Characterization, Modeling and Monitoring
- Field Study Sites
- Collaborators & Facilities

Susan Hubbard (sshubbard@lbl.gov)
Presented on behalf of LBNL SFA Research Team

Motivation

The production and testing of nuclear weapons has created a vast volume of subsurface legacy contamination that the DOE has the responsibility to locate, clean up, and monitor.

DOE spends **$6B/year** and is expected to spend approximately $**200B through** 2070 on cleanup efforts



*A **predictive understanding** of multi-scale, coupled, in-situ processes and technological developments*

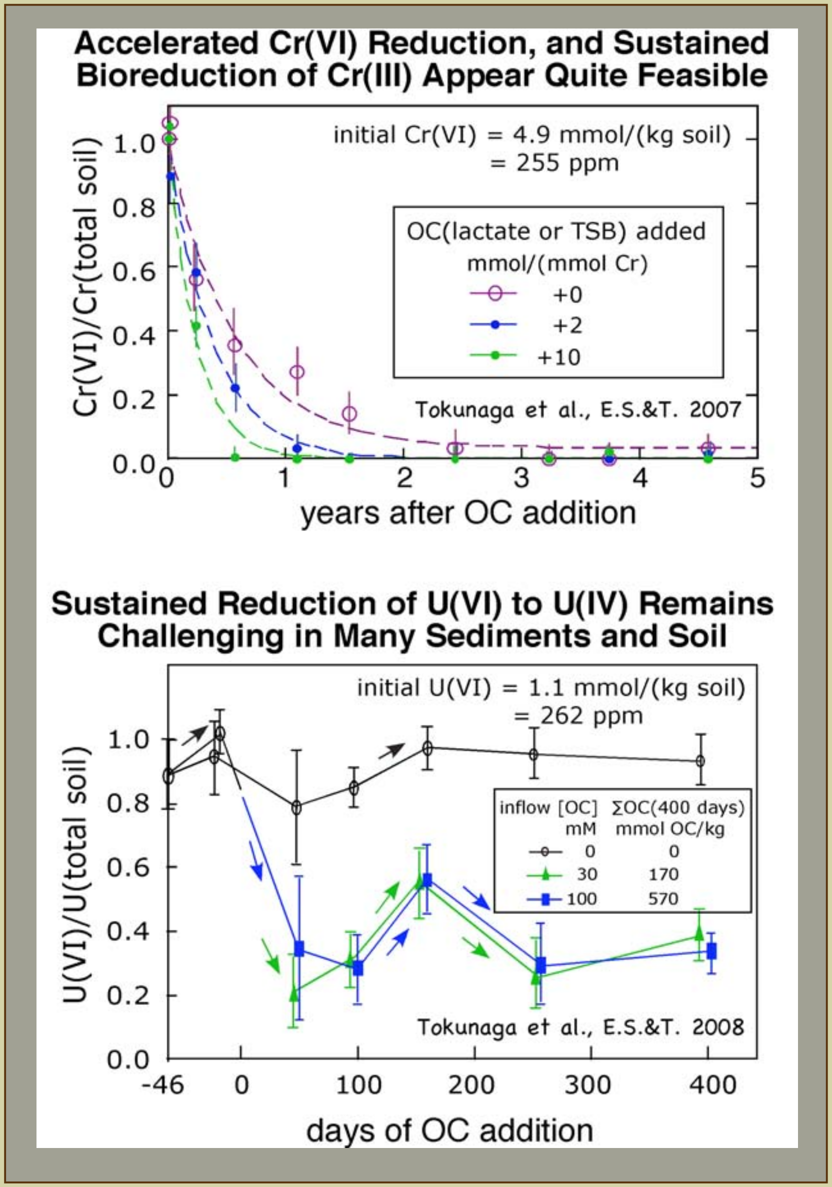
could improve and reduce the enormous cost associated with legacy waste clean up

Sustainable Systems Biogeochemistry: Critical Challenge

- Metals and many radionuclides pose daunting remediation challenges because they do not degrade to benign products, or only do so through very slow radioactive decay
  - *Half-life of ^{238}U is 4.5 billion years*
  - *Half-life of ^{90}Sr is 29 years*

- Contaminated regions will be exposed to ambient biogeochemical conditions once remedial treatments have ceased.

- A critical challenge is to develop remediation strategies for metals and radionuclides that are compatible with prevailing hydrobiogeochemical conditions so that the treatment will be sustainable.



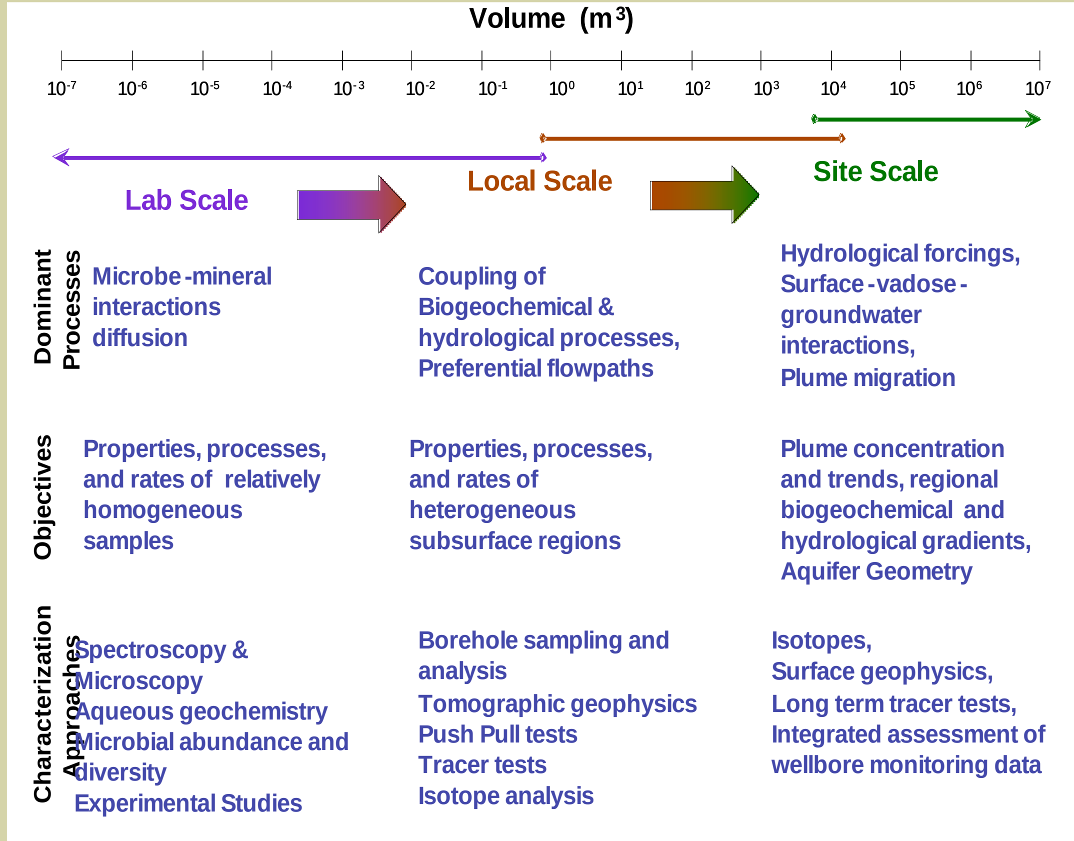
Environmental Remediation Sciences

Characterization and Modeling: Critical Challenge

BERKELEY LAB

The **natural variability**, **scale-dependence, and coupled nature** of subsurface hydrobiogeochemical properties renders characterization and mechanistic reactive transport modeling challenging.

This obstacle in turn often leads to our **inability to successfully implement field-scale remediation strategies**.



Looney&Hubbard, 2006

A **critical challenge** is to develop capabilities to quantify and predict subsurface processes in natural systems and over field-relevant scales

LBNL Subsurface Science SFA

Earth Sciences Division

CHARACTERISTICS

ddresses critical challenges in subsurface environmental science;

tilizes our recognized expertise and facilitates but permits growth in needed areas;

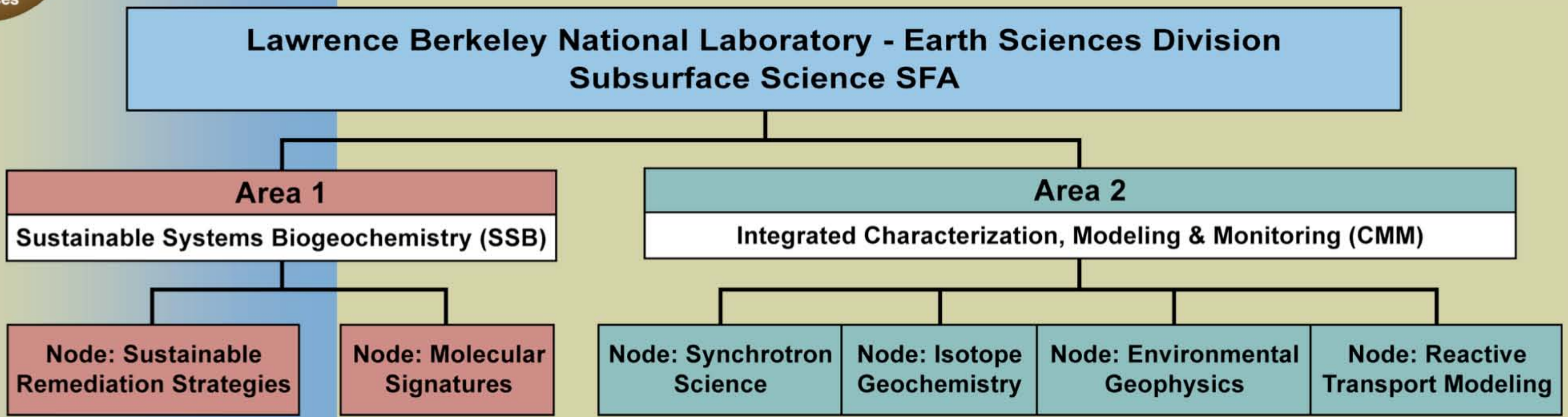
ncourages team-based as well as individual science contributions;

as significant potential for impact to DOE cleanup/stewardship

ligned with and leverages on collaborative efforts;

s flexible to permit investigation in new directions while maintaining core capabilities

SFA STRUCTURE



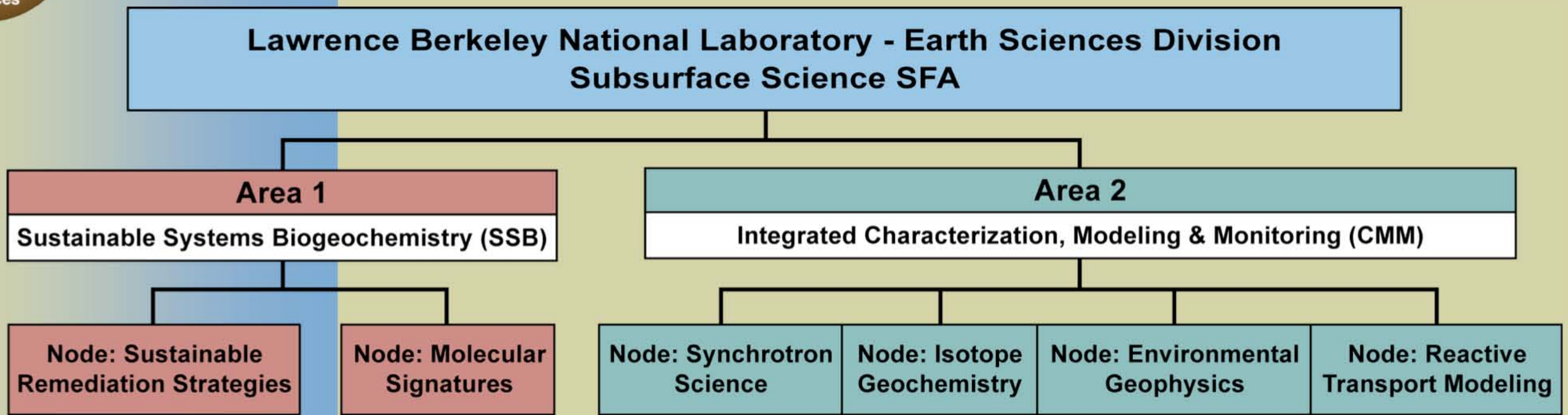
The SFA is hierarchically structured:

- **Scientific Research Areas** create synergy between scientists working on two critical challenges;

- The **Nodes** create synergy within smaller groups of scientists performing theme- or approach-based research, and to serve as a nucleus for collaborations;

- **Projects** address Node objectives and contribute to goal of Scientific Research Areas.

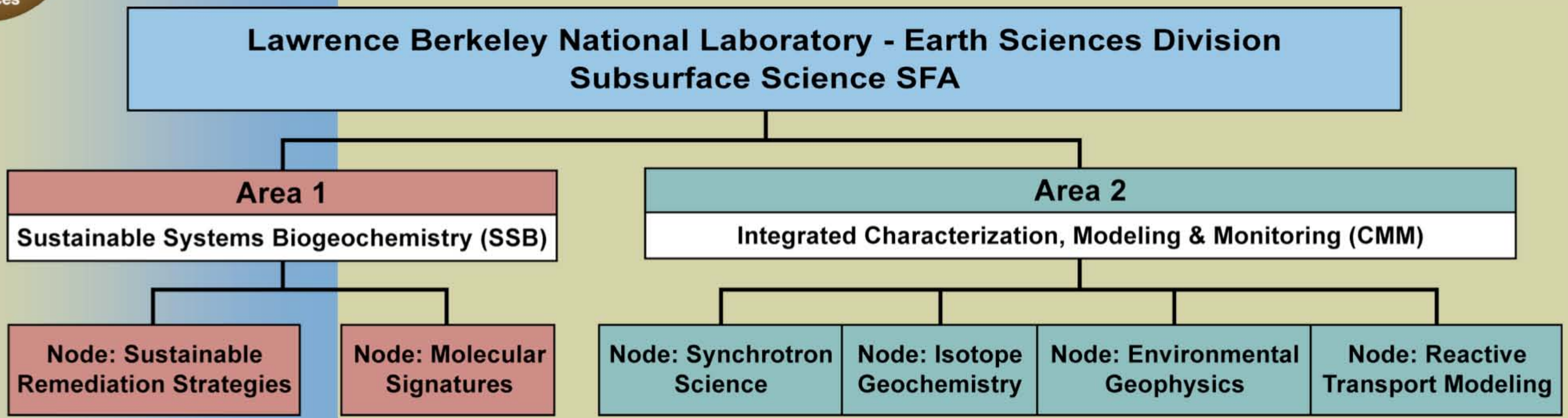
Program Structure



Area 1 Critical Challenge: Improve and quantify understanding of biogeochemical processes needed to design scientifically defensible and ***sustainable*** remediation strategies

Two theme-based Nodes

Program Structure



Area 1 Critical Challenge: Improve and quantify understanding of biogeochemical processes needed to design scientifically defensible and ***sustainable*** remediation strategies

Two theme-based Nodes

Area 2 Critical Challenge: Develop an unprecedented ability to quantify and predict subsurface processes associated with natural attenuation and active remediation through improvements in and coupling between characterization, modeling, and monitoring.

Four approach-based Nodes.

Environmental Remediation Sciences

Field Study Sites

BERKELEY LAB

Explore enhanced sustainability of Cr(VI) bioremediation at the **Hanford 100 Area**

HANFORD 100

SRS F-AREA

Develop a scientific basis for monitored natural attenuation of ^{90}Sr, ^{129}I and U at the **Savannah River Site F-Area.**

Integration of multiple CMM approaches to explore feedbacks between flow and transformations at the U contaminated **Rifle IFC**

RIFLE

Environmental Remediation Sciences

Subsurface Science SFA
Lawrence Berkeley National Laboratory - Earth Sciences Division

BERKELEY LAB

Susan Hubbard, Laboratory Research Manager
Lisa Kelly, Senior Administrator

Area 1
Sustainable Systems Biogeochemistry (SSB)

Node: Sustainable Remediation Strategies

Projects

- Cryptic Growth Strategy for Sustained Reduction of Cr(VI) (**T. Hazen**)
- Hydrogeochemical Approaches to Uranium Immobilization in Oxidizing Environments (**T. Tokunaga**)
- Natural Attenuation Mechanisms for Radionuclides (**J. Wan**)
- Enhanced Biomineralization of Phosphate minerals (**M. Conrad**)

Node: Molecular Signatures

Projects

H. Beller and E. Brodie

- Development of High-Throughput Meta-transcriptome Approaches
- Relationship between Signatures and Biogeochemical Activity

Area 2
Integrated Characterization, Modeling & Monitoring (CMM)

Node: Synchrotron Science

P. Nico

Projects

- Advancing Synchrotron Technology at the ALS
- Synchrotron Science applied to Field Study Sites
- Participation in ERSP DOE Synchrotron Program

Node: Isotope Geochemistry

D. DePaolo
J. Christensen

Projects

- Isotopic signatures of Waste Streams
- Quantifying Geochemical Transport Rates using U and Strontium isotope ratios
- Development of isotopic fractionation redox indicators

Node: Environmental Geophysics

S. Hubbard
J. Ajo-Franklin; J. Chen; M. Kowalsky; S. Pride; K. Williams

Projects

- Improved imaging Using time-lapse Geophysical Datasets
- Biogeophysical Petrophysical Relationships for Precipitate evolution
- Development and testing of Estimation Frameworks
- Advanced Instrumentation
- Systems Investigation

Node: Reactive Transport Modeling

C. Steefel
Li Li; S. Finsterle; M. Kowalsky
E. Sonnenthal; N. Spycher

Projects

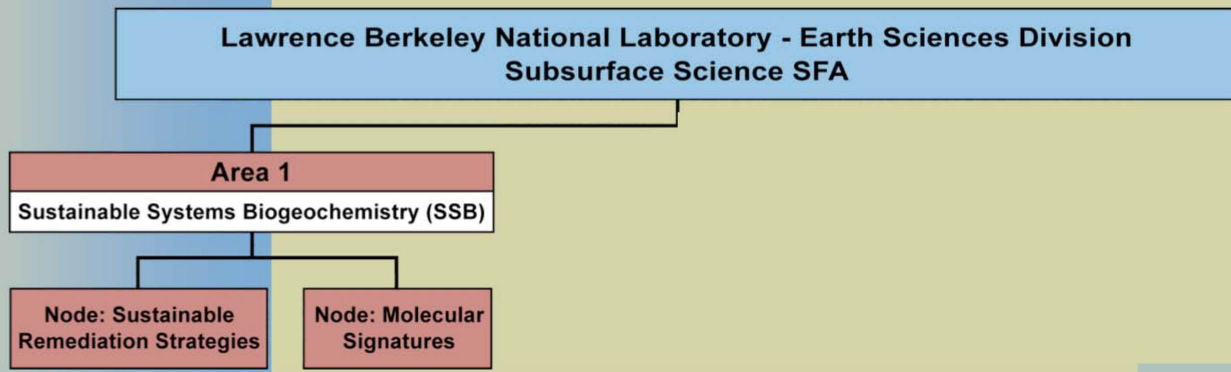
- Modeling Tool Performance Enhancements
- Incorporation of Isotope Systematics
- Microbial Community Dynamics and Biogeochemical Transport
- Joint Inversion Approaches

RIFLE
K. Williams

HANFORD 100
B. Faybishenko

SRS F-AREA
S. Hubbard

ERSP SFA Review April 9, 2008



Two Theme-Based Nodes in Area 1 SSB:

- The **Sustainable Remediation Strategies** Node will focus on understanding processes and on developing specific approaches relevant to sustainable engineered remediation and natural attenuation of key contaminants.

- The **Molecular Signatures Node** will facilitate discovery of genes that are associated with bioremediation-relevant microbial activities.

Key Investigators

*Harry Beller

*Eoin Brodie

Mark Conrad

Terry Hazen

Tetsu Tokunaga

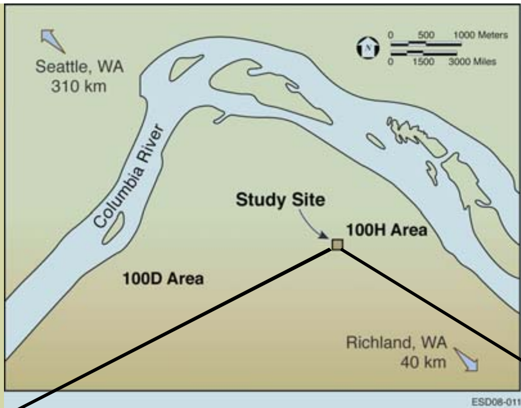
Jiamin Wan

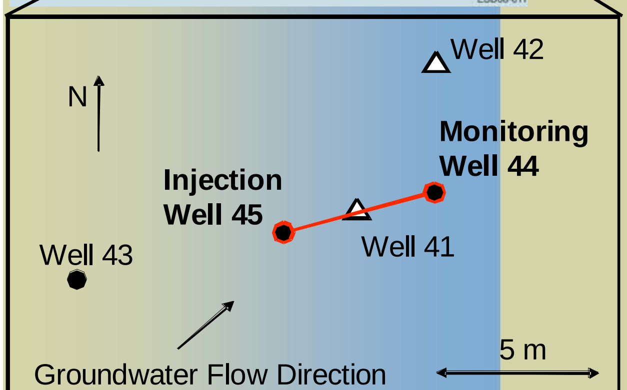
Sustainable Remediation Strategies Node

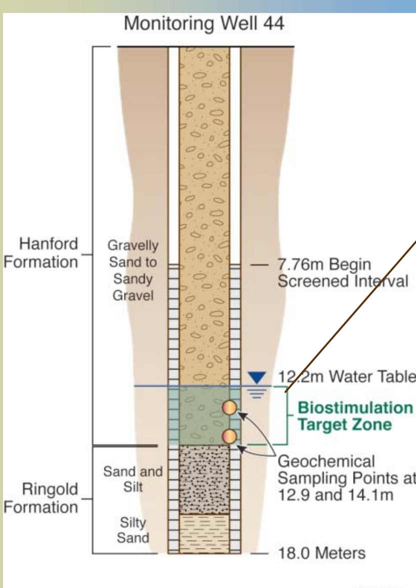
- Sustainable remediation of subsurface Cr, U, ^{90}Sr, and ^{129}I contaminated systems.
- Four key projects – expected synergistic exchanges:
    - **Remediation of U-contamination** will be investigated under a range of conditions in three projects.
    - **Redox coupling** of NO_3^-, Mn and Fe to U and Cr contaminants will be explored in two projects.
    - **Contaminant stabilization under oxidizing conditions** is a theme common to two projects.
- Some of the fundamental studies conducted in the SSB Area will be:
    - Carried out concurrently with studies in Area 2;
    - Implemented at the Field Study Sites .

Cryptic Growth Strategy for Sustained Reduction of Cr(VI)

Terry Hazen





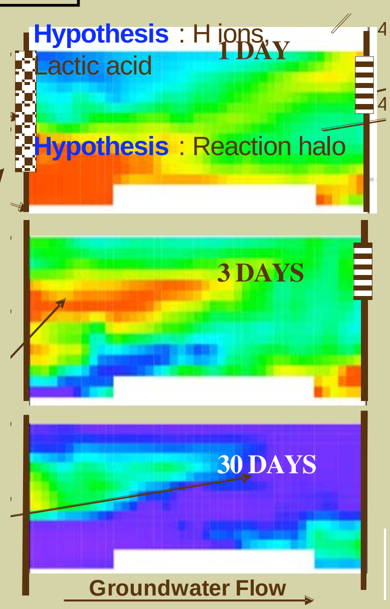


BACKGROUND:

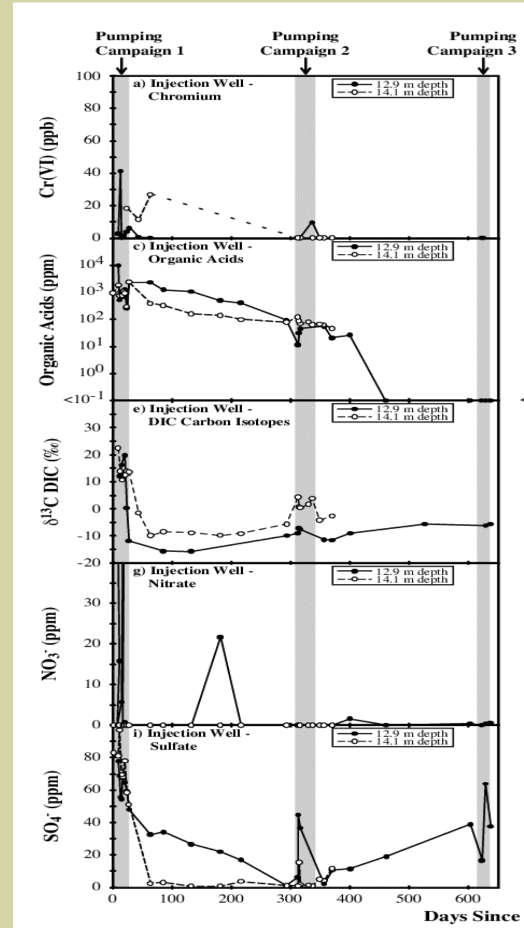
Recent research at Hanford 100H Area has established that a single injection of HRC bioreduced Cr(VI) in the groundwater

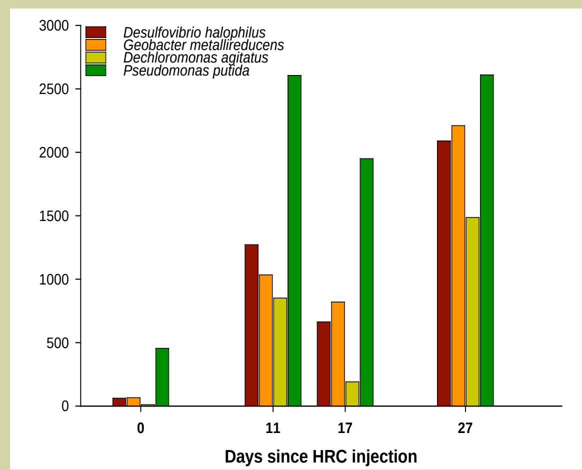
below MCL for >3 years,

even with a constant influx of Cr(VI).



Hubbard et al., ES&T, 2008





Project: Cryptic Growth Strategy for Sustained Reduction of Cr(VI)

Terry Hazen

Project Objectives:

- Explore the hypothesis that a **cryptic growth** mechanism is responsible for the sustained reduction, where:
  - Lysis of dead cells contribute to the substrate;
  - Recycling via cryptic growth promotes sustained reduction.

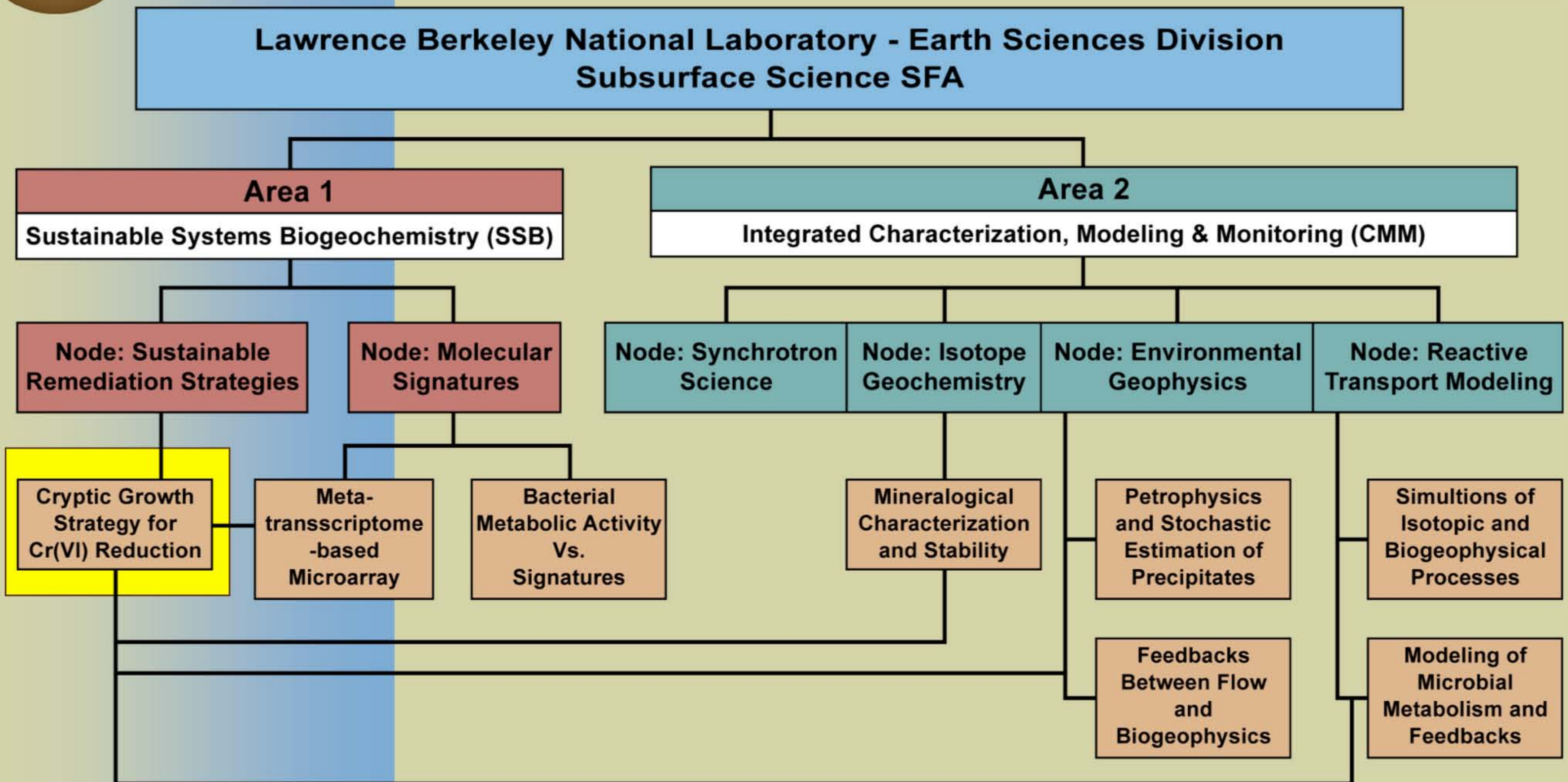
- Leverage with Genomics: GTL push pull testing to explore hypothesis that stressor resiliency can be caused by the formation of microbial assemblages that syntropically function over a wide range of redox conditions.

HANFORD 100
B. Faybishenko

Project part of Hanford 100 Field Study Site…………….

Integrated Effort at Hanford 100 Field Study Site

Boris Fabyishenko, Coordinator



Reduction Mechanism (Direct enzymatic? Abiotic? A combination?)
Mechanism and quantities of Cr(III) precipitates?
Dependence of sustained bioreduction on in-situ microbial structure?
Relevance of findings at 100H to 100D?
Role of heterogeneity on sustained bioreduction?

?

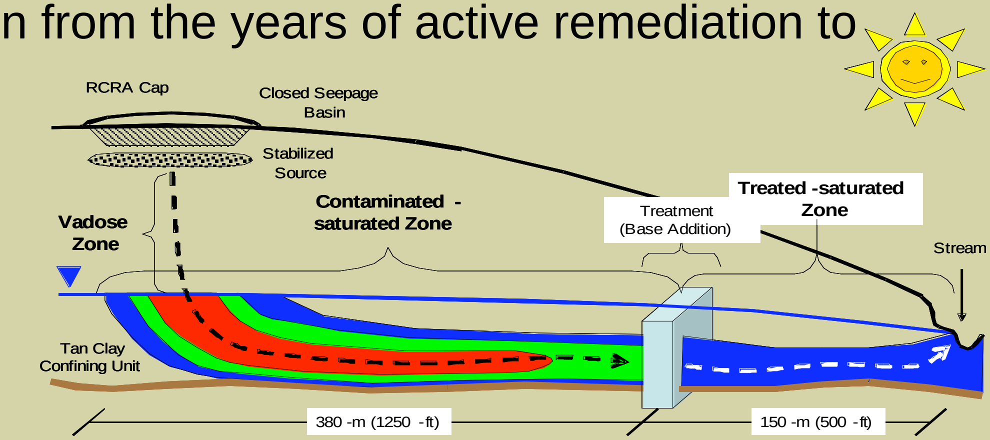
Project: Natural Attenuation Mechanisms of Contaminant Radionuclides at the Savannah F-Area

Jiamin Wan

BACKGROUND

- Savannah River Site F-Area **acidic plume includes U, ^{90}Sr, ^{129}I, and ^{99}Tc**;
- DOE is planning to make the transition from the years of active remediation to monitored natural attenuation (MNA).

HYPOTHESIS. Sorption and desorption are the dominant processes controlling natural attenuation, and development of site-specific **equilibrium/kinetic surface complexation model** can be used to assess if MNA is a viable strategy for the F-Area



2005:	FSB 95DR	FSB 130D	FSB 131D	FPZ 6A/B	
pH	3	5	10	4	pH
NO_3^-	100	25	5	140	mg/L
Sr^{90}	560	30	10	250	pCi/L
U^{238}	425	150	20	5	pCi/L
Hg	3	<0.2	<0.2	< 0.2	mg/L

APPROACH. Laboratory experiments to measure sorption and desorption rates/extents for U, 90Sr, and 129I on acid-altered and the pristine sediments as a function of pH and facies, coupled with:

- Synchrotron methods to determine contaminant speciation.
- Isotopic analyses to track the fate, transport, and rates of contaminants
- Reactive transport modeling

Savannah River Site F-Area Field Study Site

SRS F-AREA
S. Hubbard

Collaboration between LBNL SFA and EM-supported SRNL scientists and Technical Working Group focused on MNA

Discovery Research | Use-inspired Basic Research | Applied Research | Technology Maturation & Deployment

Office of Science
U.S. DEPARTMENT OF ENERGY

EM Environmental Management
safety ❖ performance ❖ cleanup ❖ closure

Goal: New knowledge
Focus: Phenomena
Metric: Knowledge Generation

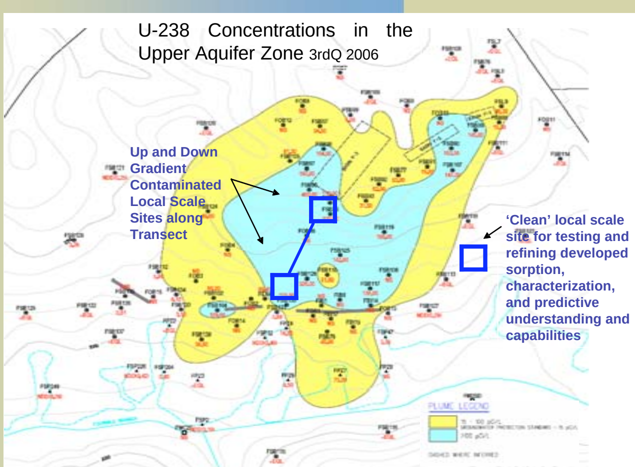
Goal: Practical targets
Focus: Performance
Metric: Milestone achievement

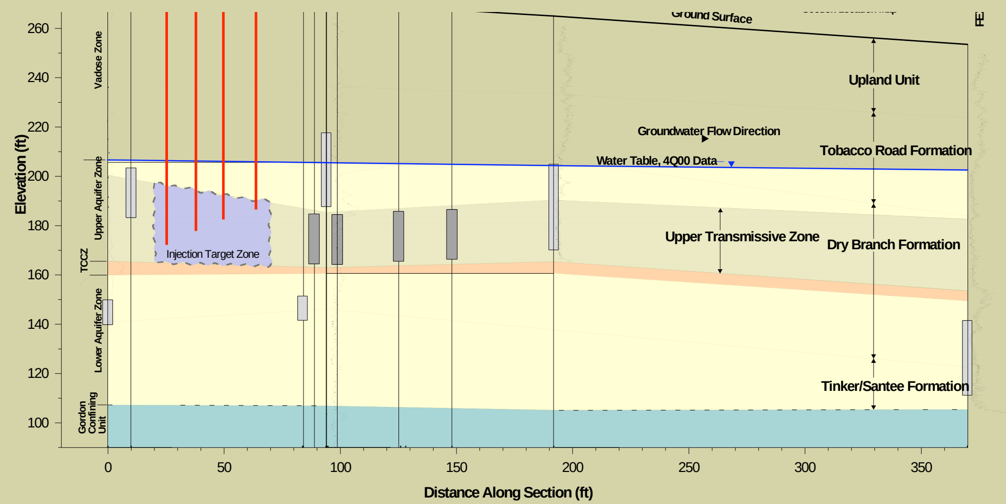
LBNL Foci at SRS F-Area Field Study Site

- **Geochemical Process. Sorption models** can be developed to quantify rates of key metal and radionuclide constituents as a function of pH and reactive facies.

- **Characterization.** Development and implementation of **Isotopic Indicators** and **Reactive Facies Framework** to facilitate the characterization of critical hydrobiogeochemical processes and rates across scales

- **Reactive Transport Modeling.** Through incorporation of developed facies-based sorption model and facies-based multi-scale characterization, **mechanistic** reactive transport modeling of plume evolution and migration can be performed with sufficient accuracy to predict behavior of system over field relevant scales





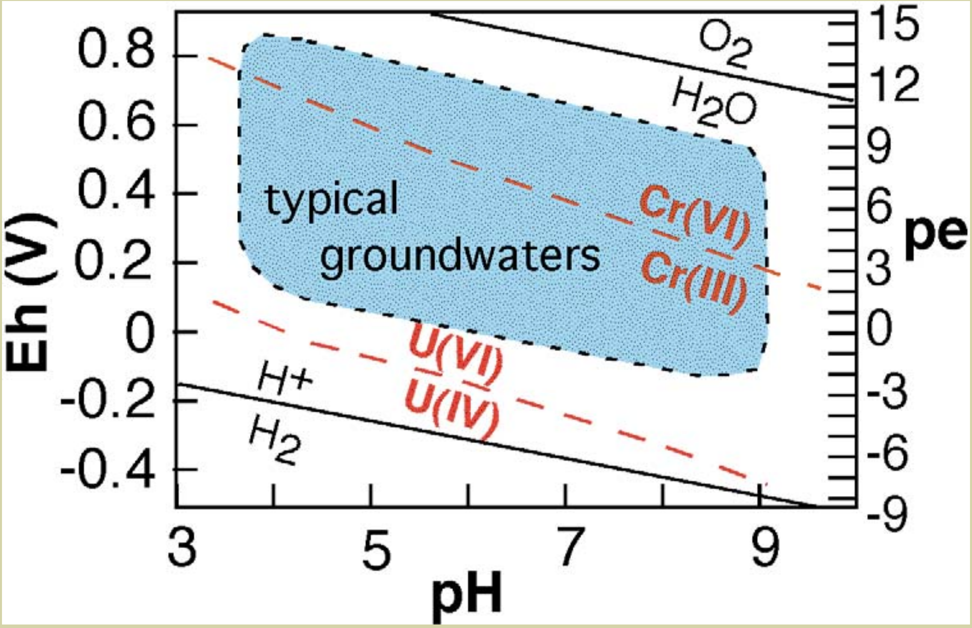
Project: Hydrogeochemical Approaches to Uranium Immobilization in Oxidizing Environments

Tetsu Tokunaga

Background/Motivation:

- U contaminated environments are not naturally strongly reducing.
- Sustaining U bioreduction will require indefinite periodic supply of electron donor.

Objective: Identify strategies for sustainable remediation of U-contaminated systems *that are compatible with prevailing oxidizing site conditions.*



Sustainability of an in-situ redox manipulation can be partly evaluated by comparing the targeted redox state with redox conditions that prevail in the subsurface.

Approach:

1. Re-evaluate all factors that can constrain groundwater U concentrations under oxidizing conditions and select candidate strategies.
2. Batch testing of U(VI) removal from aqueous phases of contaminated sediments, combined with XRD and EXAFS for determination of resulting solid and surface U(VI) phases.
3. Laboratory column testing of U(VI) immobilization strategies
4. Field trial(s) of oxic-immobilization strategies.

Project: Enhanced Vadose Zone Mineralization

Mark Conrad

MOTIVATION

- Significant inventories of vadose zone contaminants pose a long-term threat to groundwater at a number of DOE sites.
- Phosphates are stable under oxic conditions and will readily incorporate ^{90}Sr and U into their mineral structure and will scavenge them from co-existing pore fluids.

OBJECTIVE. Develop strategies to **promote precipitation of phosphate minerals in unsaturated rocks and sediments**.

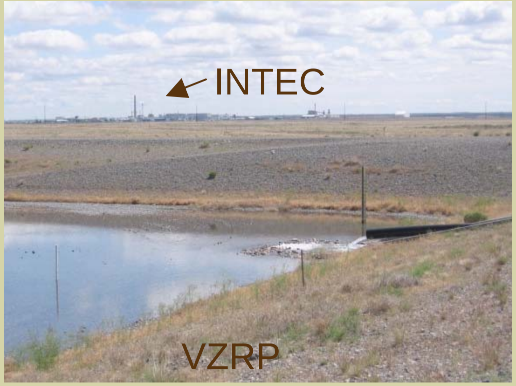
•Tri-ethyl phosphate (TEP) is an organophosphate compound that may provide good phosphate source for mineralization and can be readily distributed in unsaturated materials.

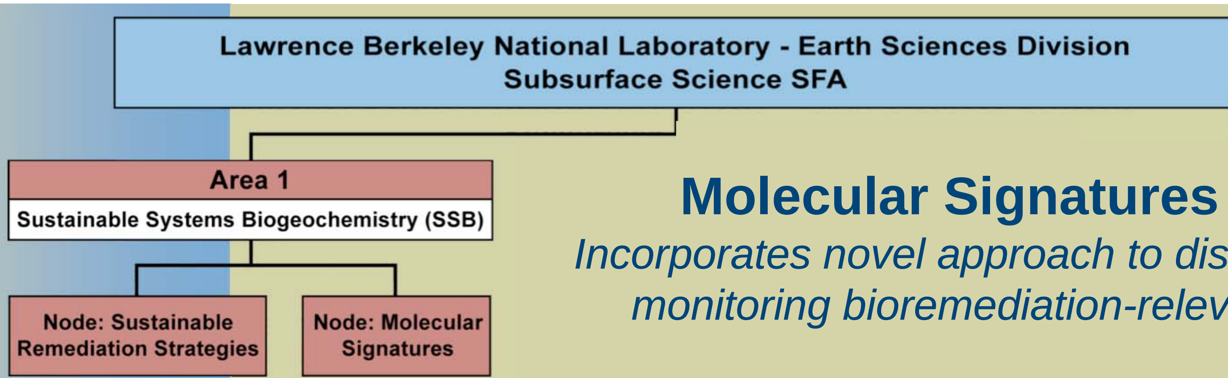
APPROACH. Using experimental and numerical approaches:

•Identify mineral precipitates and reaction rates;

•Quantify U and ^{90}Sr uptake.

•Develop strategies for enhancing microbial rates of TEP degradation and phosphate release under variably saturated conditions.





Molecular Signatures Node

Incorporates novel approach to discovering and monitoring bioremediation-relevant genes

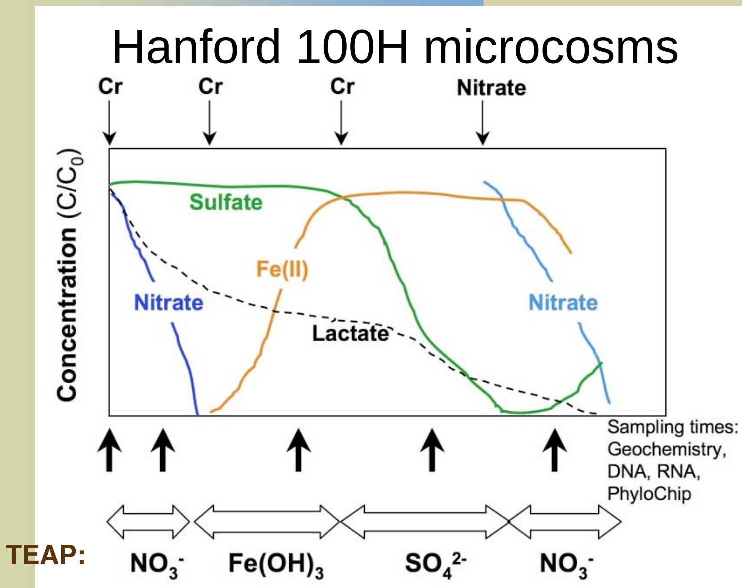
MOTIVATION

- The vast metabolic and phylogenetic diversity in natural subsurface systems poses a challenge, as all key gene/protein sequences needed to monitor bioremediation-relevant activities are not available in data repositories (e.g., GenBank).
- Need to integrate molecular-level understanding to specific, bioremediation-relevant metabolic activities simulated in reactive transport modeling.

Molecular Signatures Node

Harry Beller and Eoin Brodie

OBJECTIVE (meta-transcriptome-based microarrays): Develop a novel and high-throughput approach that uses the meta-transcriptome* to design high density oligonucleotide microarrays that can be used to identify highly expressed genes in a specific community under conditions of interest, without requiring any *a priori* hypotheses about which genes the community might be expressing or prior sequence information from data repositories. → **Bioremediation-relevant Signature Discovery**



Field relevant meta-transcriptome source

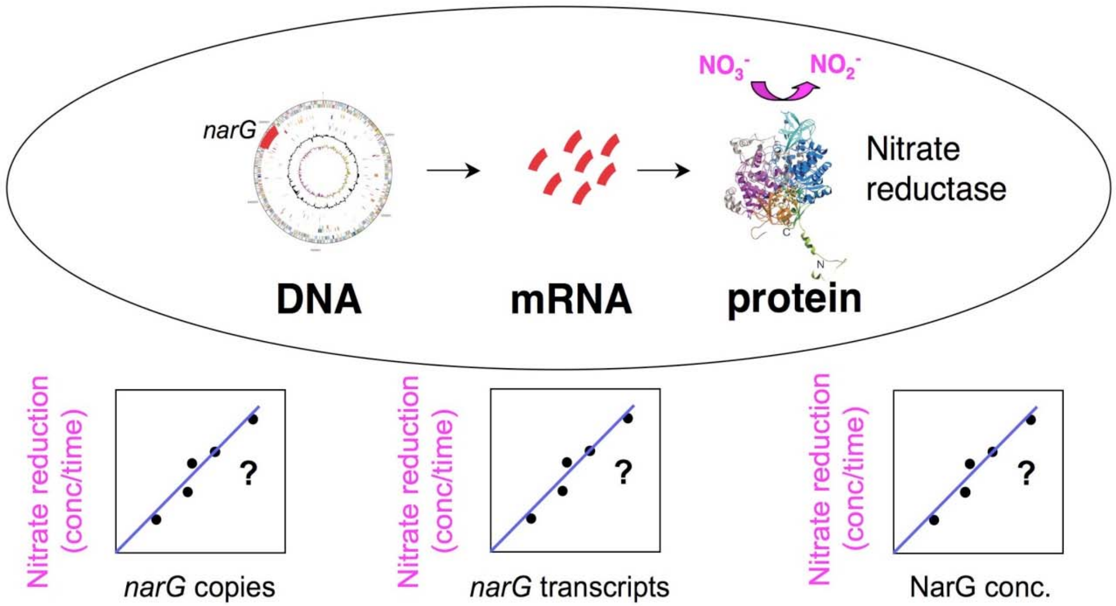
Isolate and pool community mRNA → Sequence meta-transcriptome at JGI (454) → Design custom Hanford 100H microarrays → Apply microarrays to push-pull tests at Hanford

*cDNA representing the collective mRNA transcripts from the entire community:
genes in the metagenome are expressed under a given set of conditions.

Molecular Signatures Node

Harry Beller and Eoin Brodie

OBJECTIVE: 'Activity signature correlations': Use well-characterized bacterial cultures to assess whether correlations between biogeochemical activities and *field-measurable* molecular signatures (based on DNA, mRNA, or protein) exist. ➡ Eventual link with Reactive Transport Models



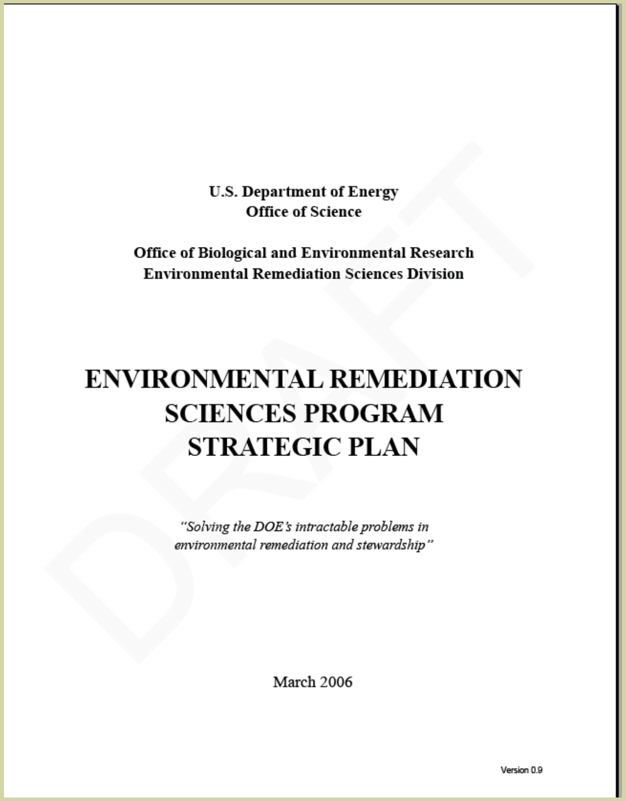
Link to reactive-transport models - -

***In situ* nitrate reduction rate:**	***In situ* nitrate reduction rate:**	***In situ* nitrate reduction rate:**
Population (# gene copies)*	**# transcript copies***	**Amount of enzyme***
x	**x**	**x**
slope	**slope**	**slope**

***Field result from qPCR or proteomic analysis of aquifer sample**

The Sustainable Systems Biogeochemistry Area will address several ERSP Strategic Goals, including:

- *“Determine **key reactions and degradation pathways** involved in radionuclide and metal transformations and immobilization”;*
- *“Build on **new tools in genomics** and proteomics to explore the genetic diversity and dynamics of microbial communities (with an emphasis on how these communities respond to the **stress** of contamination and remediation, and how they **can be sustained** for the purposes of natural attenuation)”;*
- *“Define and exploit microbial metabolic processes critical to **controlling contaminant mobility**” (using both remediation and natural attenuation).”*
- *“Develop **sound foundations for remediation to guide decisions** at DOE sites.”*


U.S. Department of Energy
Office of Science

Office of Biological and Environmental Research
Environmental Remediation Sciences Division

ENVIRONMENTAL REMEDIATION
SCIENCES PROGRAM
STRATEGIC PLAN

“Solving the DOE’s intractable problems in environmental remediation and stewardship”

March 2006

Version 0.9

DRAFT

Environmental Remediation Sciences

BERKELEY LAB

Area 2

Lawrence Berkeley National Laboratory - Earth Sciences Division
Subsurface Science SFA

Area 2
Integrated Characterization, Modeling & Monitoring (CMM)

Node: Synchrotron Science	Node: Isotope Geochemistry	Node: Environmental Geophysics	Node: Reactive Transport Modeling

Key Investigators

*Jonathan Ajo-Franklin
Jinsong Chen
John Christiansen
Don DePaolo
*Stefan Finsterle
Susan Hubbard
*Mike Kowalsky
Peter Nico
*Steve Pride
Eric Sonnenthal
*Nic Spycher
Carl Steefel
Ken Williams

OBJECTIVE: Develop an unprecedented ability to quantify and predict subsurface processes associated with natural attenuation and targeted manipulations.

•Four Approach-based Nodes
•Projects will tackle challenges unique to each approach;
•Document the synergies that come from integration of multiple approaches;
•Test and implement advances at several Field Study Sites.

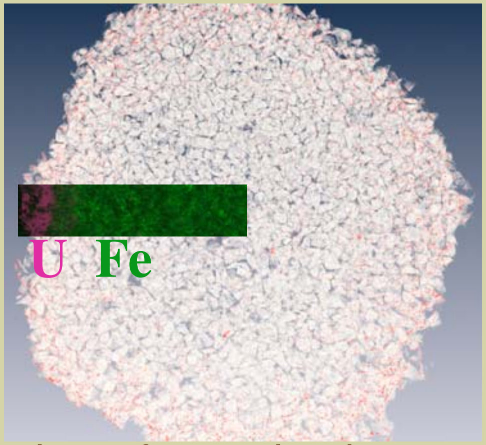
Environmental Remediation Sciences

Synchrotron Science Node

Peter Nico

MOTIVATION:

- Understanding of contaminant dynamics requires information about chemical form and distribution and associations in multiple dimensions.
- The Environmental suite of beamlines at the ALS span an energy range from infrared to hard x-ray, and spatial scales from nanometer to centimeter.



3D image of Fe coated sand aggregate with 2D image showing extent of U penetration after 20days

(Celine Pallud , Scott Fendorf)

OBJECTIVE: Develop and apply new synchrotron techniques to interrogate physicochemcial properties and processes.

APPROACH

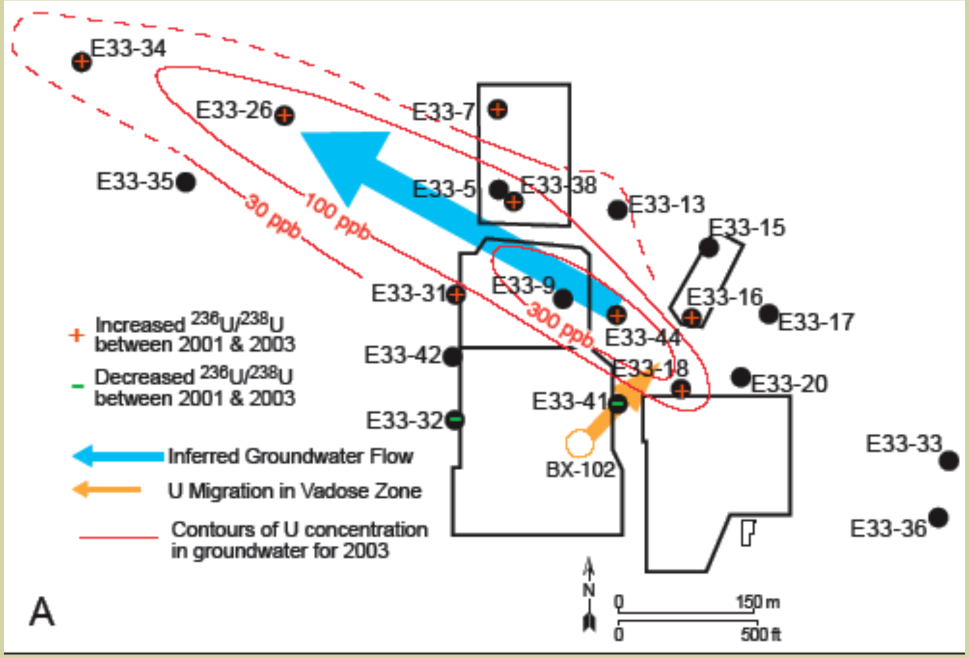
- Advance Environmental Synchrotron Technology at the ALS.
  - Integrated 3-D microtomography and 2-D microprobe chemical speciation.
  - Dynamic 3-D chemical and oxidation state imaging.
  - sFTIR for real time imaging of biomineralization processes**.**
- Integrate Synchrotron Science at Field Study Sites.

Flow through 3-D microtomography chamber

Isotope Geochemistry Node

Don DePaolo and John Christensen

OBJECTIVE: Improve the use of isotope measurements for developing conceptual models for and monitoring subsurface properties and processes.



Tracking source and pathway of U contamination through vadose and groundwater at Hanford 200E Area (Christensen et al., 2004)

MOTIVATION: Provide constraints on:

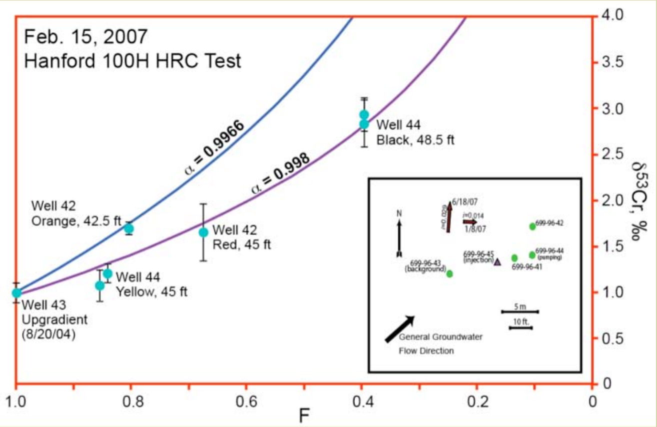
1. Contaminant sources and fates;
2. Contaminant transport through the vadose zone and within groundwater;
3. Water-rock interaction, its mechanism and rates;
4. The extent, progress and mechanisms of biogeochemical transformation of contaminants

Isotope Geochemistry Node

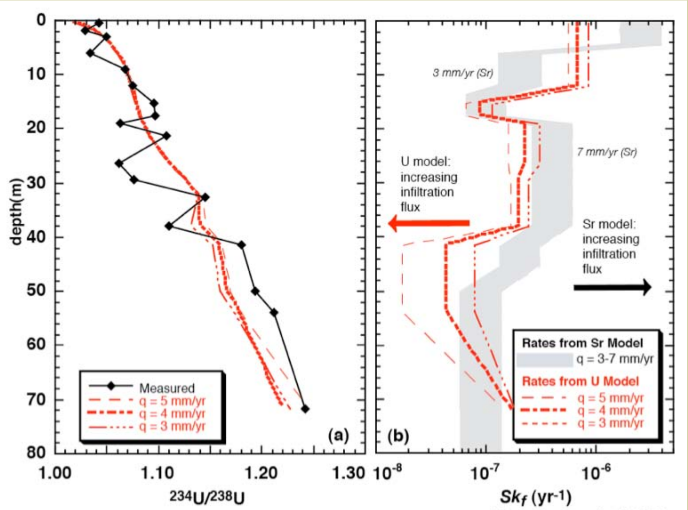
Don DePaolo and John Christensen

APPROACH

Isotopic Indicators of Redox Zonation.
Laboratory experiments to determine isotopic fractionation factors for nitrate, CO_2, sulfate, Fe, Cr, and methane under various conditions and their changes during evolving conditions



Mineral/Fluid Interactions.
Laboratory experiments to explore biogeochemical factors affecting Sr, Ca, Mg & U exchange between fluids and solids.



Maher et al. 2006

Synergies:

- Isotopic systematics into **reactive transport models** (w/RTM Node)
- Integration at **Field Study Sites** and other sites.

Environmental Geophysics Node

Susan Hubbard

OBJECTIVE:

Improve the use of geophysical methods for characterizing properties and monitoring processes associated with natural attenuation and active remediation.

MOTIVATION:

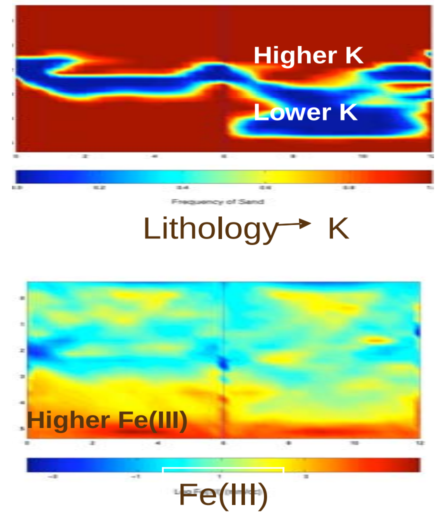
‘Plume scale’ characterization of flow properties;

Relationship between microscale processes and macroscale geophysical measurements;

Quantitative monitoring of biogeochemical transformations;

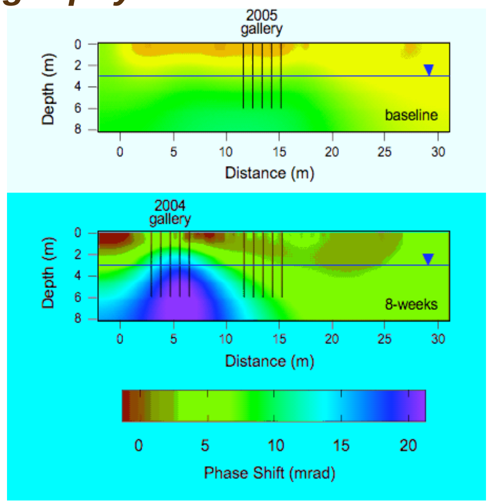
System process understanding.

‘Hydrogeophysics’



Lithofacies and sediment geochemistry estimating (Chen et al., 2006)

‘Biogeophysics’



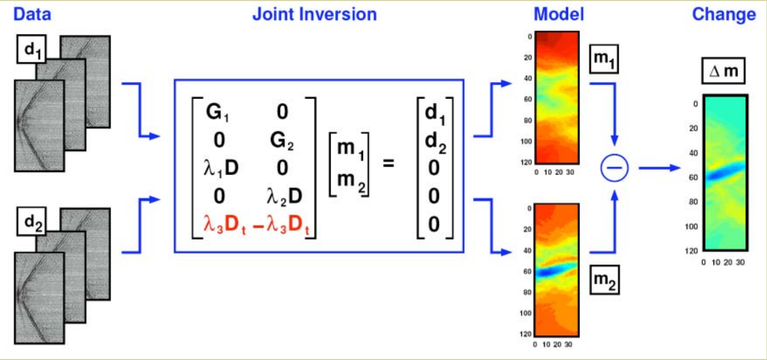
Development of an electrical phase anomaly associated with a biostimulation experiment (Williams et al., 2008)

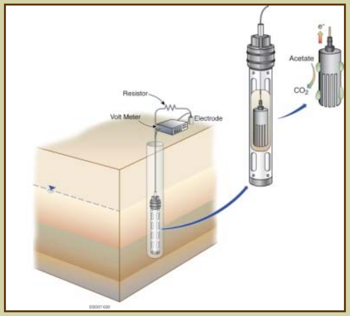
Environmental Geophysics Node
Susan Hubbard

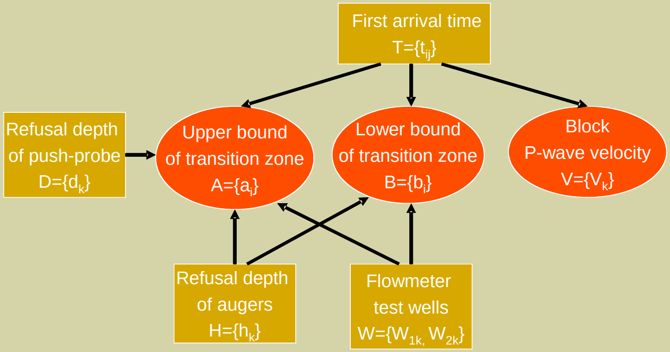
Environmental Remediation Sciences

APPROACH

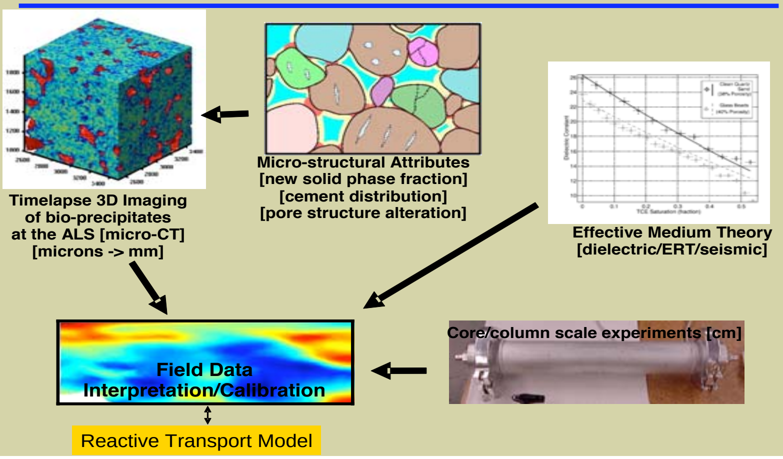
- **Imaging.** Improve acquisition and inversion of time-lapse datsets;
- **Petrophysics**. Focus on geophysical responses to formation of precipitates and scaling;
- **Estimation.** Geochemical estimation framework and multi-scale reactive facies framework.
- **Advanced Instrumentation**. Electrode based approaches and continuous active source seismic system.
- **Systems Investigations** using above advances to explore feedbacks between flow characteristics and biogeochemical transformations.







Connecting Biologically-Induced Microstructures To Macroscopic (Geophysical) Properties



Reactive Transport Modeling (RTM) Node

Carl Steefel

OBJECTIVE

- Develop capabilities to predict multi-scale, coupled, *in-situ* processes that govern sustained remediation or MNA of metals and radionuclides.

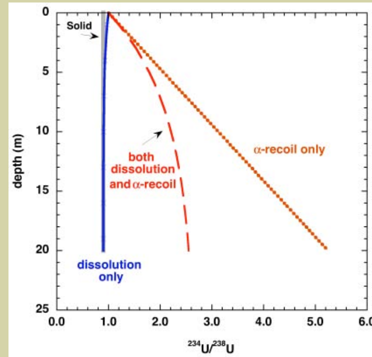
MOTIVATION

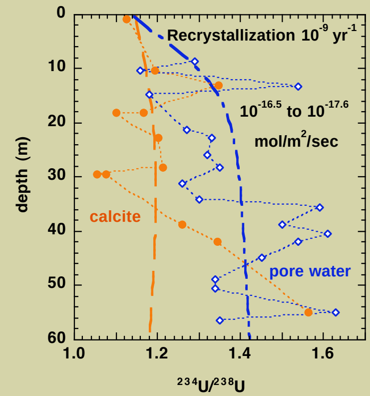
- Efficient design and testing of remediation strategies
- Scientifically defensible predictions of natural attenuation
- Maximum use of fundamental science through development and application of “mechanistic” process models
- Multi-scale, multi-physics, multi-dimensional environmental problems require high performance computing

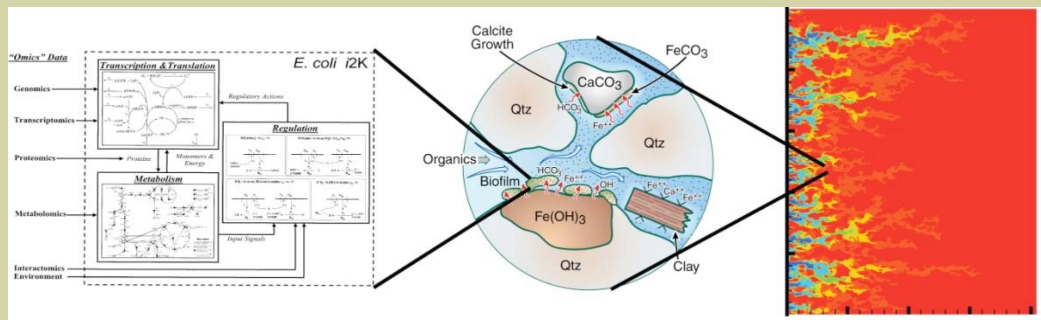
Reactive Transport Modeling Node

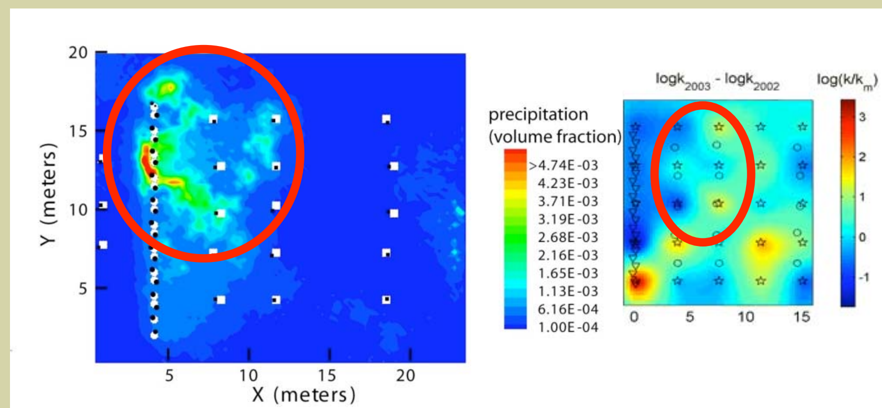
Carl Steefel

- APPROACH
  - Incorporation of stable and radiogenic isotopes into multicomponent RT models
  - Coupling of microbial community dynamics and biogeochemical transport
  - Joint geophysical-biogeochemical inversion approach
  - Enhancement of computational efficiency of Berkeley Lab RTM simulators









Rifle Field Study Site

RIFLE
K. Williams

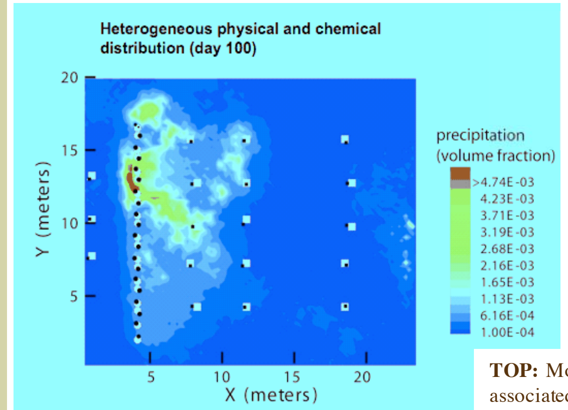
Explore and document synergies that come from integration of multiple CMM approaches

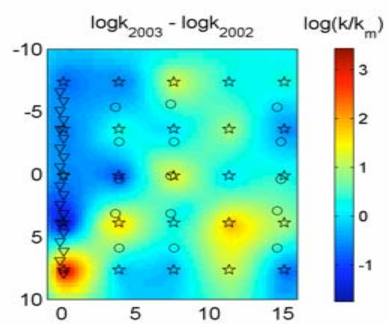
Hydro-biogeophysics

Isotope Geochemistry

Reactive transport modeling

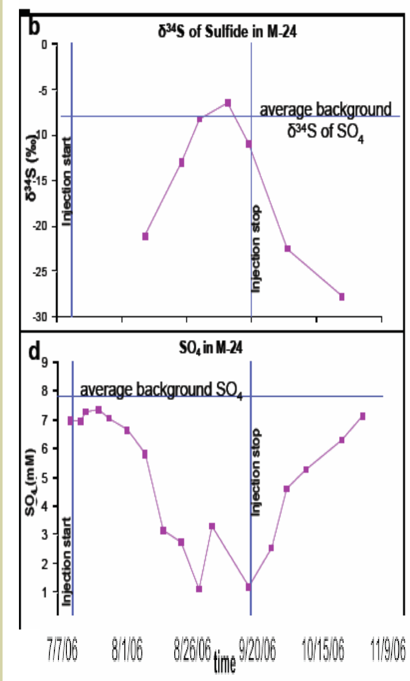
- Explore feedbacks between flow characteristics and biogeochemical transformations.

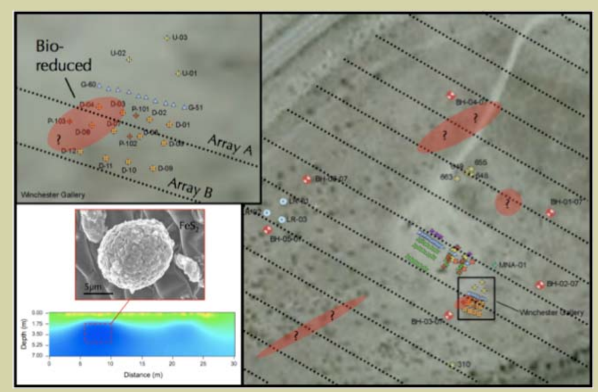




TOP: Modeling results associated with the prolonged acetate injection during the 2002 experiment, indicating the influence of correlated physical and geochemical heterogeneity on the spatial distribution of developed calcite and FeS precipitates.

Bottom: Estimated change in log permeability associated with the developed precipitates, obtained using ITOUGH2 and time -lapse bromide data.





The Integrated Characterization, Modeling, and Monitoring Scientific Research Area will address several ERSP Strategic Goals, including:

- *"Development of new measurement and monitoring tools that will permit interrogation of coupled biological, chemical, and physical processes in natural systems and often in a minimally invasive manner*";

- "*Improved ability to predict transport, transformations, and attenuation associated with remedial strategies";*

- "*Development of field-validated, robust tools for validation of predictive models and remediation strategies and for long-term performance modeling and of large-scale, fully coupled transport simulators*".

U.S. Department of Energy
Office of Science

Office of Biological and Environmental Research
Environmental Remediation Sciences Division

ENVIRONMENTAL REMEDIATION SCIENCES PROGRAM STRATEGIC PLAN

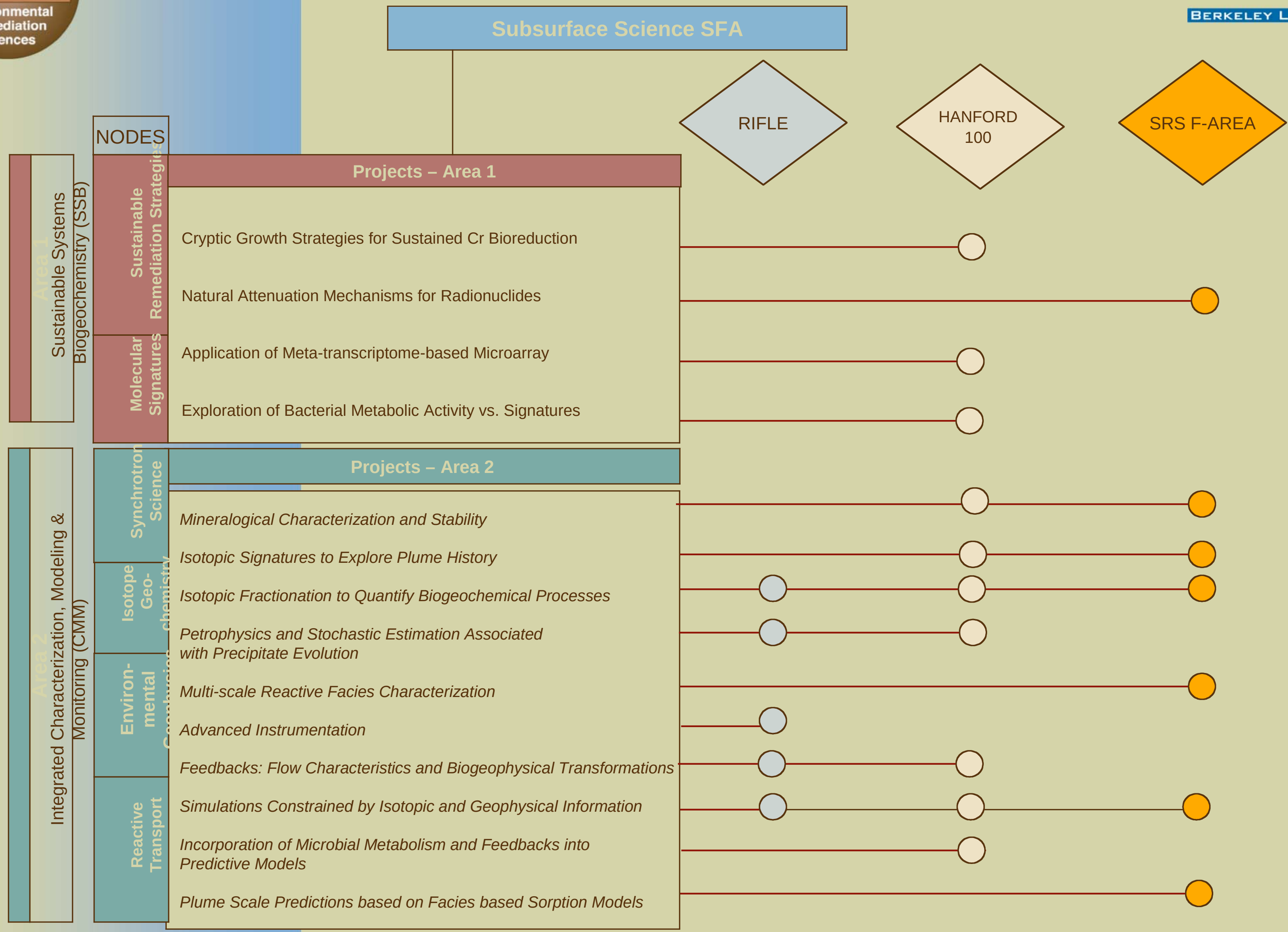
"Solving the DOE's intractable problems in environmental remediation and stewardship"

March 2006

Version 0.9

DRAFT

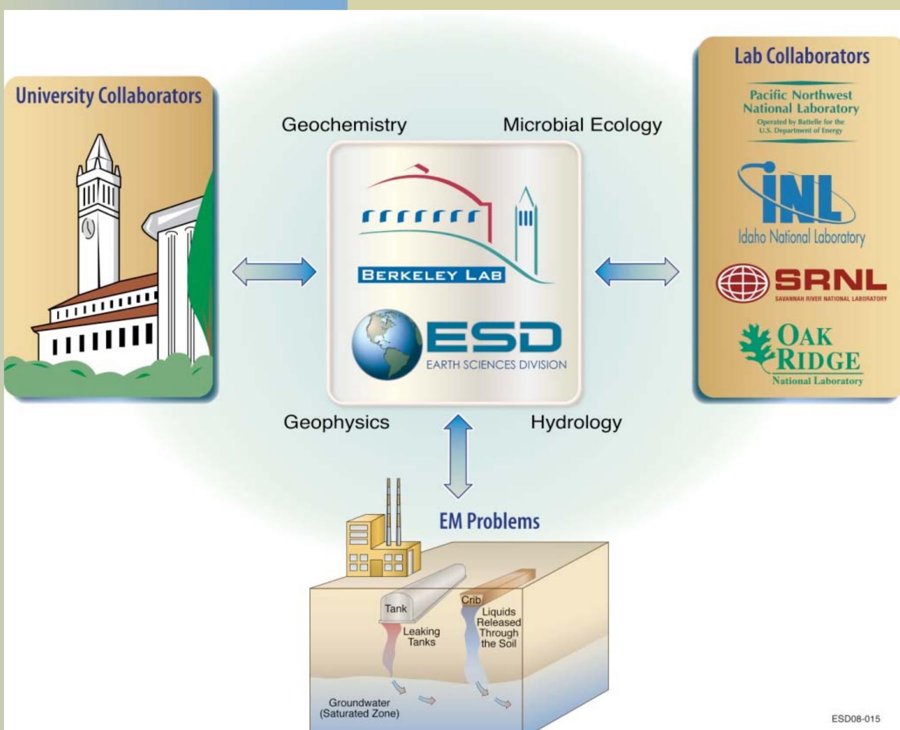
Integration of Scientific Research Areas and Field Study Sites



ERSP SFA Review April 9, 2008

LBNL SFA Collaborators

The node structure has been designed to enhance existing and encourage new ***collaborations*** with University and National Laboratory Scientists, as well as increase the impact of ERSP science at EM sites.



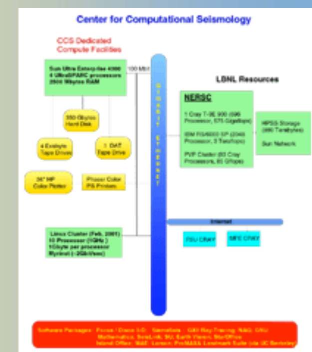
COLLABORATORS to LBNL
Earth Science Division
who participate in* or augment SFA through leveraging:

ERSP
GTL
EM
BES
LBNL SFA

Investigator	Source	Institution
Arkin, Adam		LBNL
Bargar, John		Stanford
Chorover, J.		UA
Davis, J.		USGS
Denham, Miles		SRS
Dresel, Ev an		PNNL
Fields, Matthew		MSU
Fendorf, Scott		Stanford
Firestone, Mary		UC Berkeley
Fruchter, John		Fluor Hanford
Fujita, Yoshiko		INL
Gaughan, Tom		SGCP
Hull, Larry		INL
Istok, Jack		OSU
Johnson, T.		Univ. I llinois
Kaipio, Jari	XXX X	Univ. Kuopio
Kaplan, Dan		SRNL
Kelly, Shelly		APS
Kemner, Ken		ANL
Lipton, Mary		PNNL
Long, Phil		PNNL
Lovley, Derek		UMass
Petersen, Scott		Fluor Hanford
Redden, G.		INL
Serne, R. Jeffre y		PNNL
Shadt, Chris		ONRL
Shuh, David		LBNL
Slater, Lee	XXXX	U. Rutgers
Stahl, David		UW
Sobecky, P.		Georgia Tech
Tamura, N.		ALS
Truex, Mike		PNNL
Versteeg, Roelof		INL
Wall, Judy		UMC
Wang, Zheming		EMSL
Zachara, John		PNNL
Zhou, Jizhong		UO

The program will take advantage of state-of-the-art ***facilities*** at LBNL……

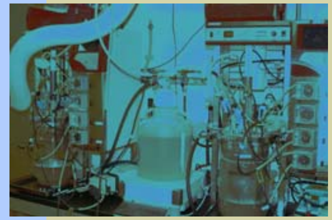
Geophysical Computing



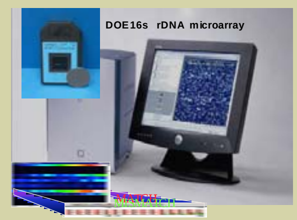
Molecular Foundry

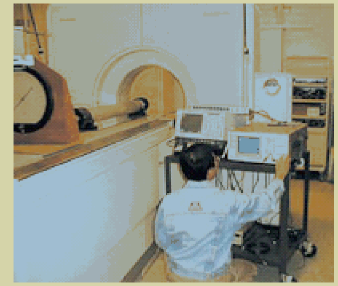
ALS

Isotope Lab



Molecular Microbiology Lab



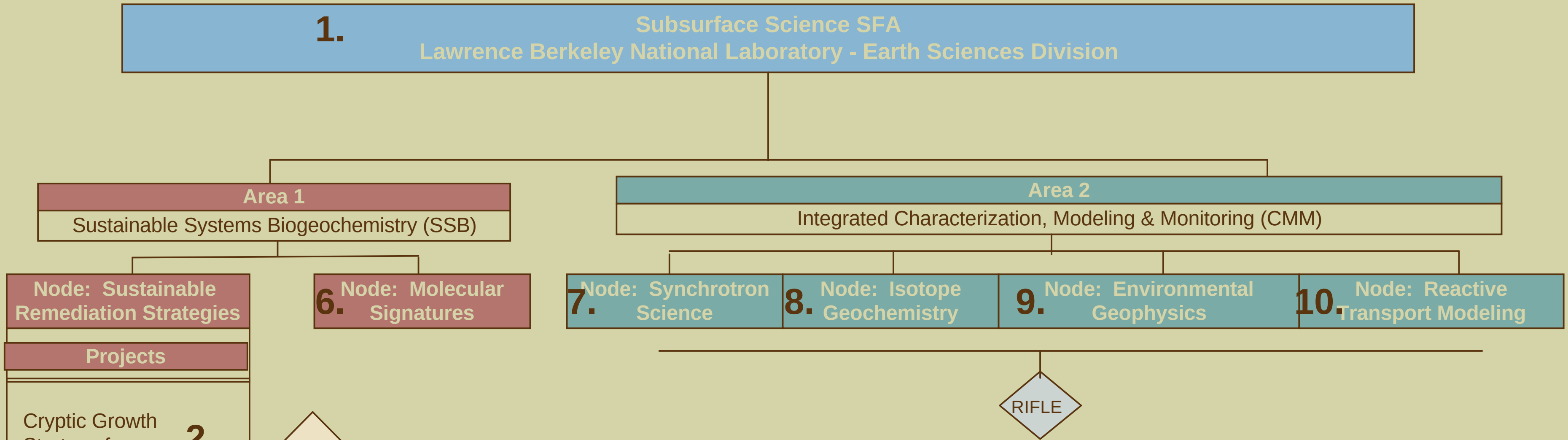


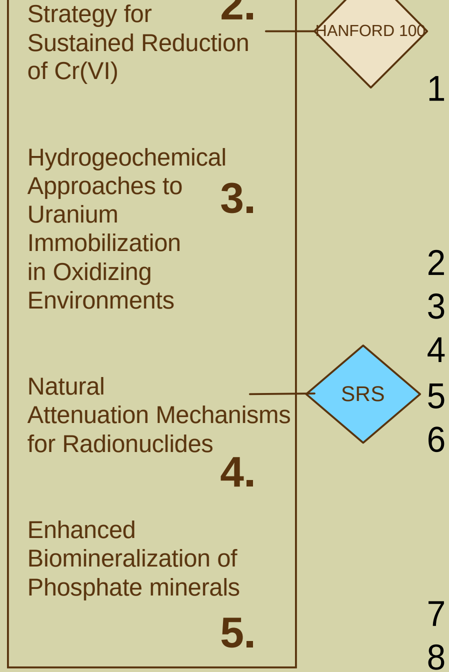
Rock and Soils Lab

NERSC and Computing Cluster

……as well as other ERSP-supported facilities.

Thank you! Please visit our tern Posters:





TEN LBNL SFA POSTERS

1. LBNL Subsurface Science SFA Overview - Susan Hubbard

Sustainable Systems Biogeochemistry (SSB)
Scientific Research Area

2. Cryptic Growth Strategy at the Hanford 100 Area – Terry Hazen and Boris Faybishenko.
3. Uranium Immobilization in Oxidizing Environments – Tetsu Tokunaga
4. Natural Attenuation Mechanisms for Radionuclides – Jiamin Wan
5. Enhanced Biomineralization of Phosphate Minerals – Mark Conrad
6. Molecular Signatures Node – Harry Beller and Eoin Brodie

Integrated Characterization, Modeling, and Monitoring (CMM)
Scientific Research Area

7. Synchrotron Science Node – Peter Nico
8. Isotope Geochemistry Node – Don DePaolo and John Christensen
9. Environmental Geophysics Node – Susan Hubbard and Ken Williams.
10. Reactive Transport Node – Carl Steefel

Summary

- **The proposed SFA will:**
  - Address two critical environmental science challenges- advances should be relevant across the DOE complex;
  - Utilize and extend LBNL’s recognized capabilities and facilities;
  - Promote synergy through multi-disciplinary and team-based research;
  - Increase the impact of ERSP research to DOE clean-up effort.

- Thank you