CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

October 2015

Sustainable Groundwater Management in CA Agriculture

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UC DAVIS

UNIVERSITY OF CALIFORNIA

Photo: Justin Sullivan / Getty Images

Veronica Rocha / Los Angeles Times

Lake Mendocino, 12/2013
Jay Jasperse / SCWA

Brad Zweerink for Earth Justice

Jim Wilson/ The New York Times

Jim Wilson/ The New York Times

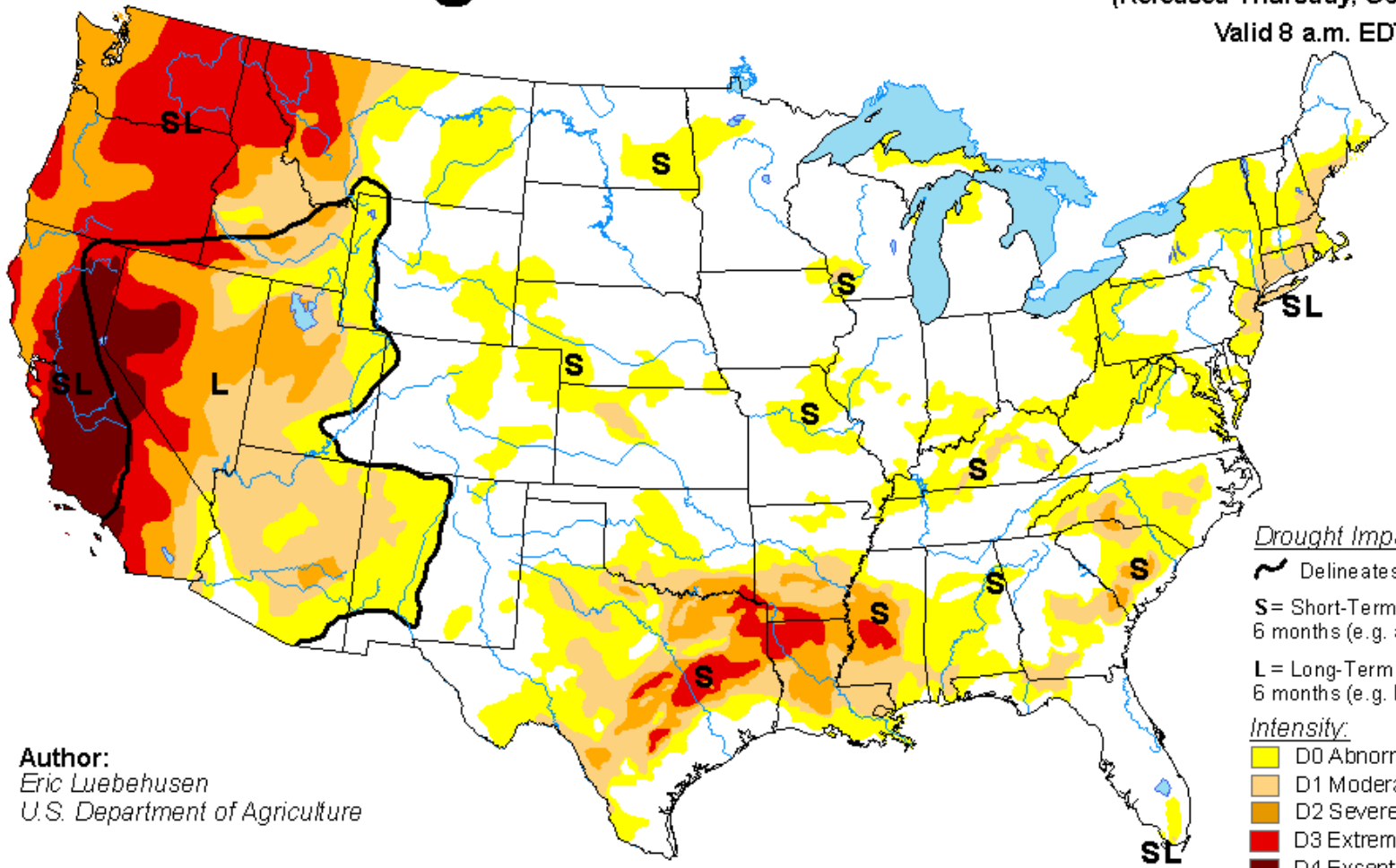
Jim Wilson/ The New York Times

U.S. Drought Monitor

September 29, 2015

(Released Thursday, Oct. 1, 2015)

Valid 8 a.m. EDT



Author:
Eric Luebehusen
U.S. Department of Agriculture

Drought Impact Types:

Delineates dominant impacts

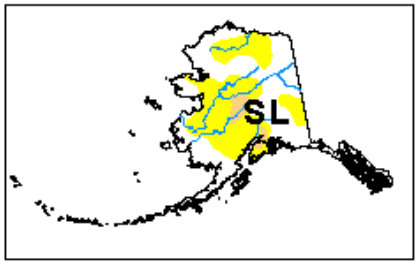
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

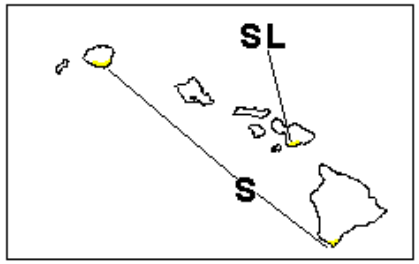
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

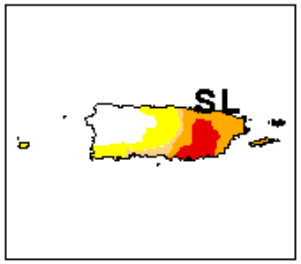
Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.





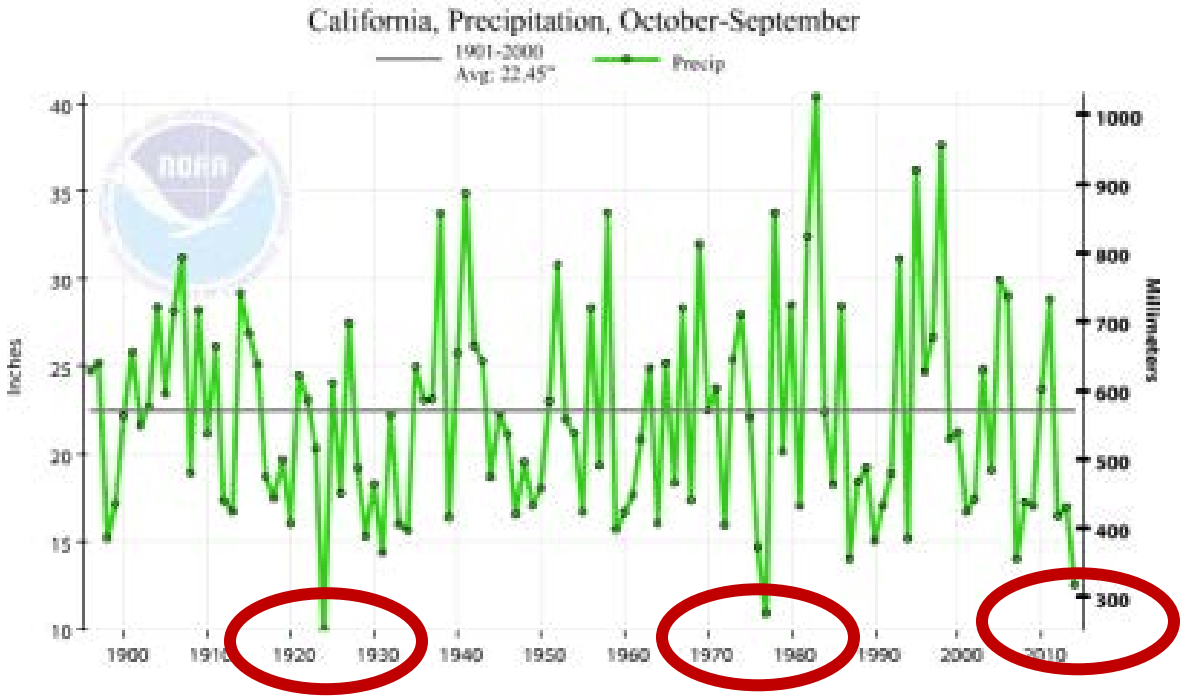


USDA

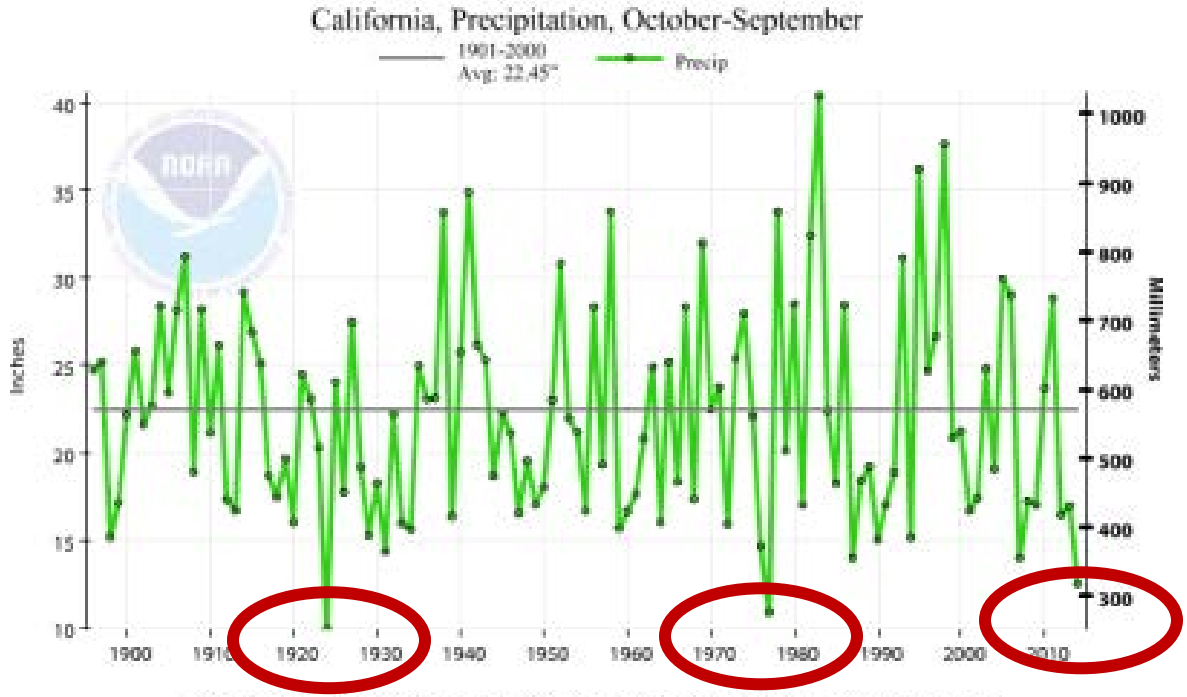
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

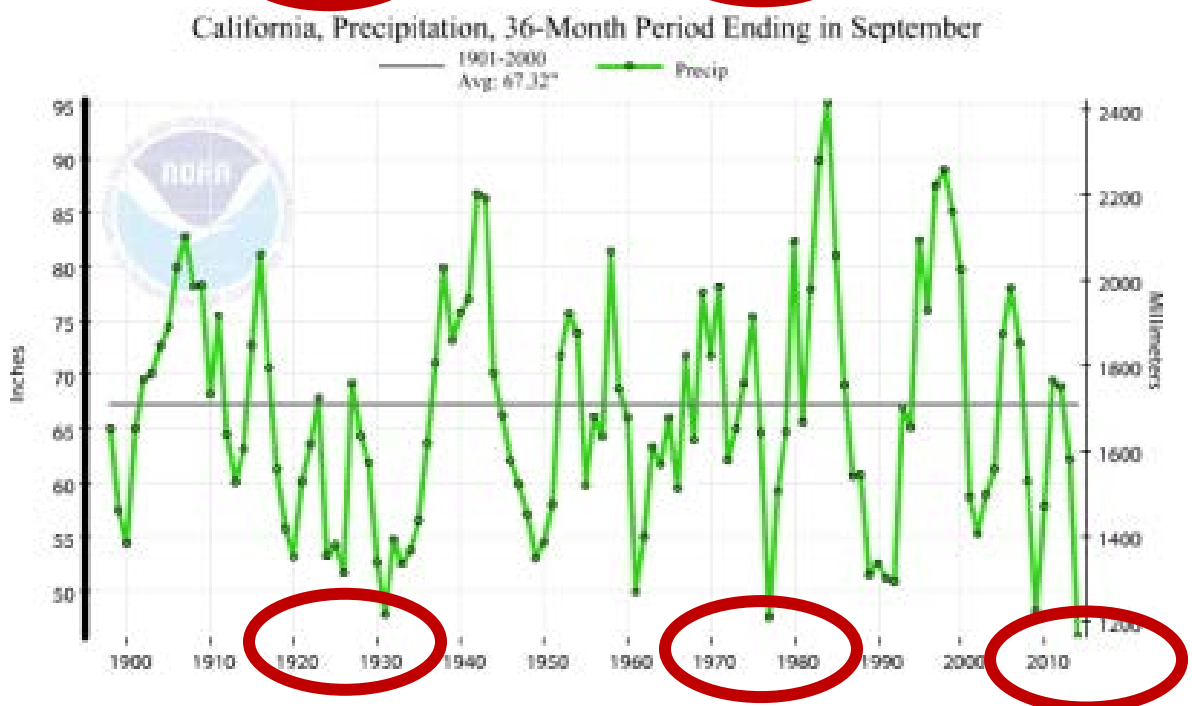
Annual P [inches]



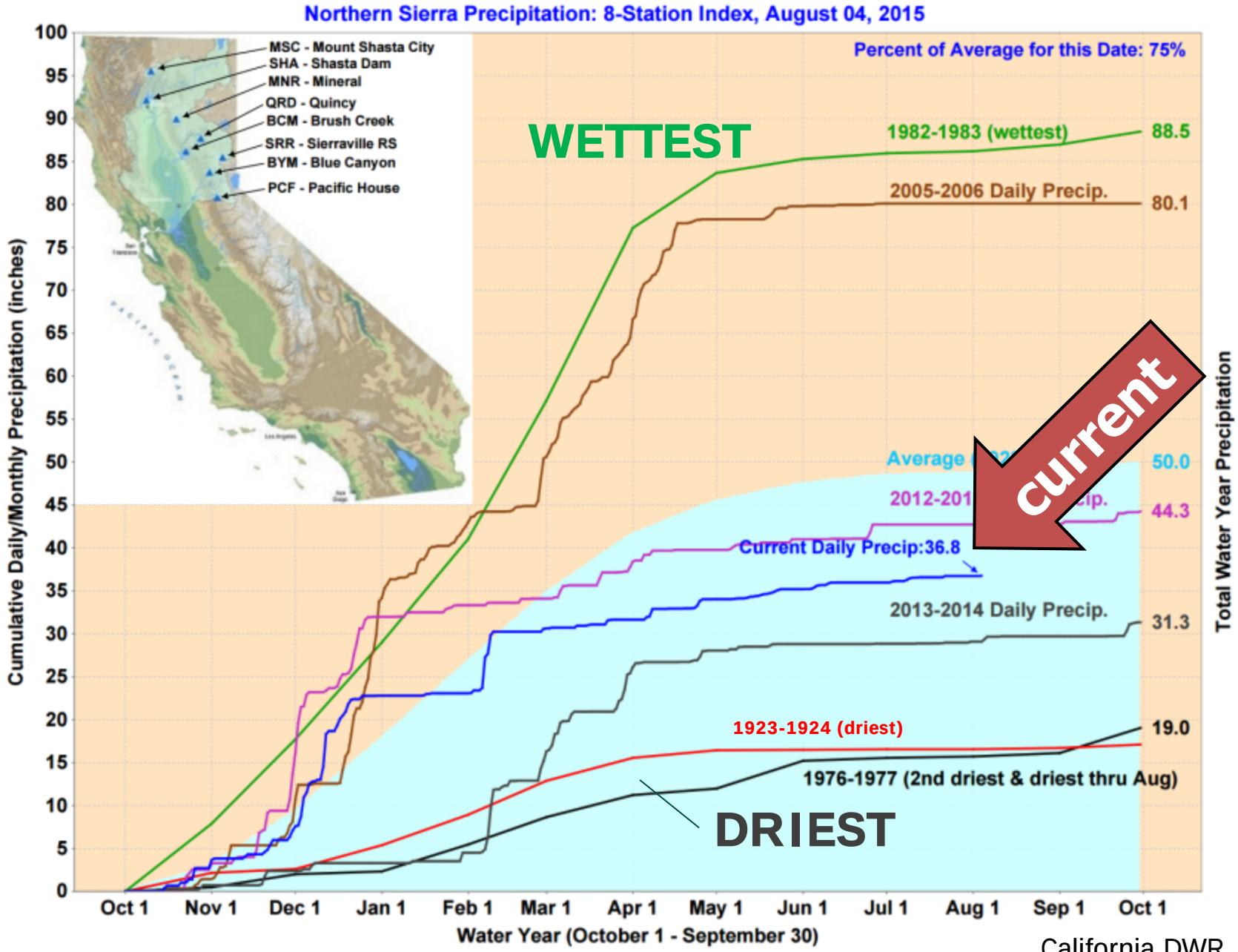
Annual P [inches]



Tri-annual P [inches]

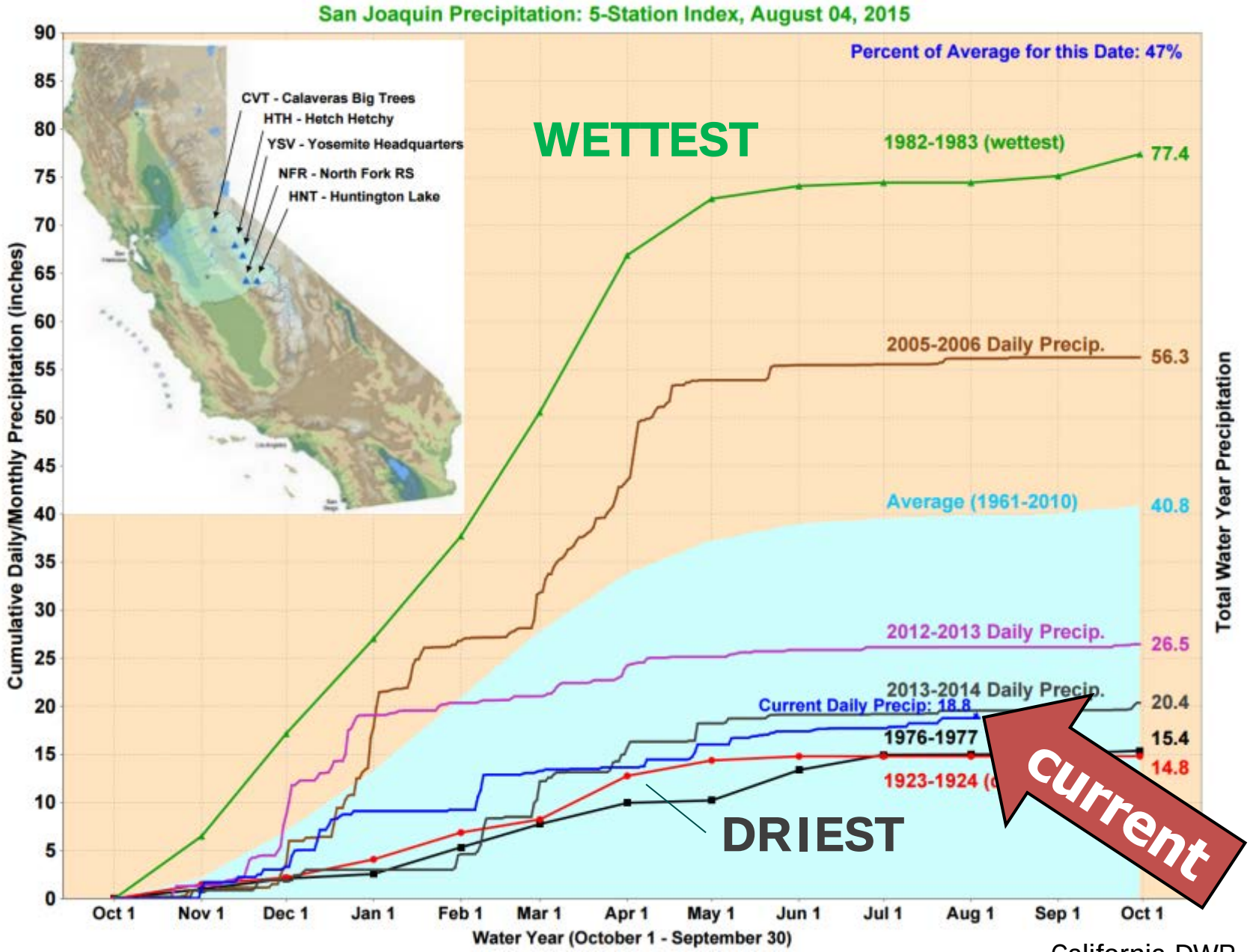


Cumulative Precipitation October - September



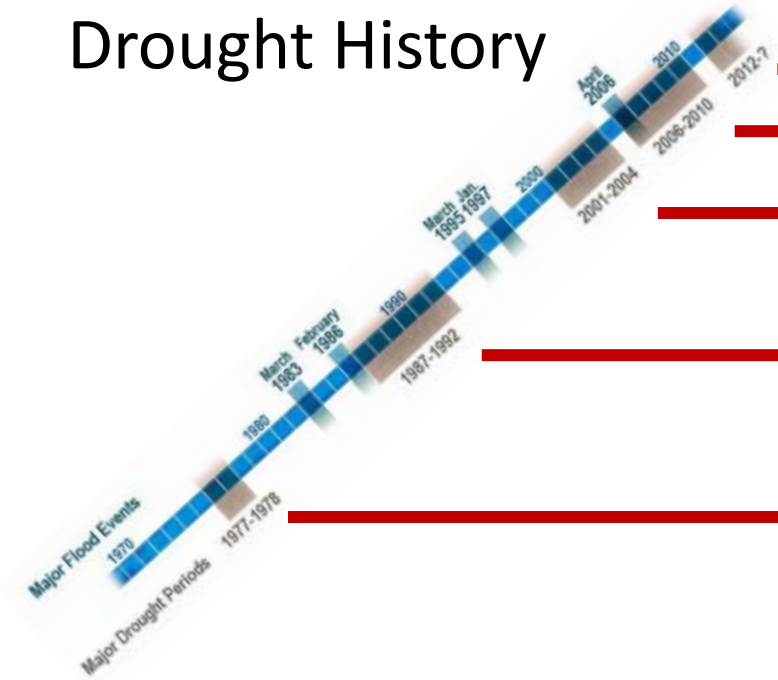
California DWR, 2015

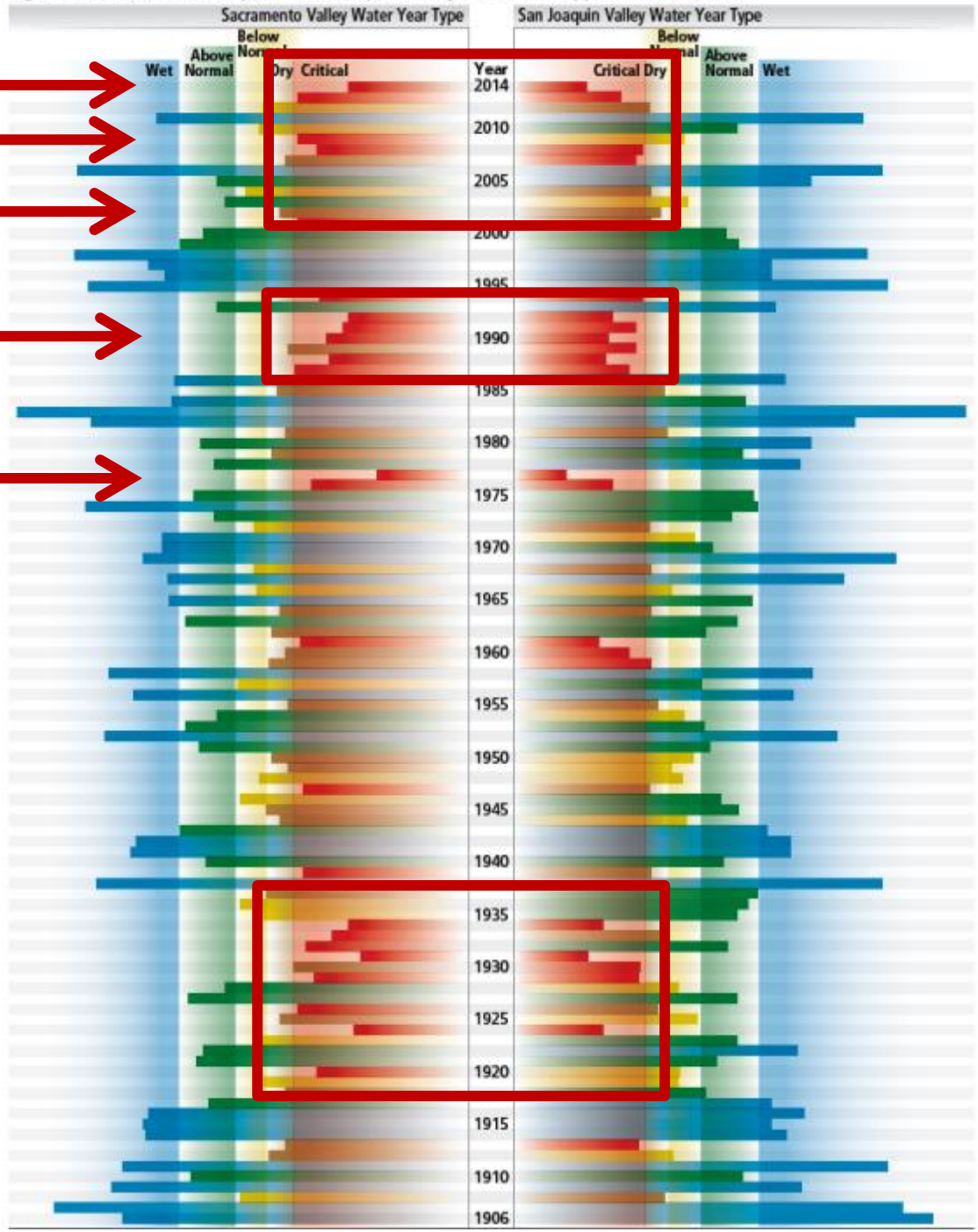
Cumulative Precipitation October - September



California DWR, 2015

Drought History

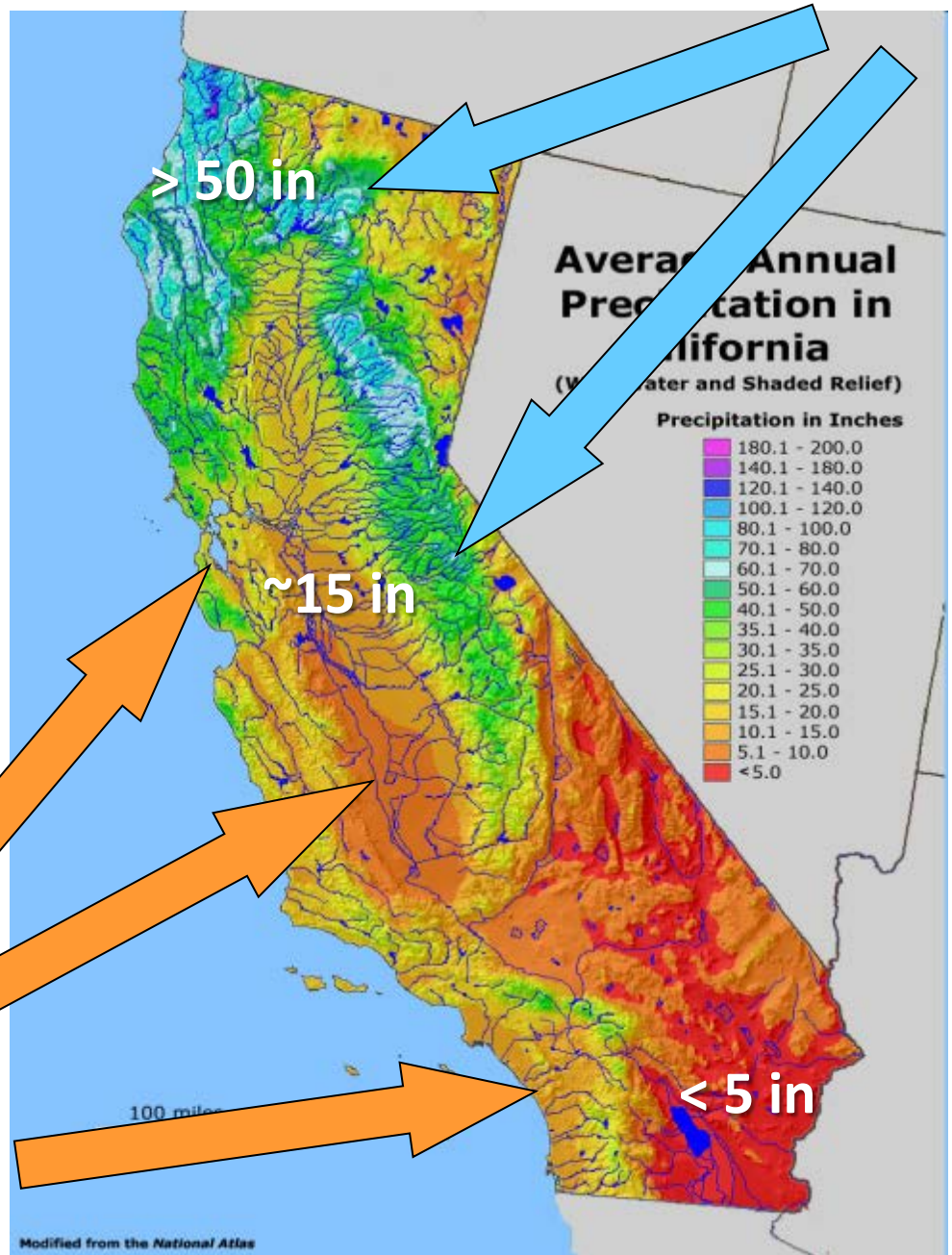




California Department of Water Resources;
Drought Response Update Fall 2014

RAIN

Space and Time
Disconnect
between
Water Supply
and
Water Use

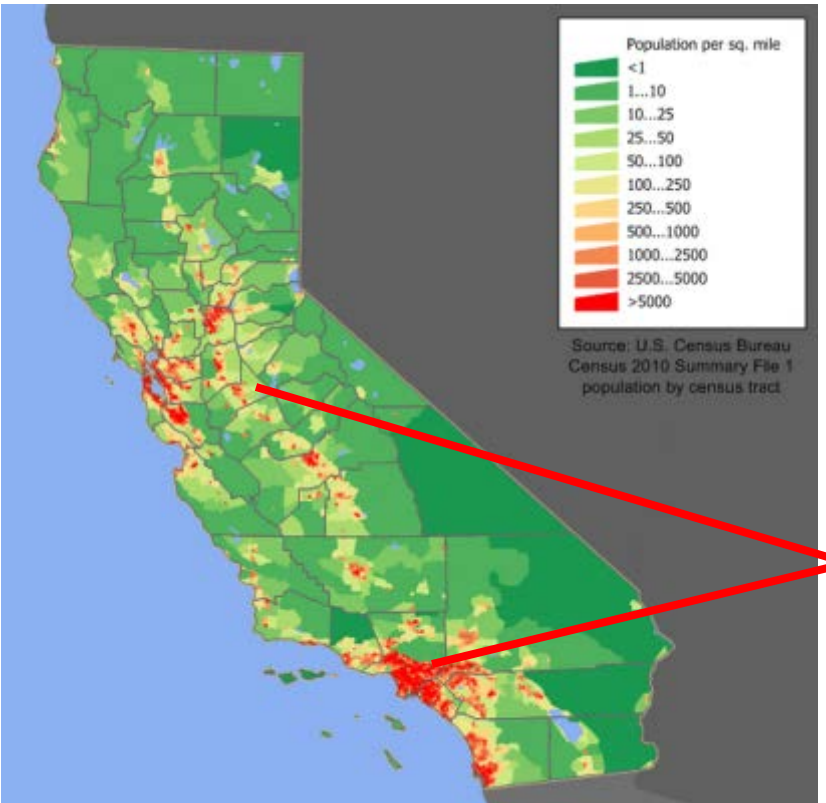


WATER USERS

California's Water Users

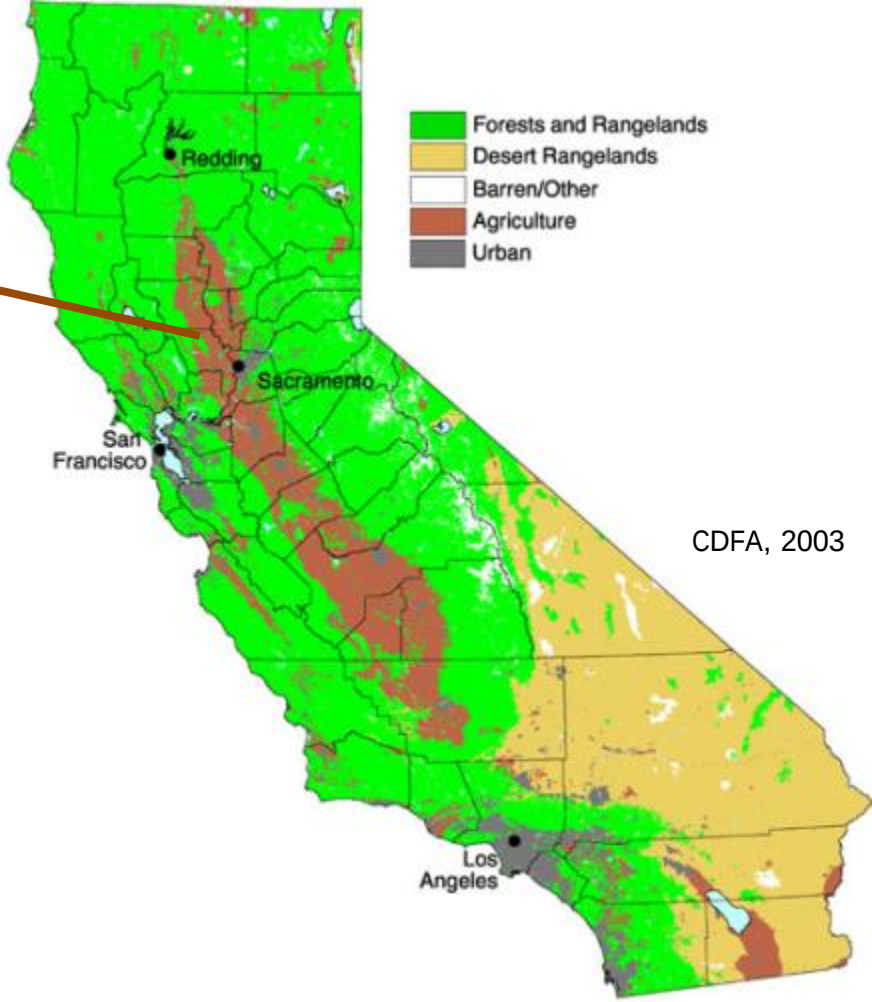
Irrigated Agriculture
9.5 million acres
(4 million ha)

applied water use:
27 – 35 MAF
(35 – 45 km^3)



Population
38 million people

water use:
8 MAF (10 km^3)



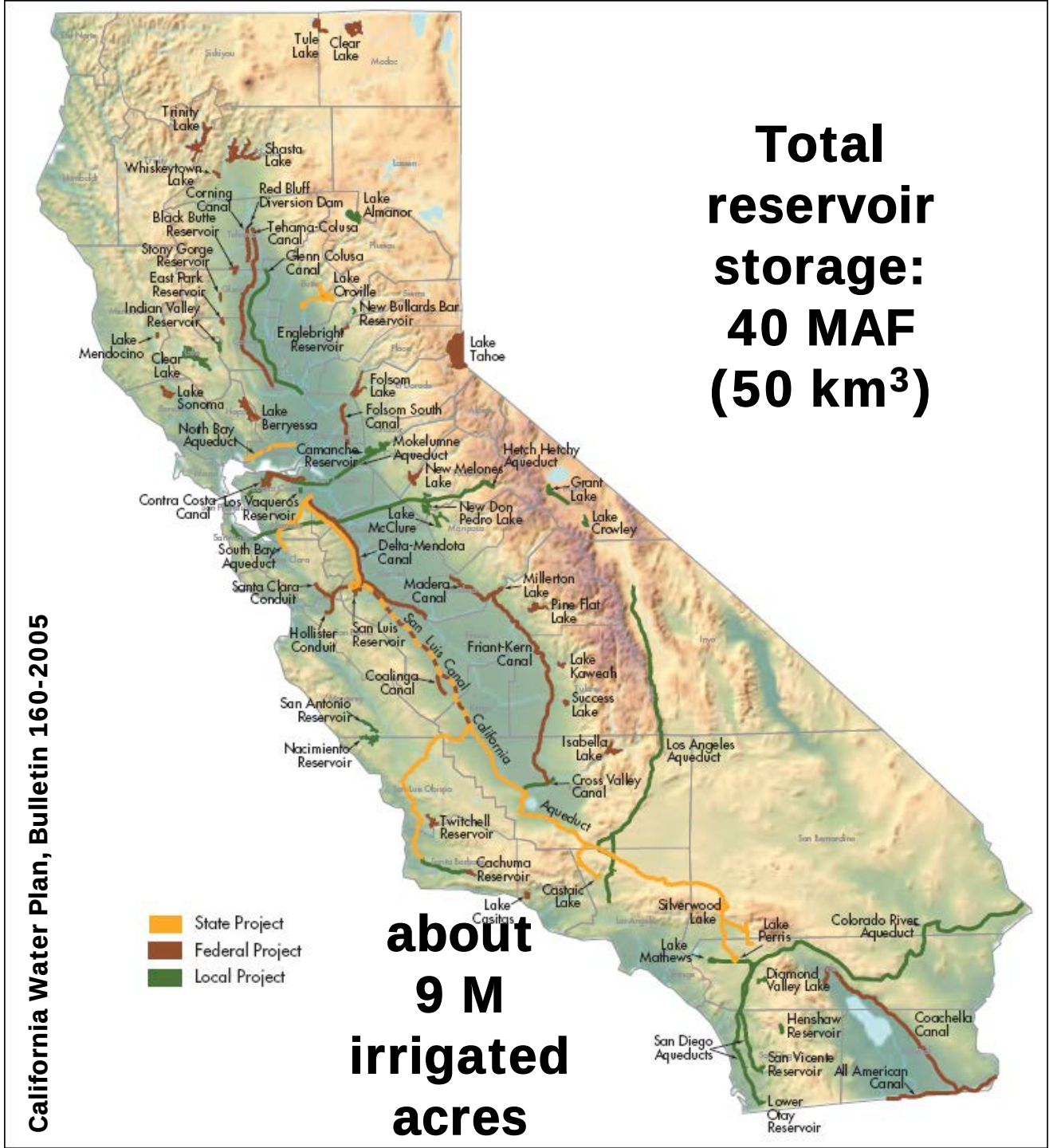
CDFA, 2003

Environment
&
protected streams,
wetlands:
45 MAF (55 km^3)

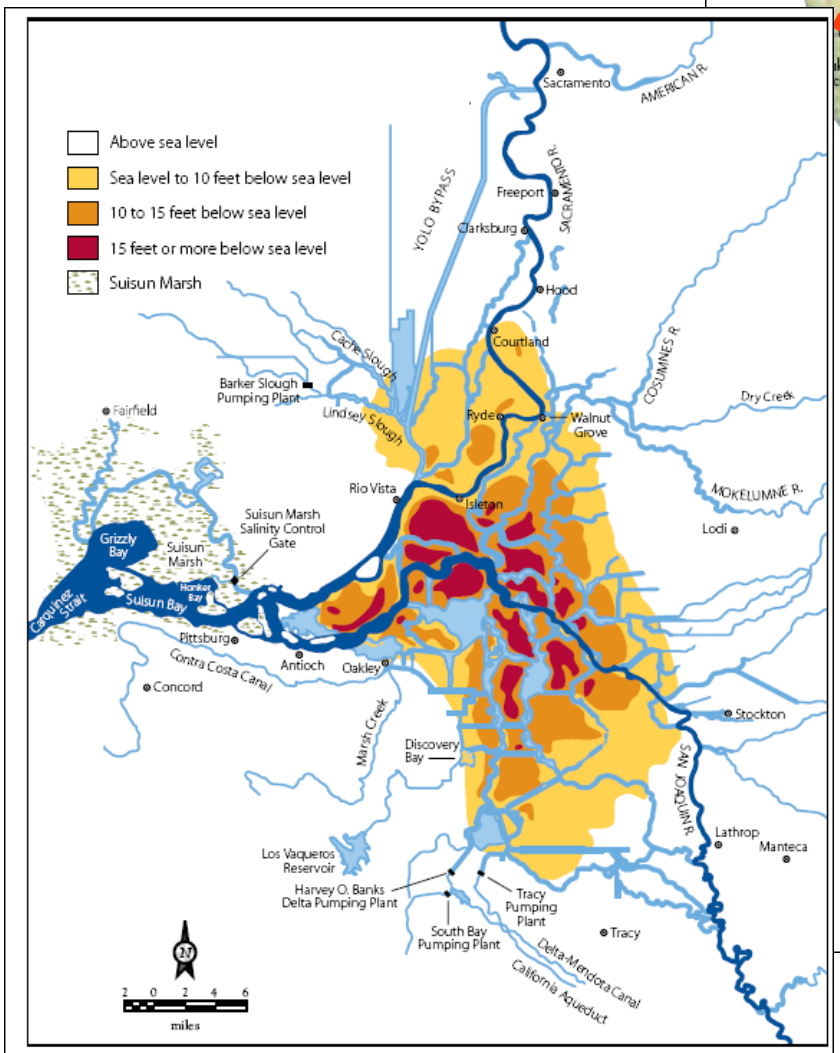
MAF = million acre-feet

California Water Infra-structure:

Bridging the Spatial and Temporal Disconnect between SUPPLY and USE

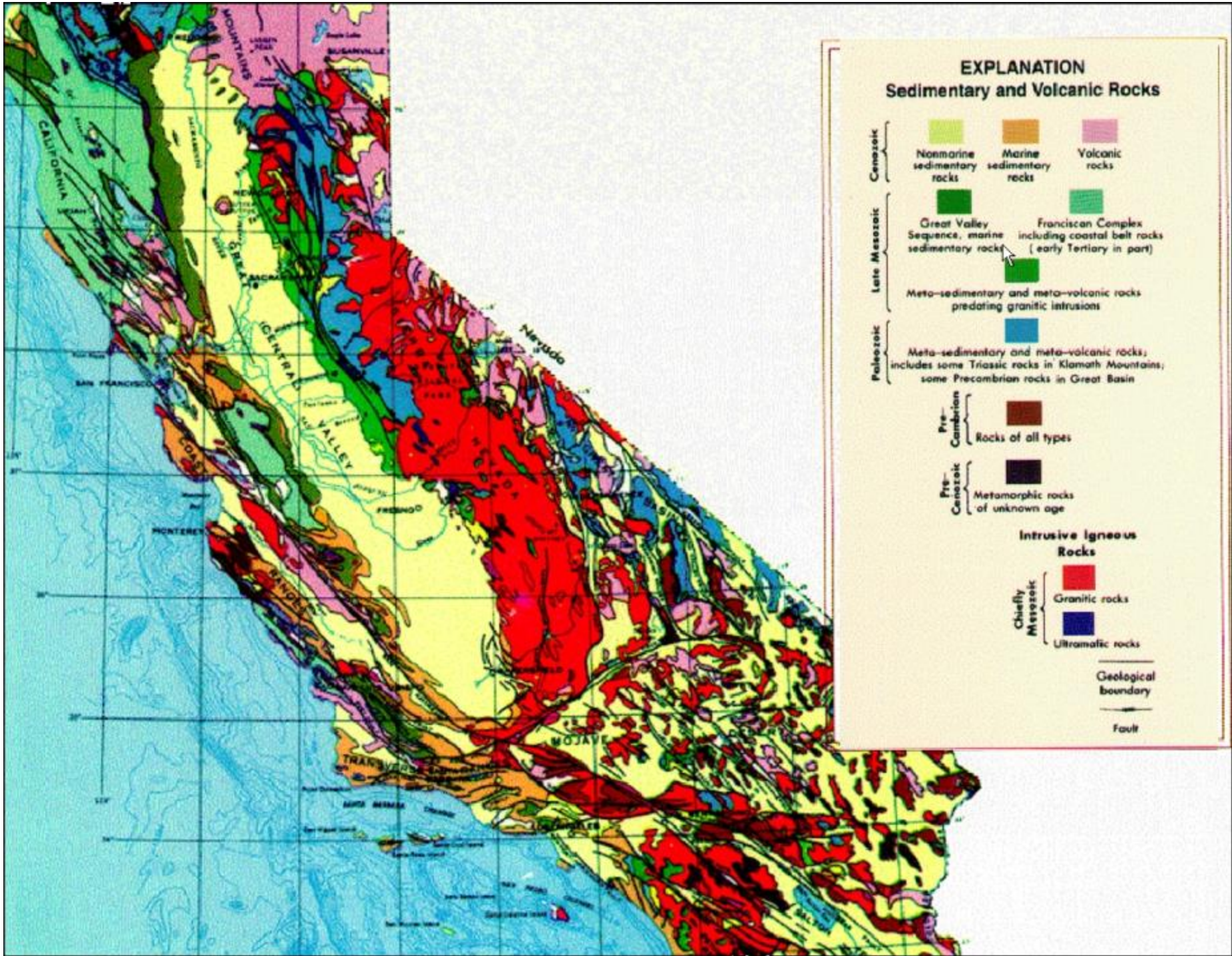


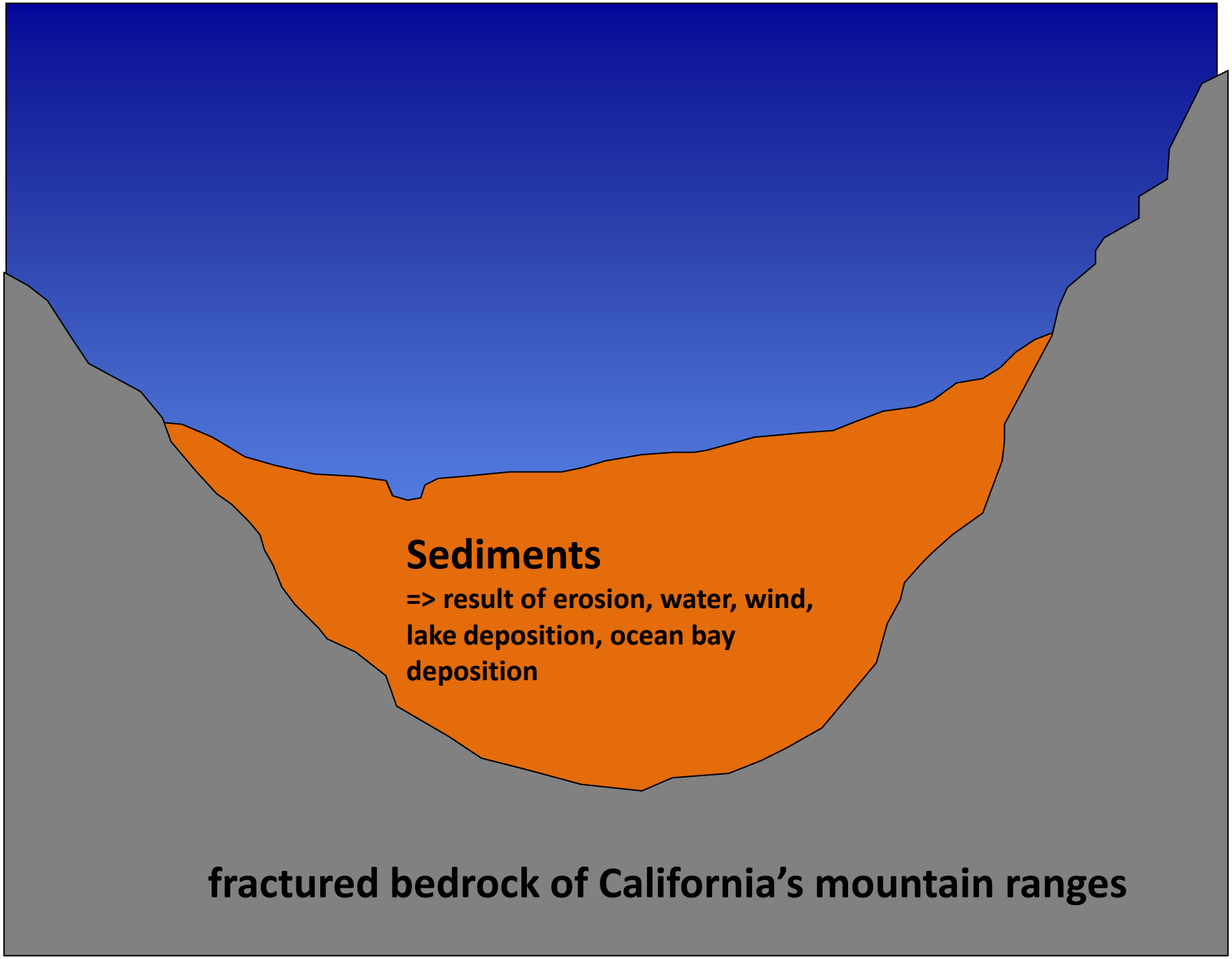
Central Water Hub: Sacramento – San Joaquin Delta

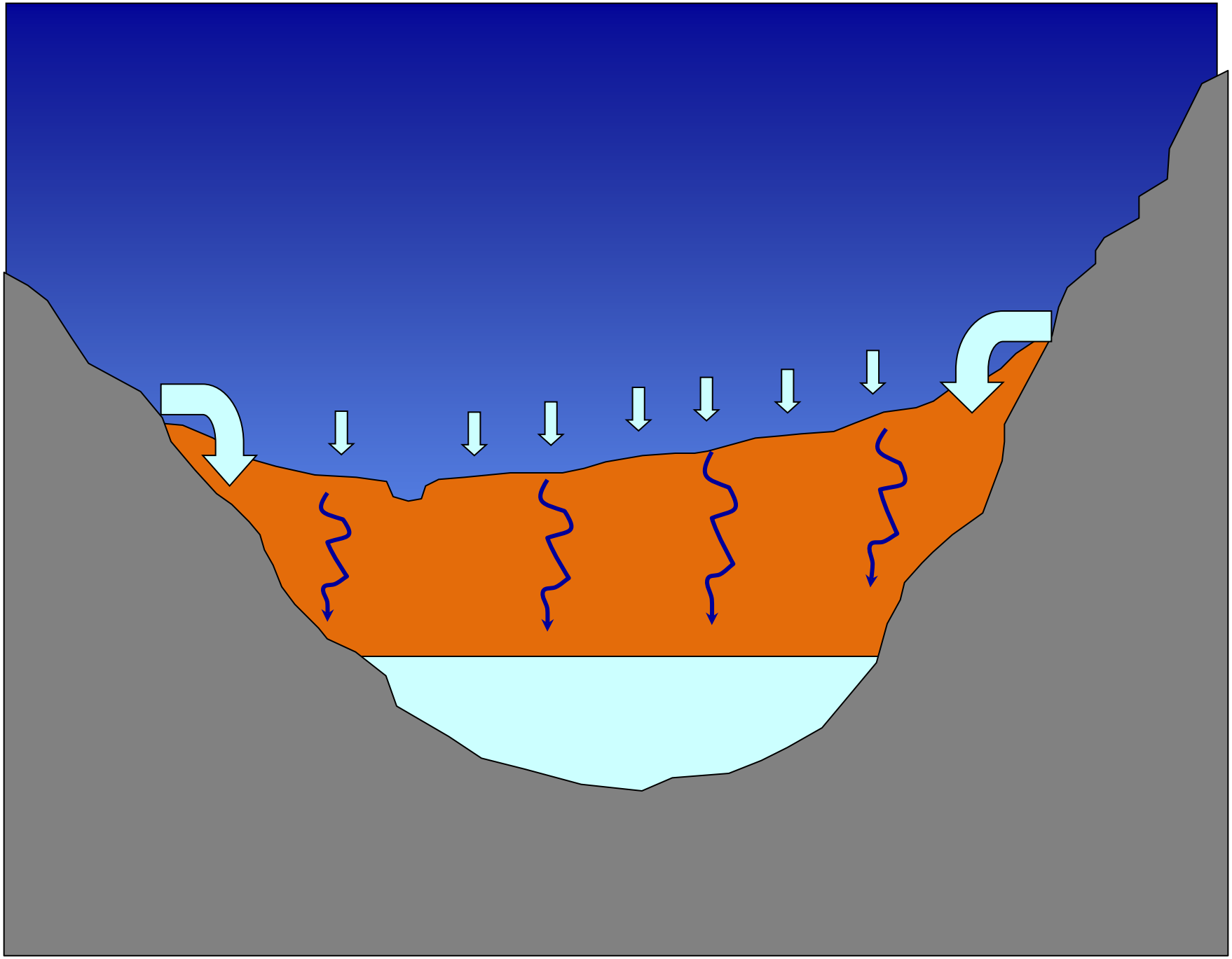


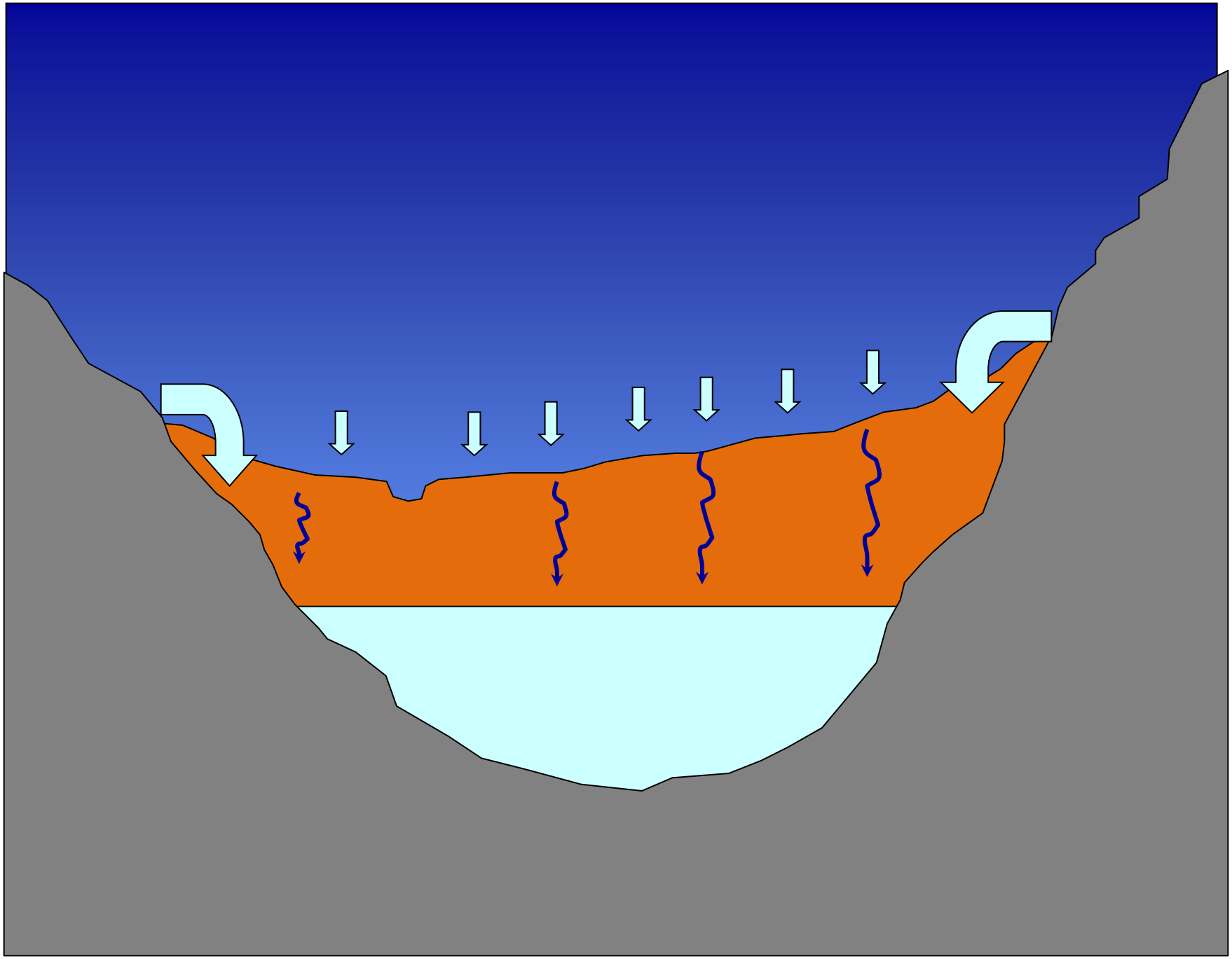
SOURCE: Department of Water Resources, Sacramento–San Joaquin Delta Atlas (1995).

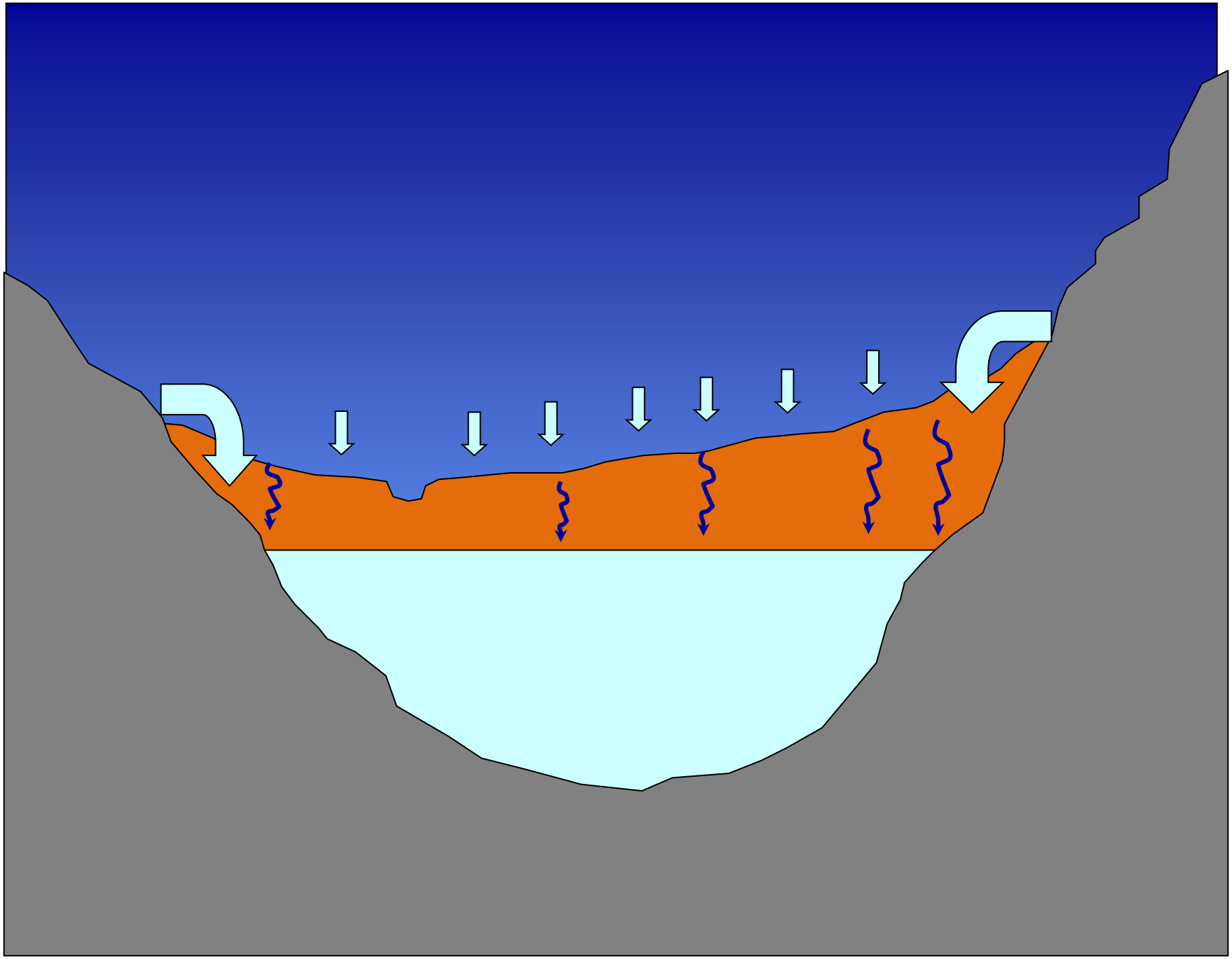
California Water Plan, Bulletin 160-2005

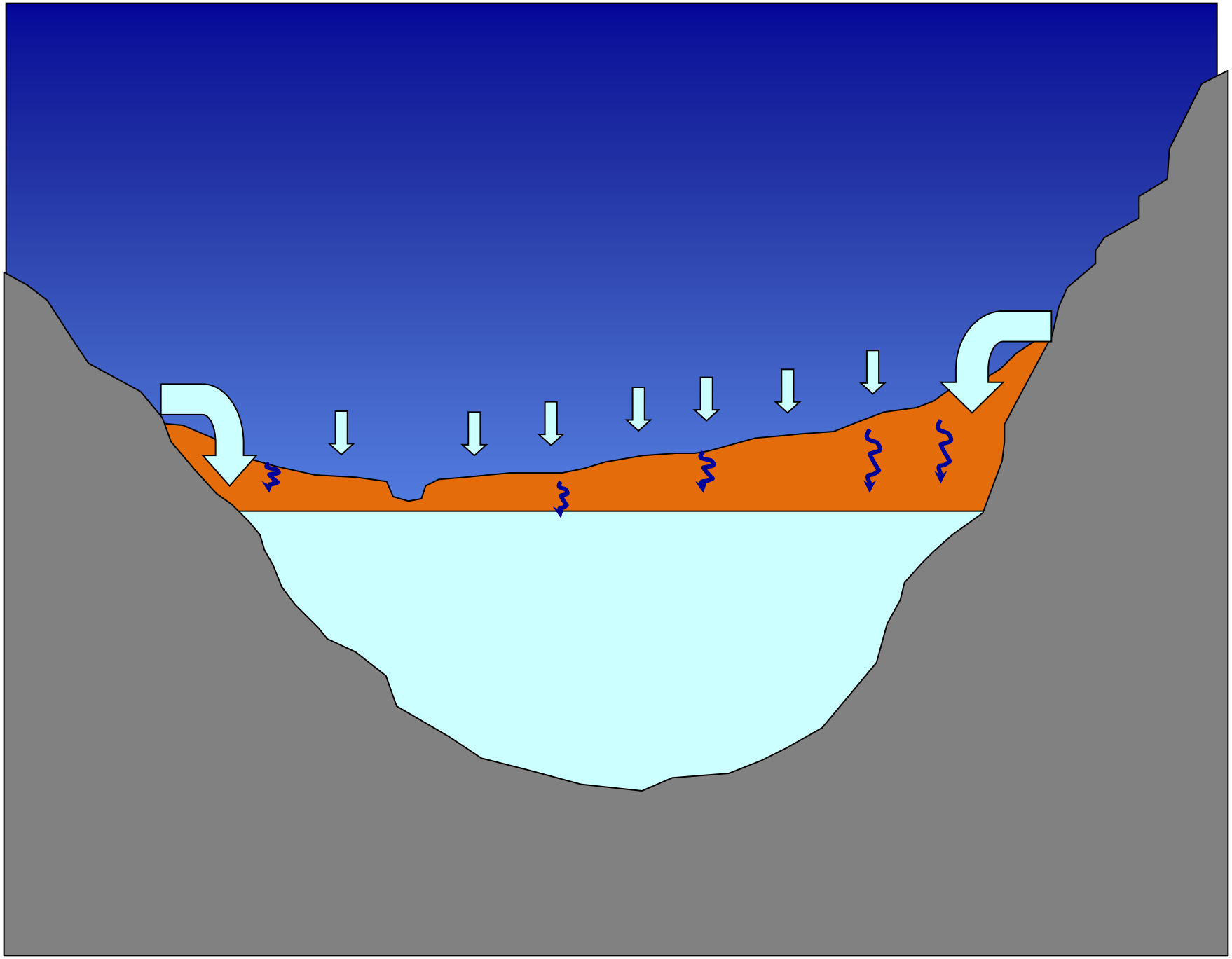

EXPLANATION
Sedimentary and Volcanic Rocks
Cenozoic
Nonmarine sedimentary rocks
Marine sedimentary rocks
Volcanic rocks
Late Mesozoic
Great Valley Sequence, marine sedimentary rocks
Franciscan Complex including coastal belt rocks (early Tertiary in part)
Meta-sedimentary and meta-volcanic rocks predating granitic intrusions
Paleozoic
Meta-sedimentary and meta-volcanic rocks; includes some Triassic rocks in Klamath Mountains; some Precambrian rocks in Great Basin
Pre-Cambrian
Rocks of all types
Pre-Cenozoic
Metamorphic rocks of unknown age
Intrusive Igneous Rocks
Chiefly Mesozoic
Granitic rocks
Ultramafic rocks
Geological boundary
Fault
CALIFORNIA
MOUNTAINS
SUSANVILLE
GREAT
CENTRAL
VALLEY
SAN FRANCISCO
MONTEREY
FRESNO
Nevada
MOJAVE
TRANSVERSE
SALTON

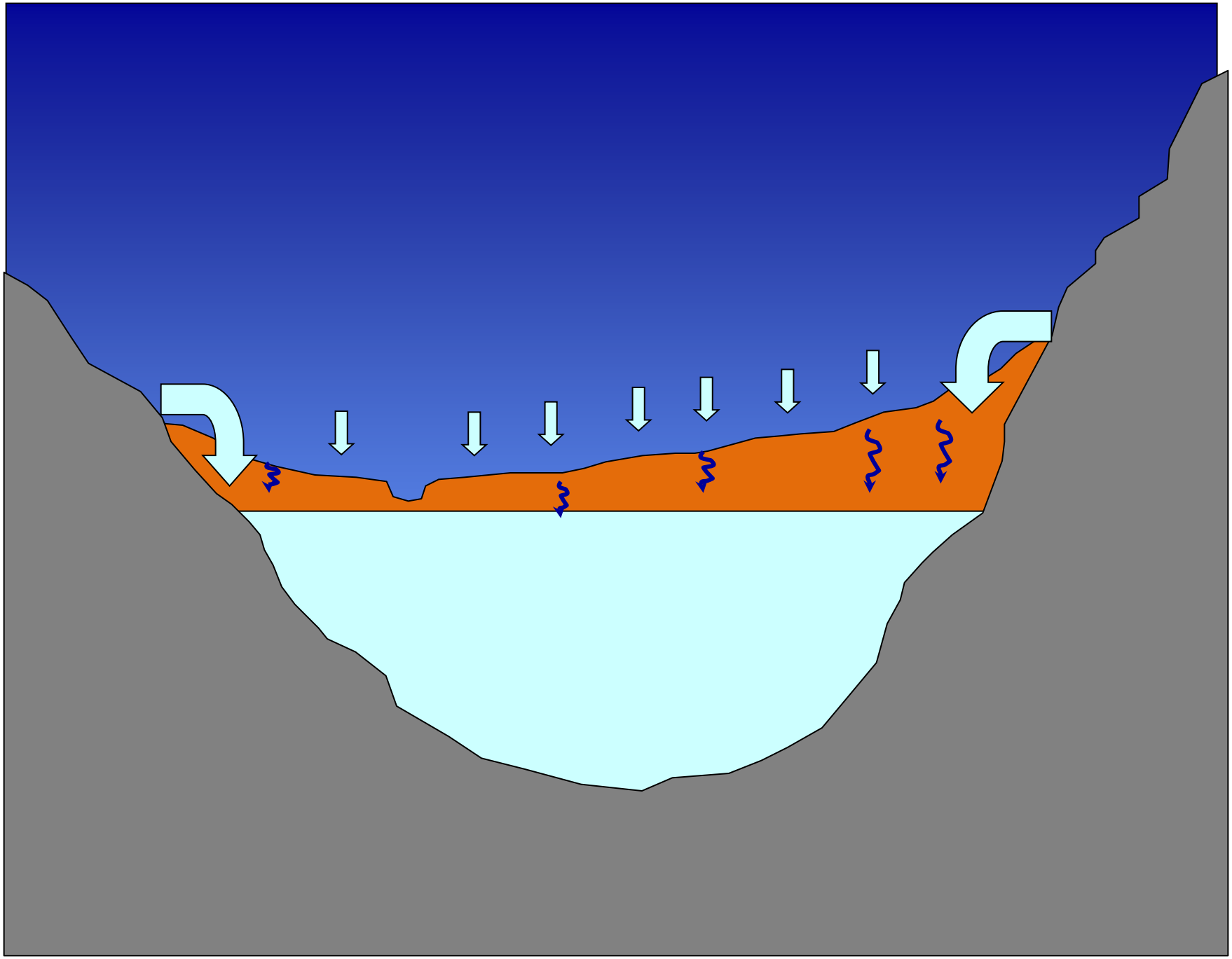

Sediments
=> result of erosion, water, wind, lake deposition, ocean bay deposition
fractured bedrock of California's mountain ranges

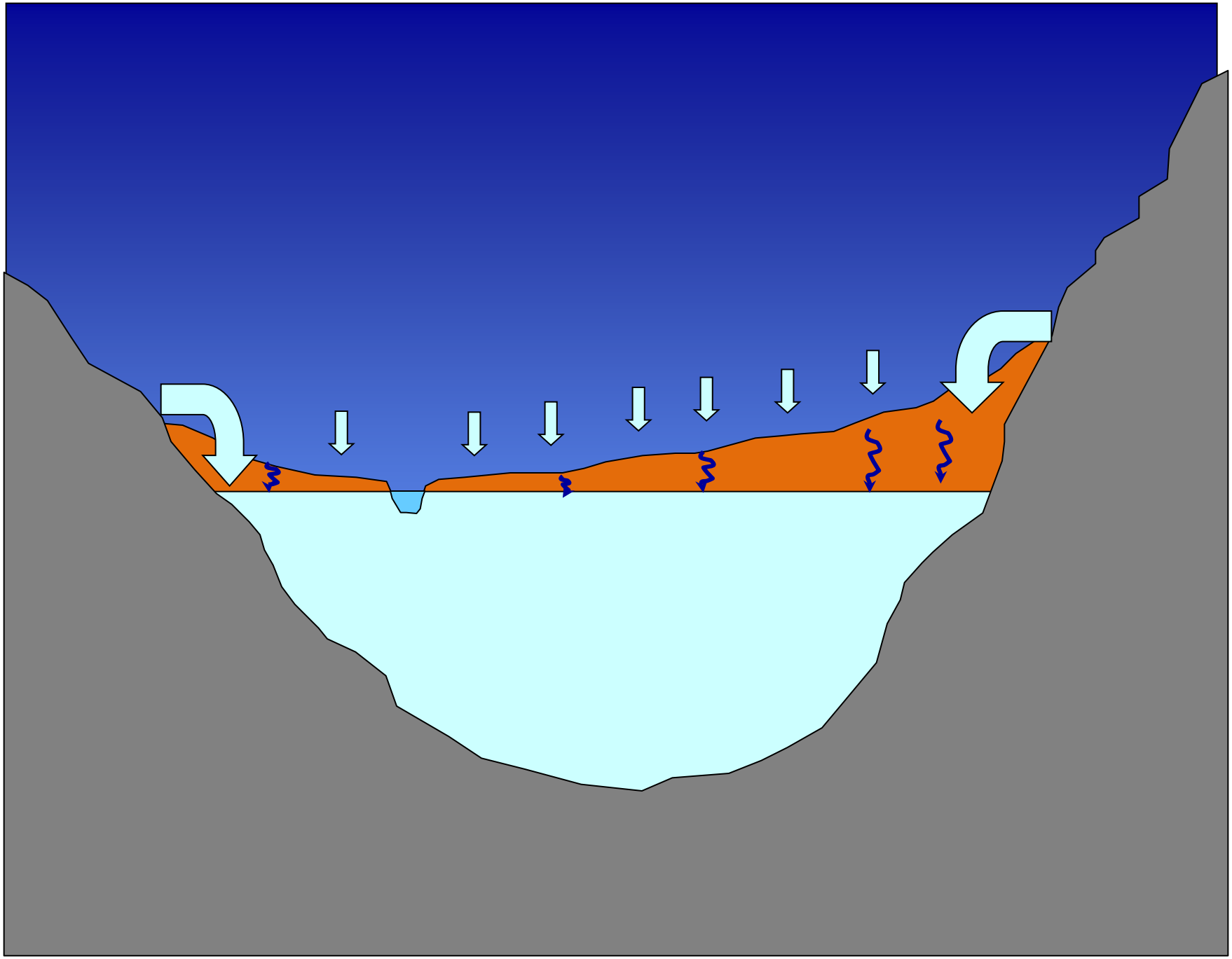


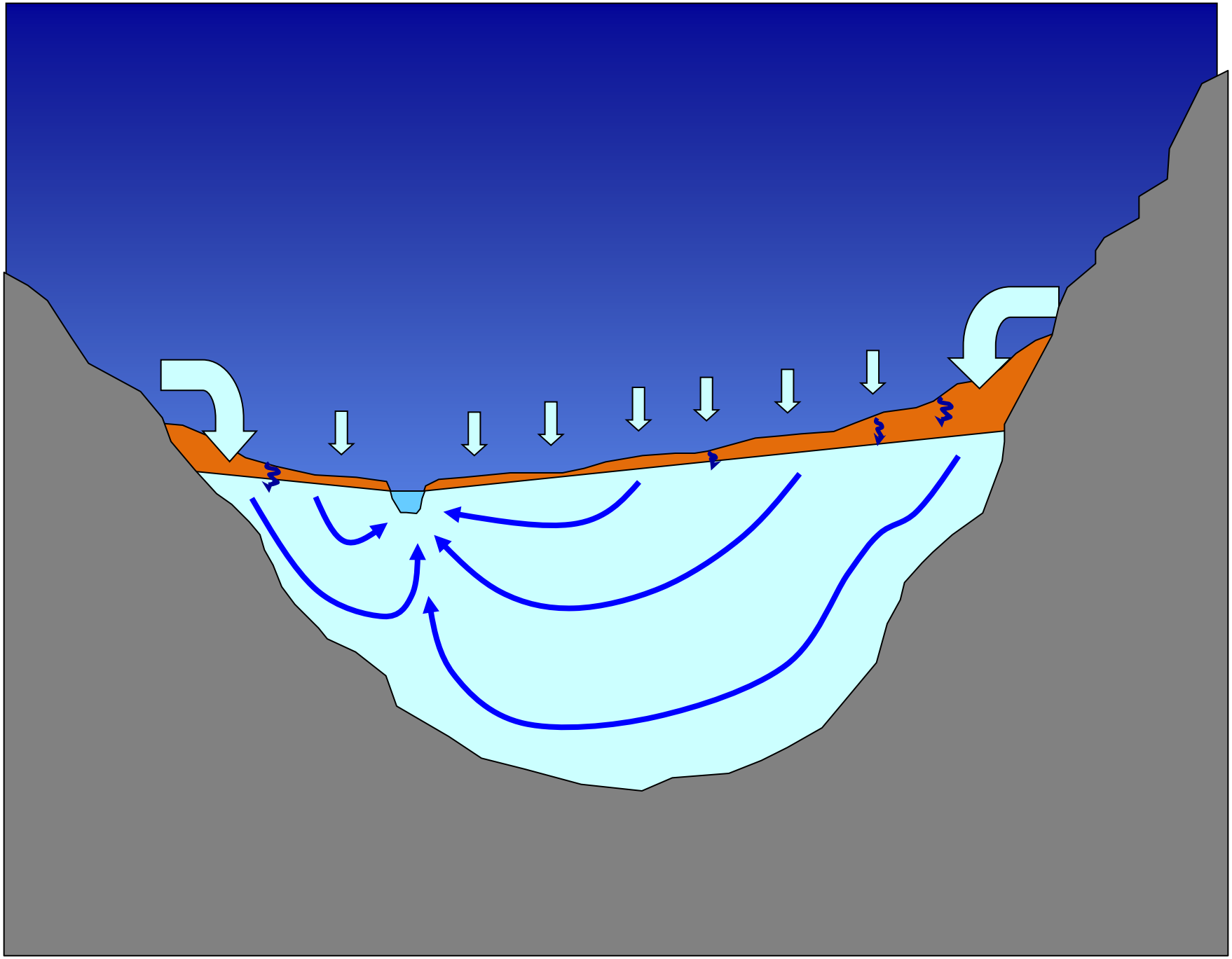


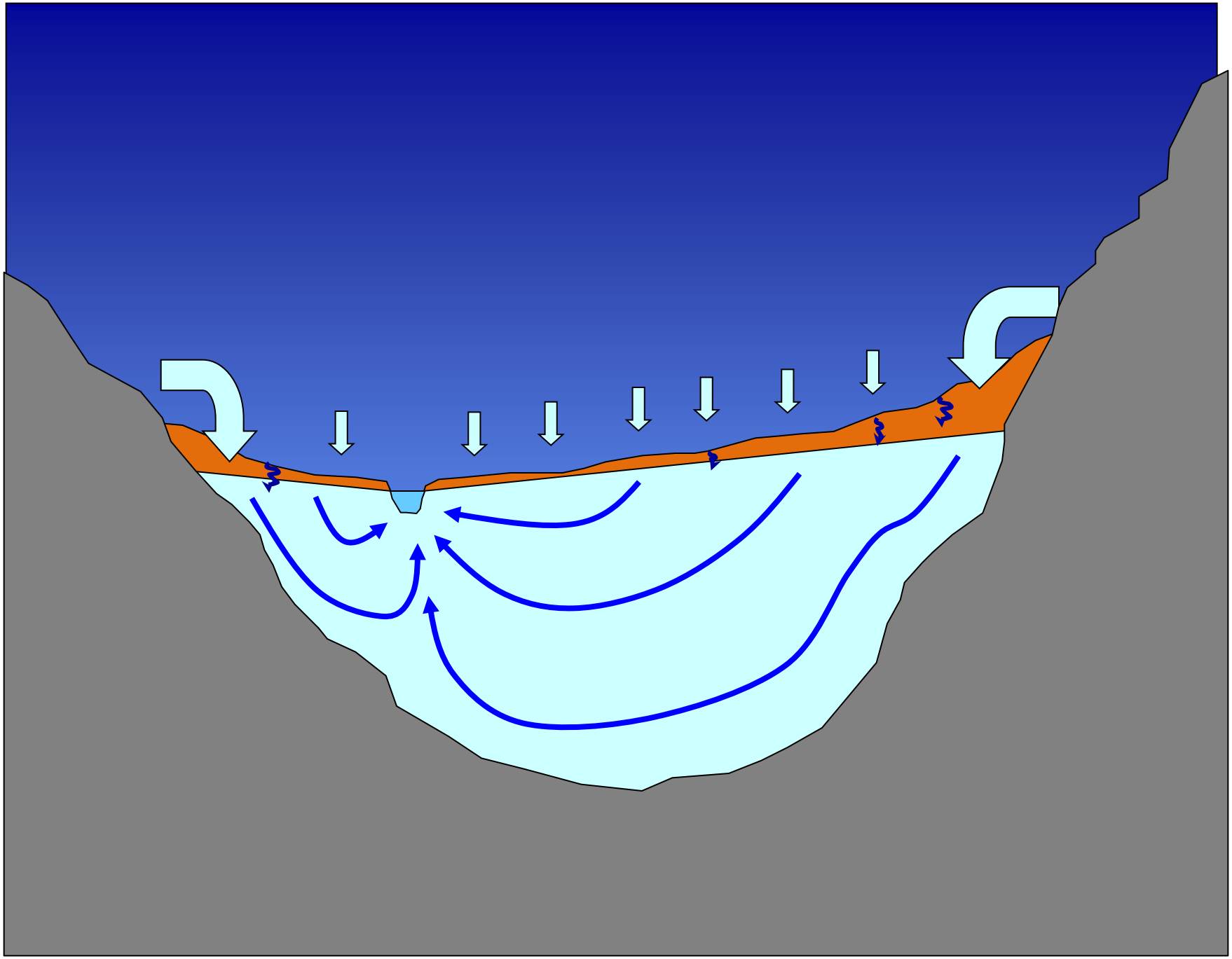


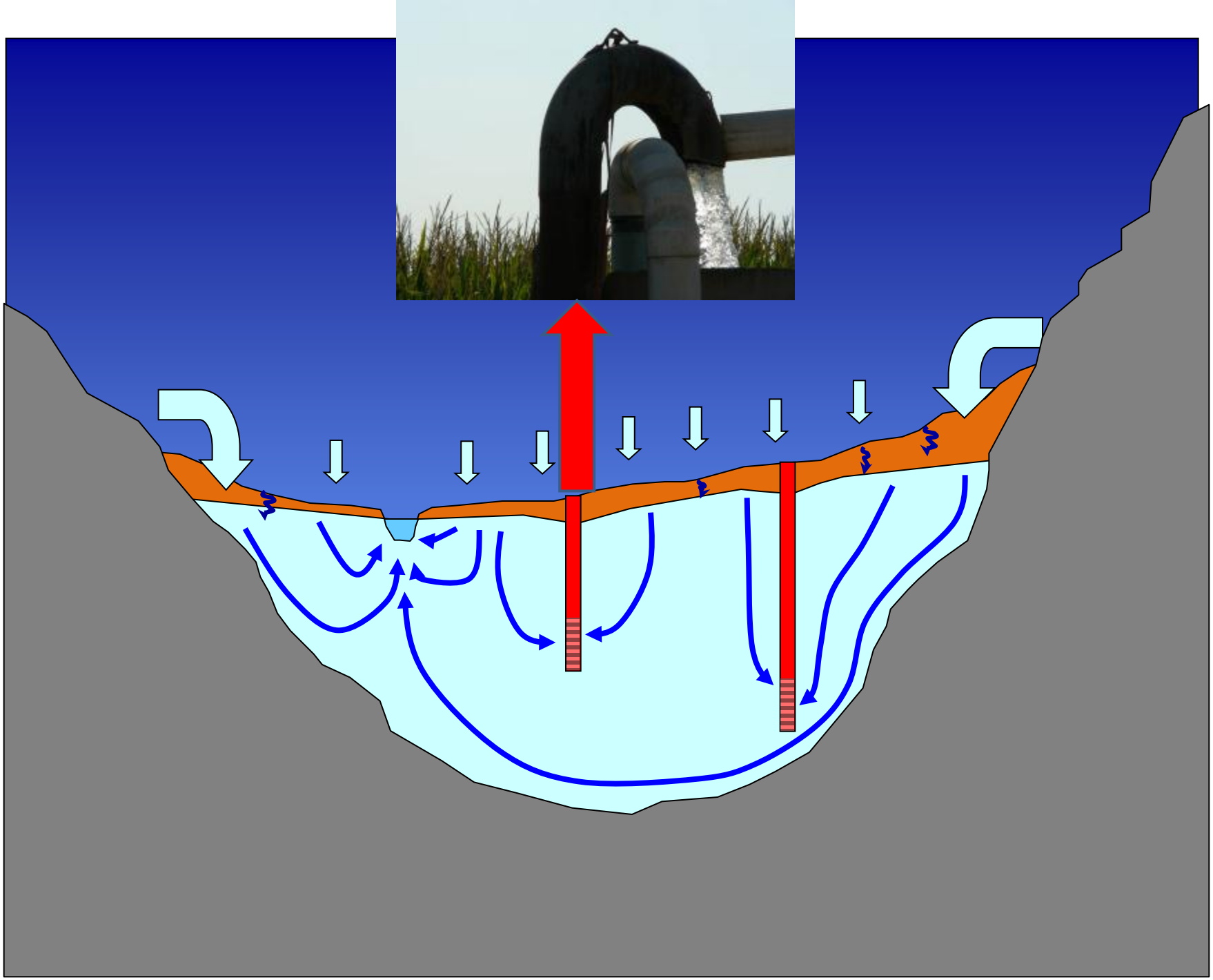


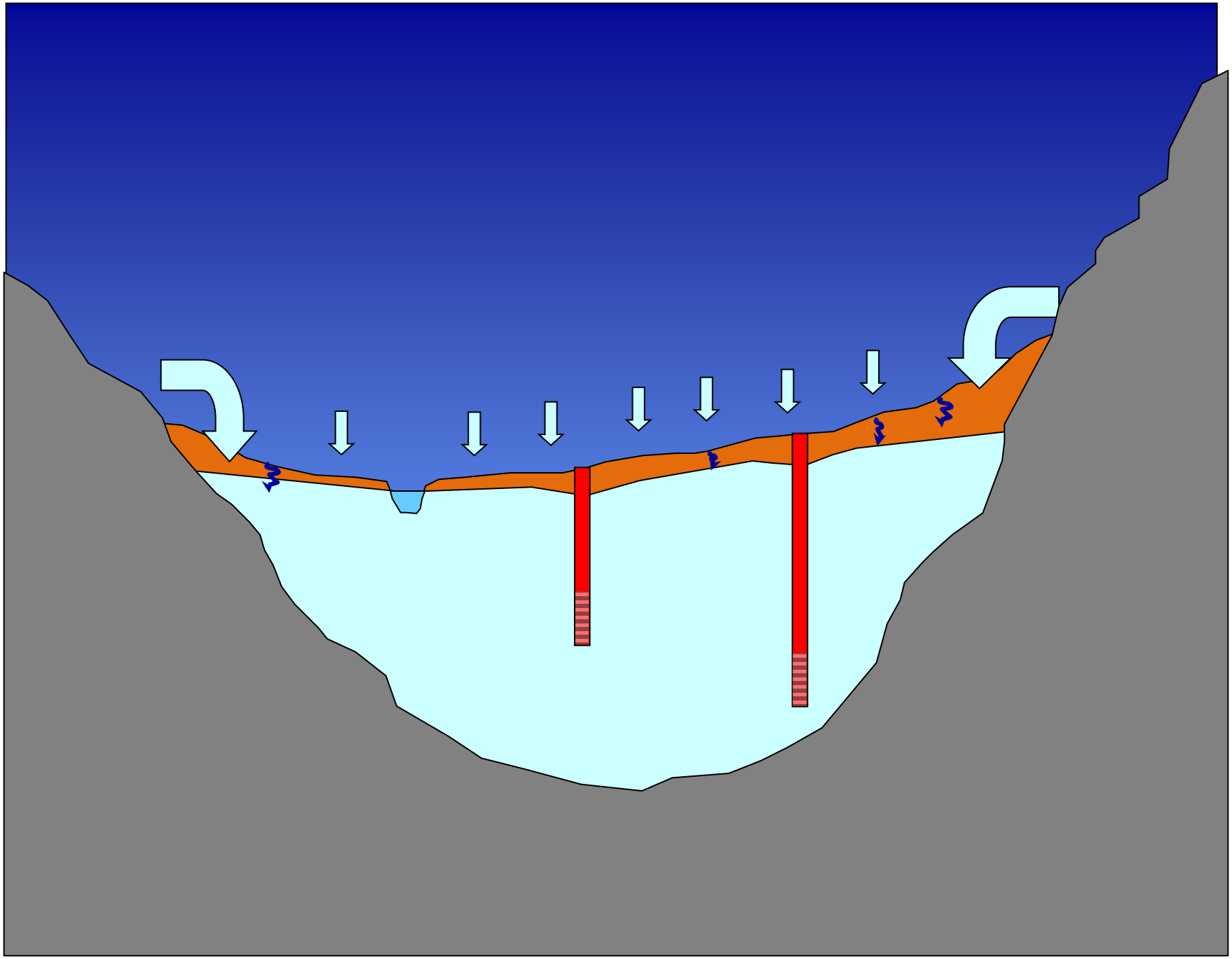


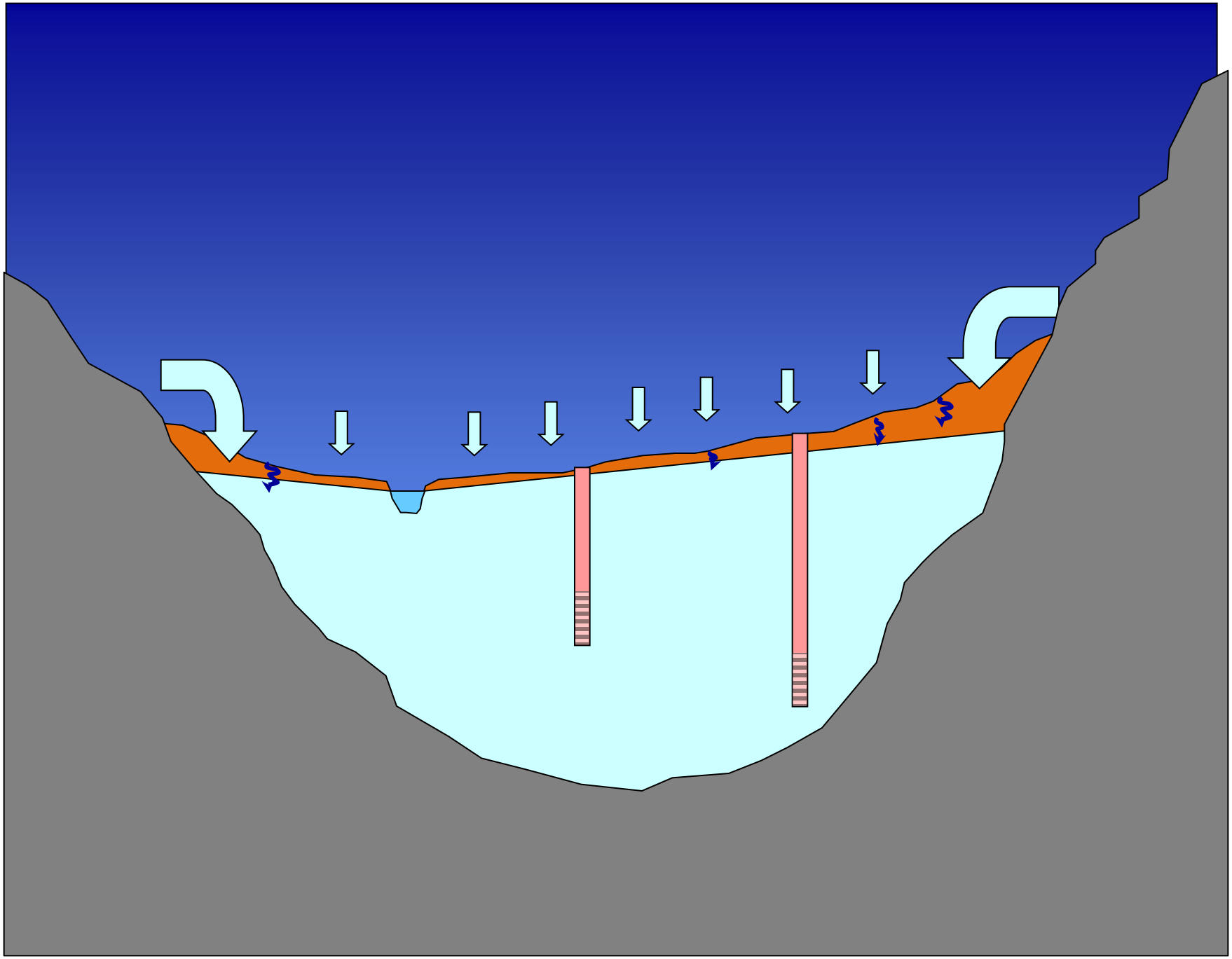


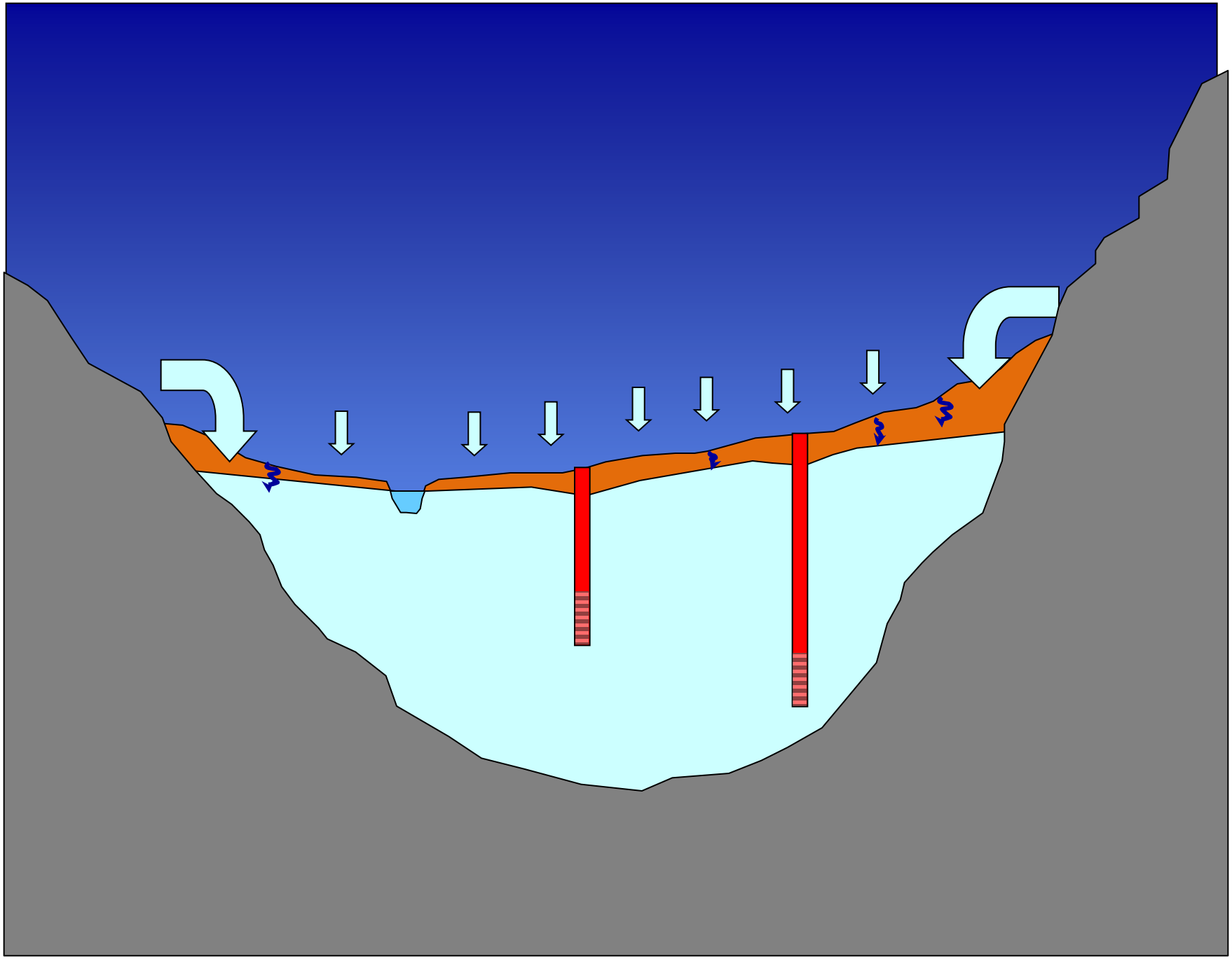


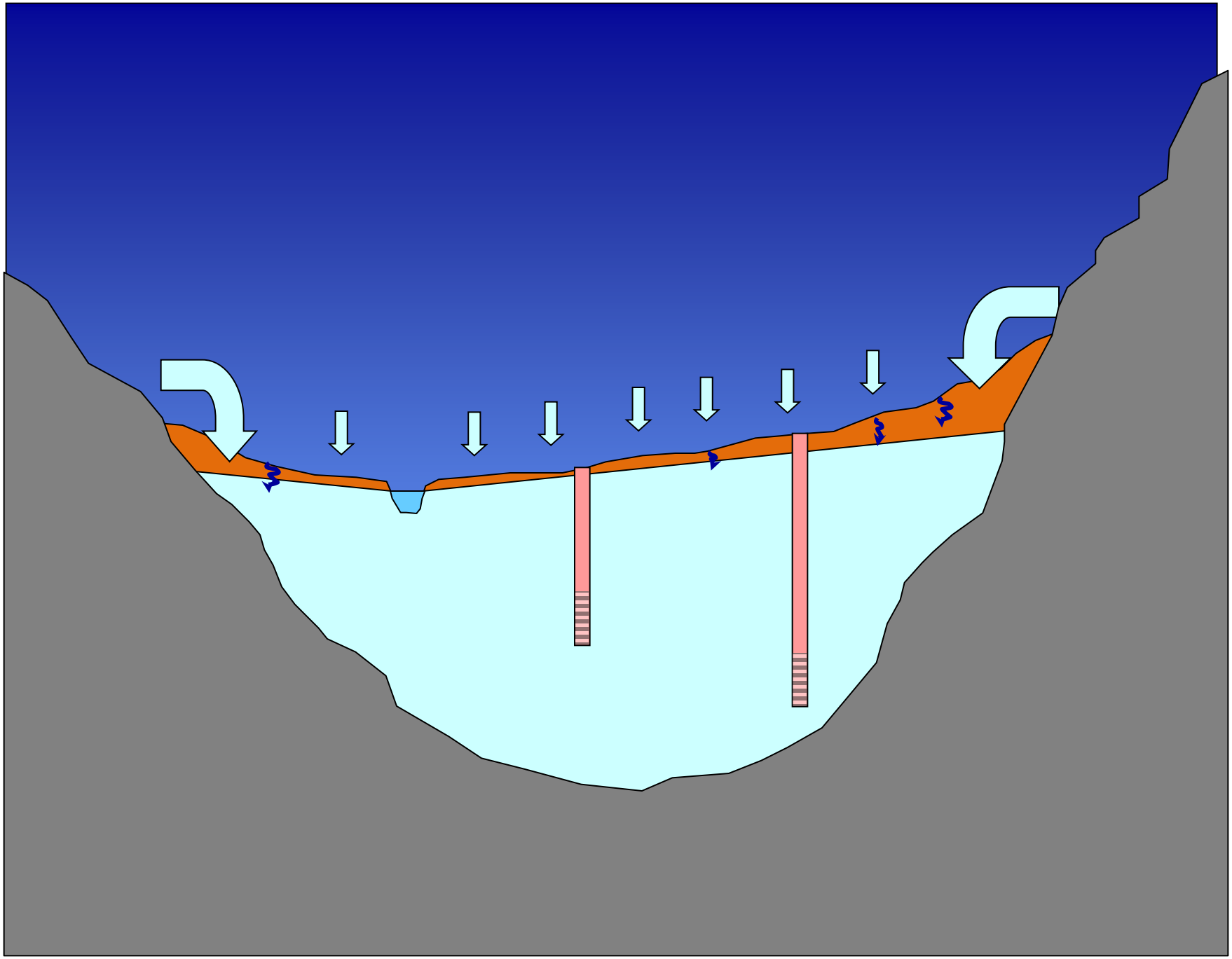


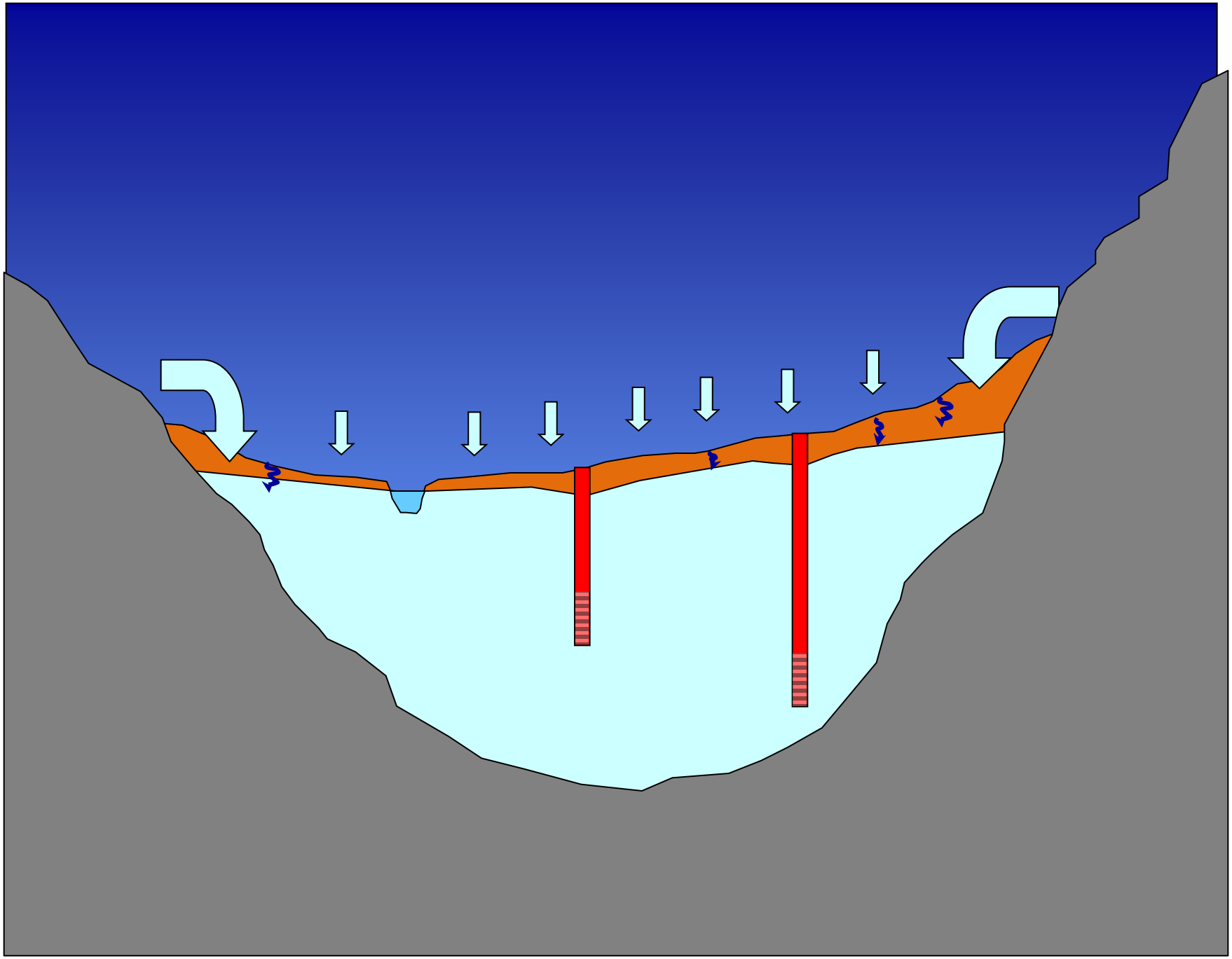


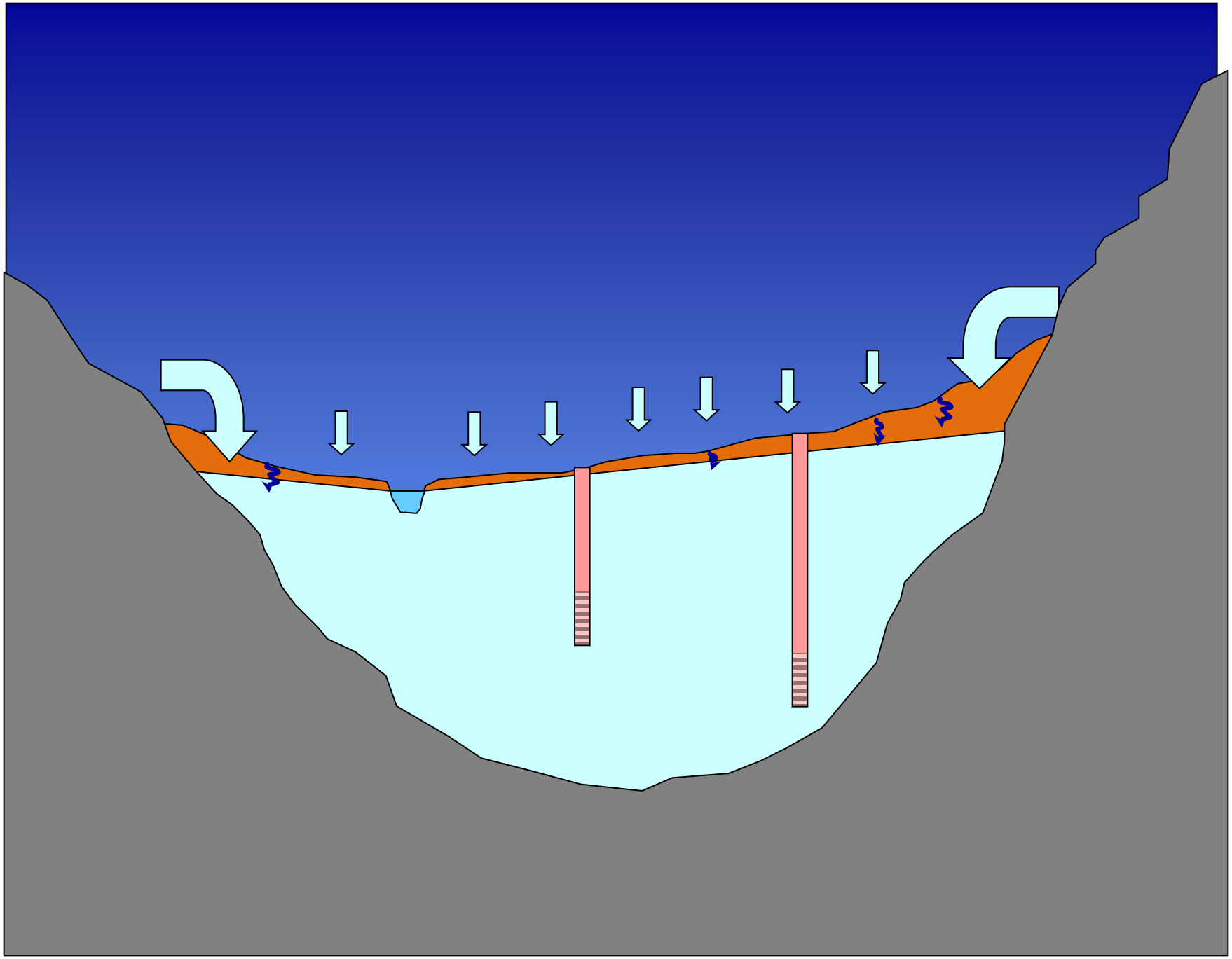


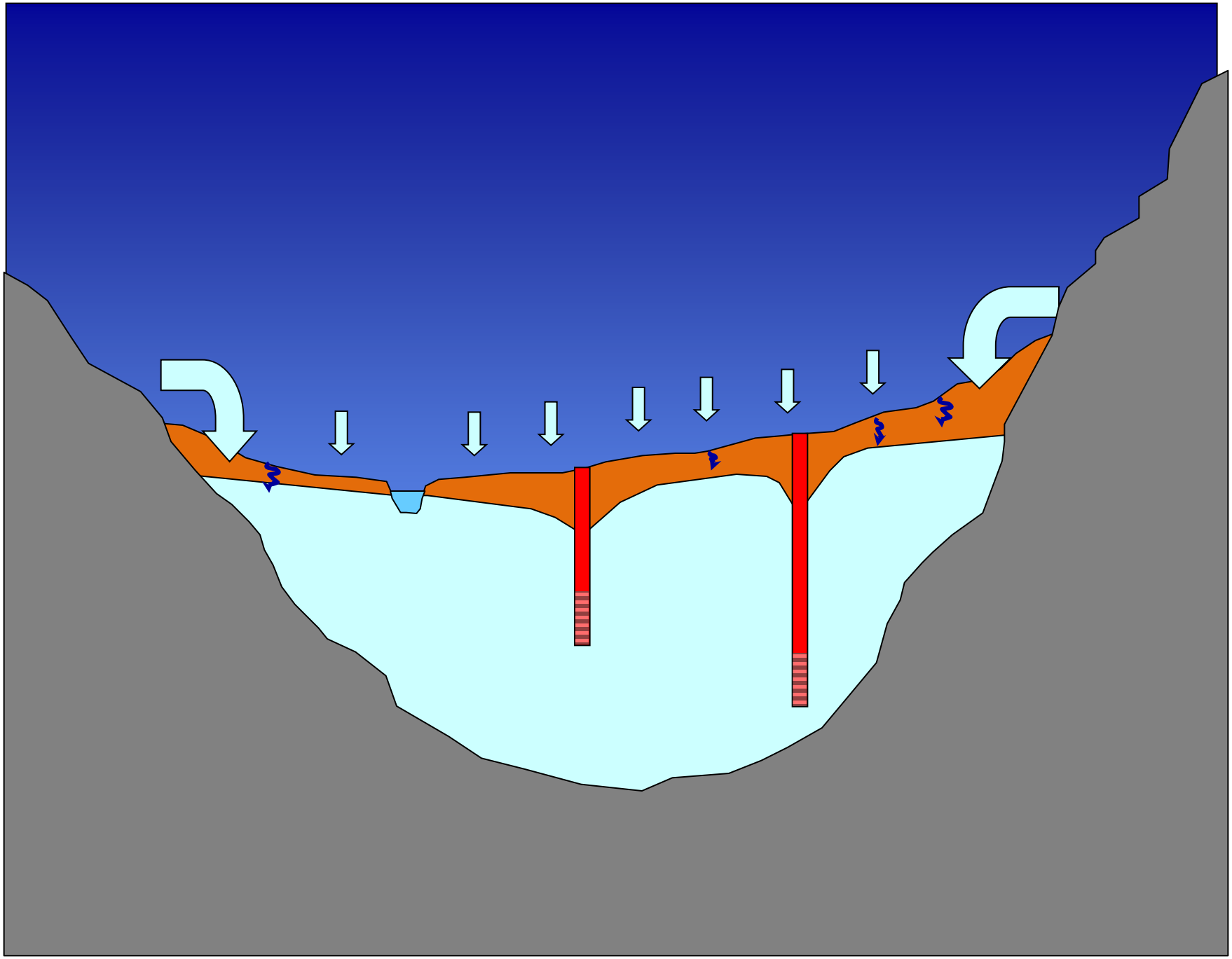


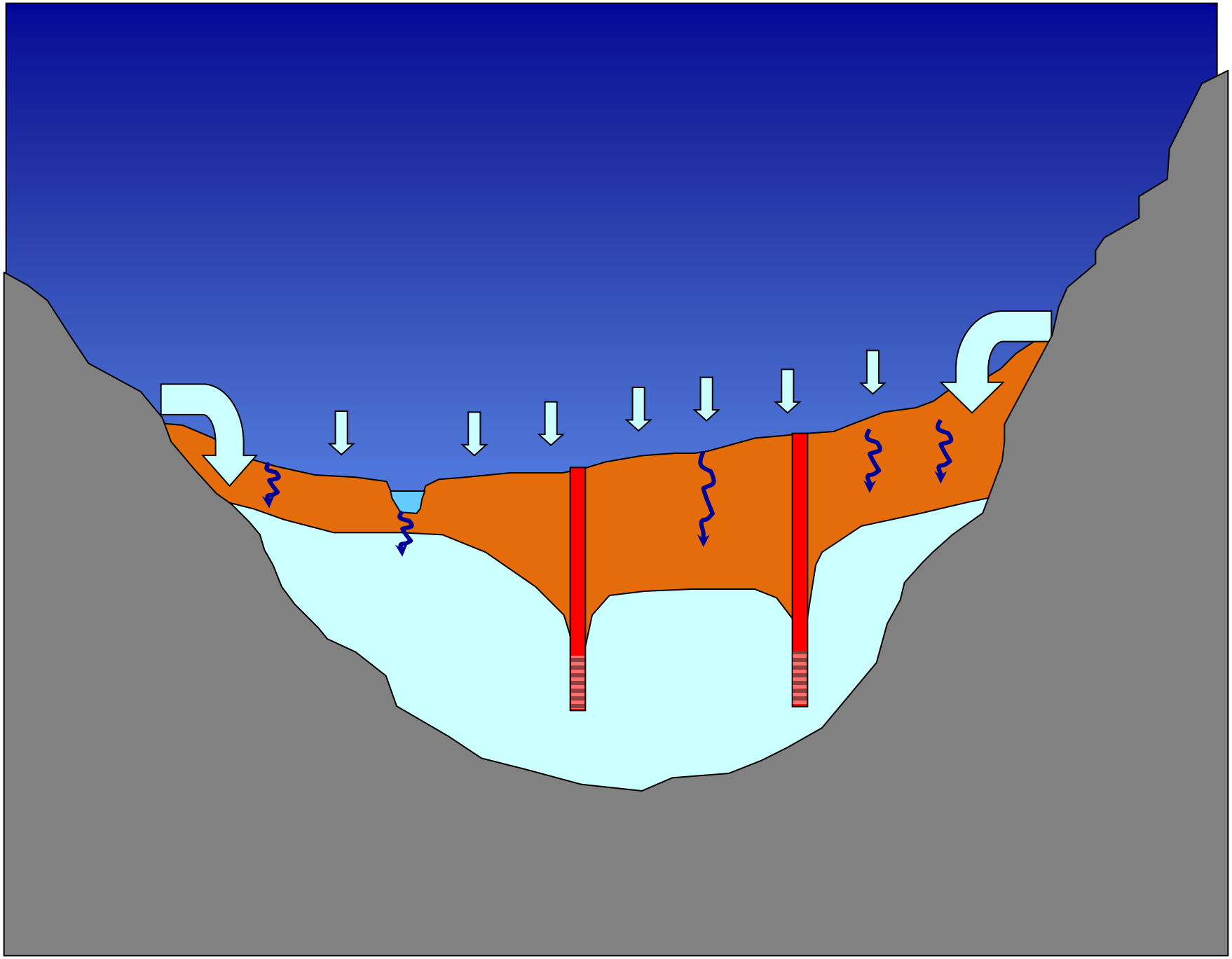


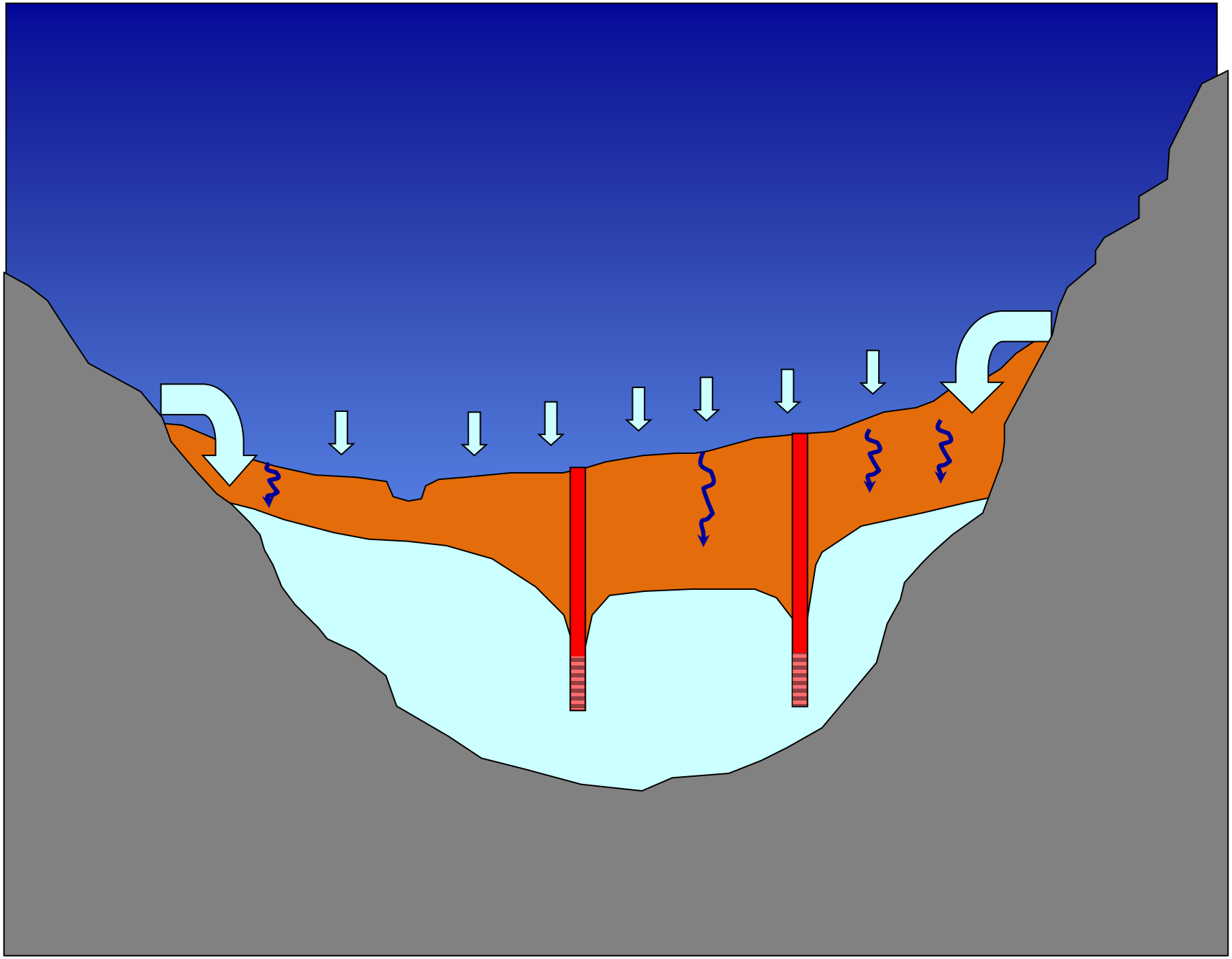












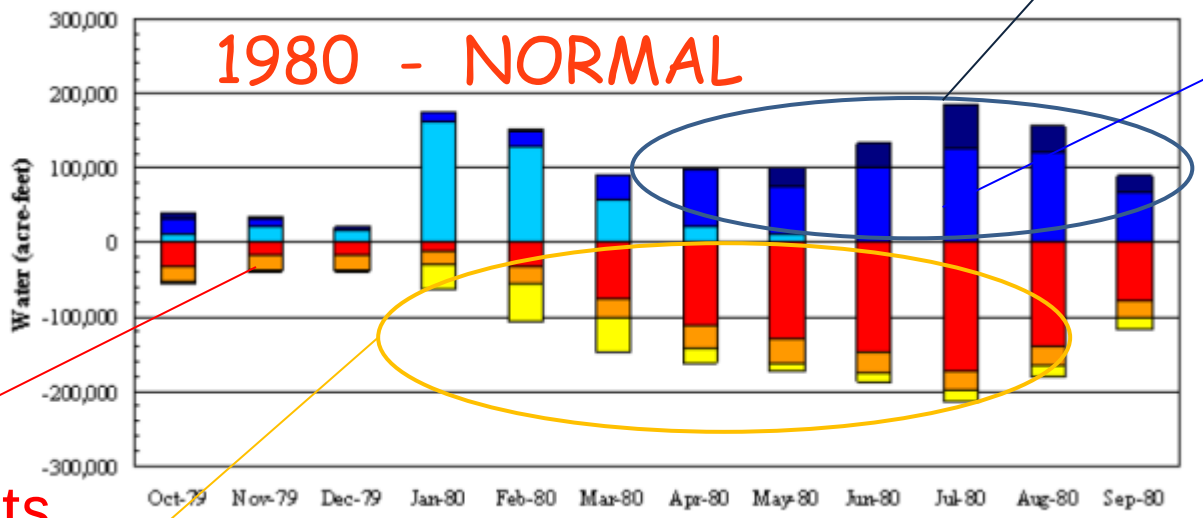
Monthly Landscape Water Budget
October – September

Tule River Basin, Tulare County

groundwater extraction

river water

rain



crops/plants

recharge

Ruud, Harter et al., 2003, 2004

Monthly Landscape Water Budget
October – September

Tule River Basin, Tulare County

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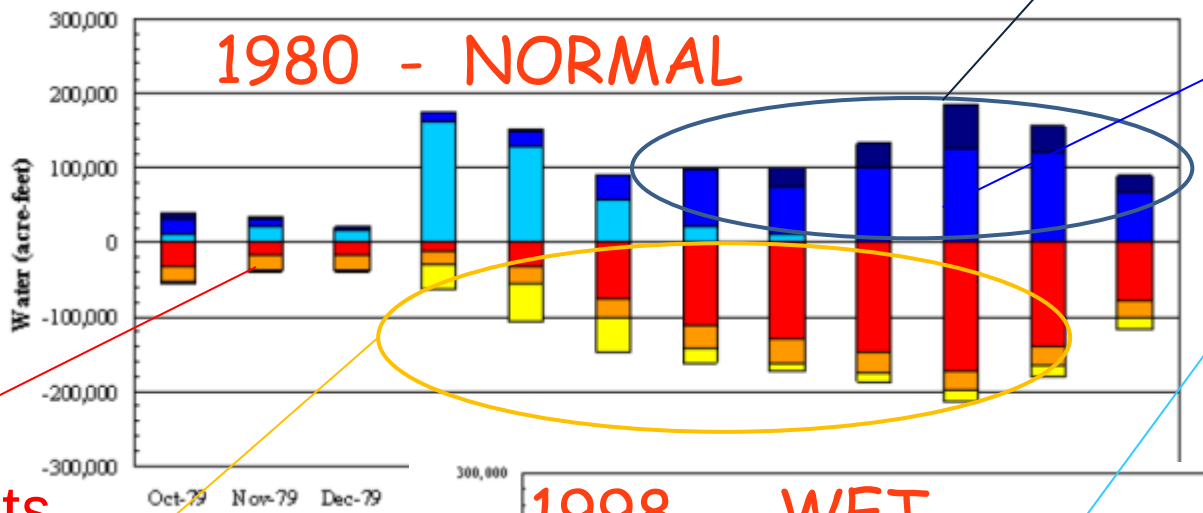

crops/plants

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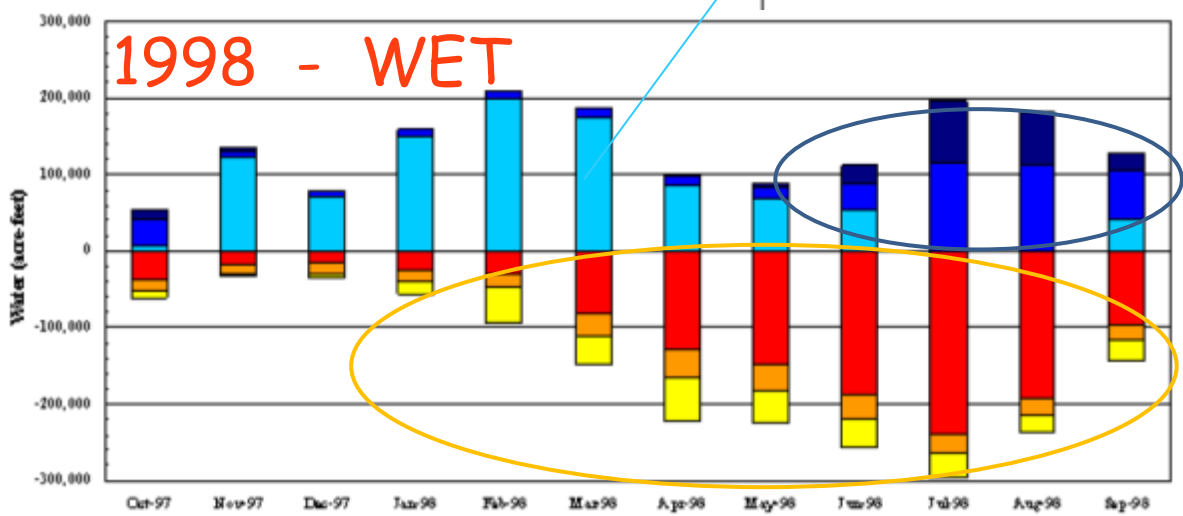
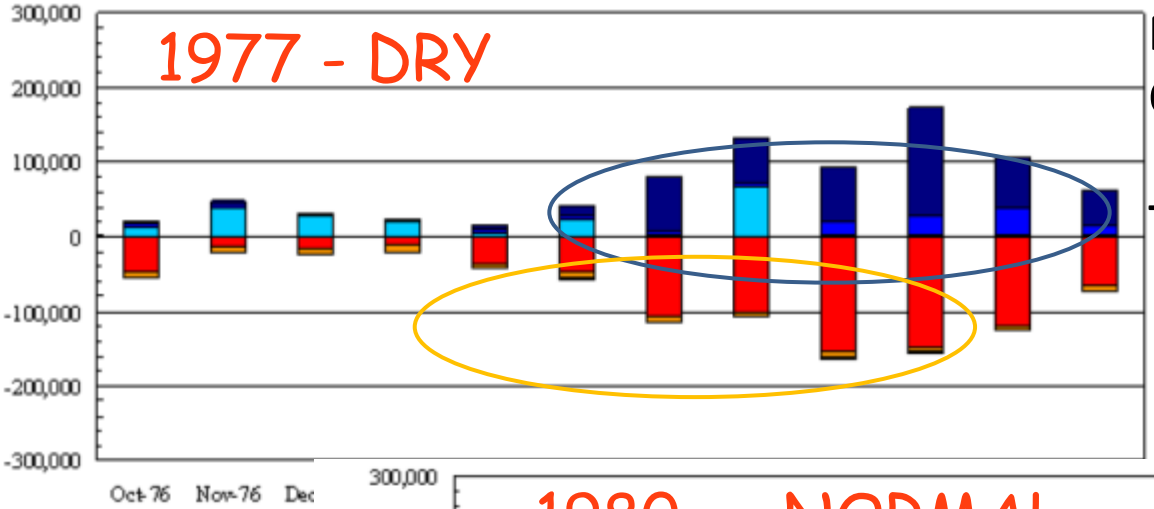
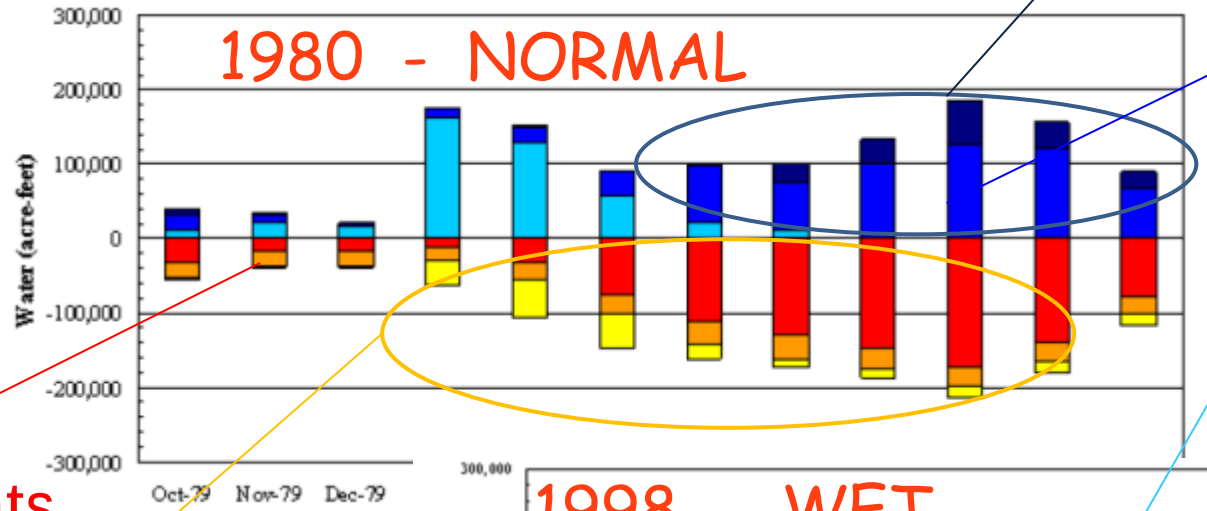


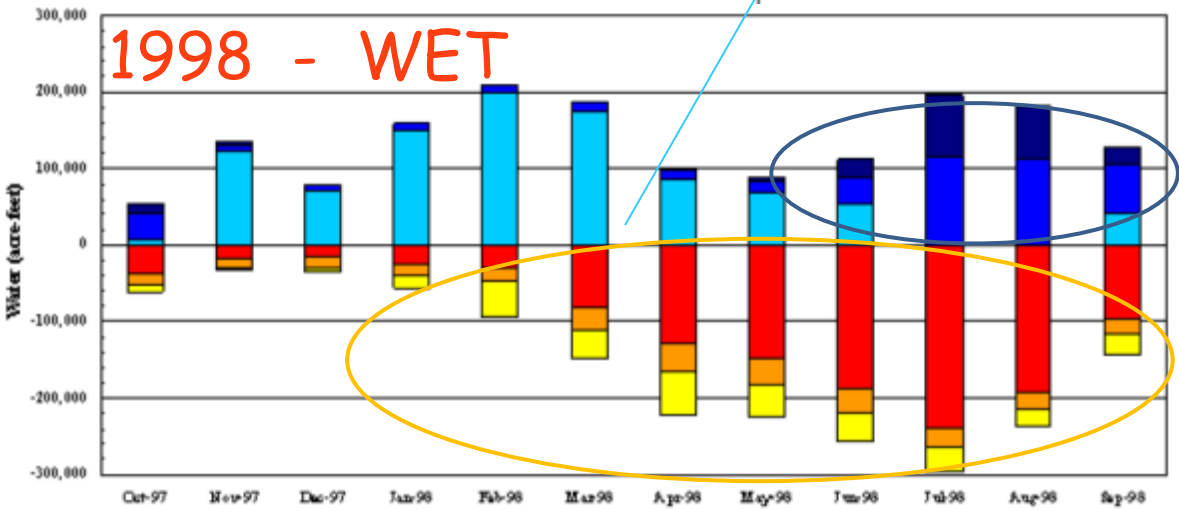
Ruud, Harter et al., 2003, 2004

Monthly Landscape Water Budget
October – September

Tule River Basin, Tulare County







groundwater extraction

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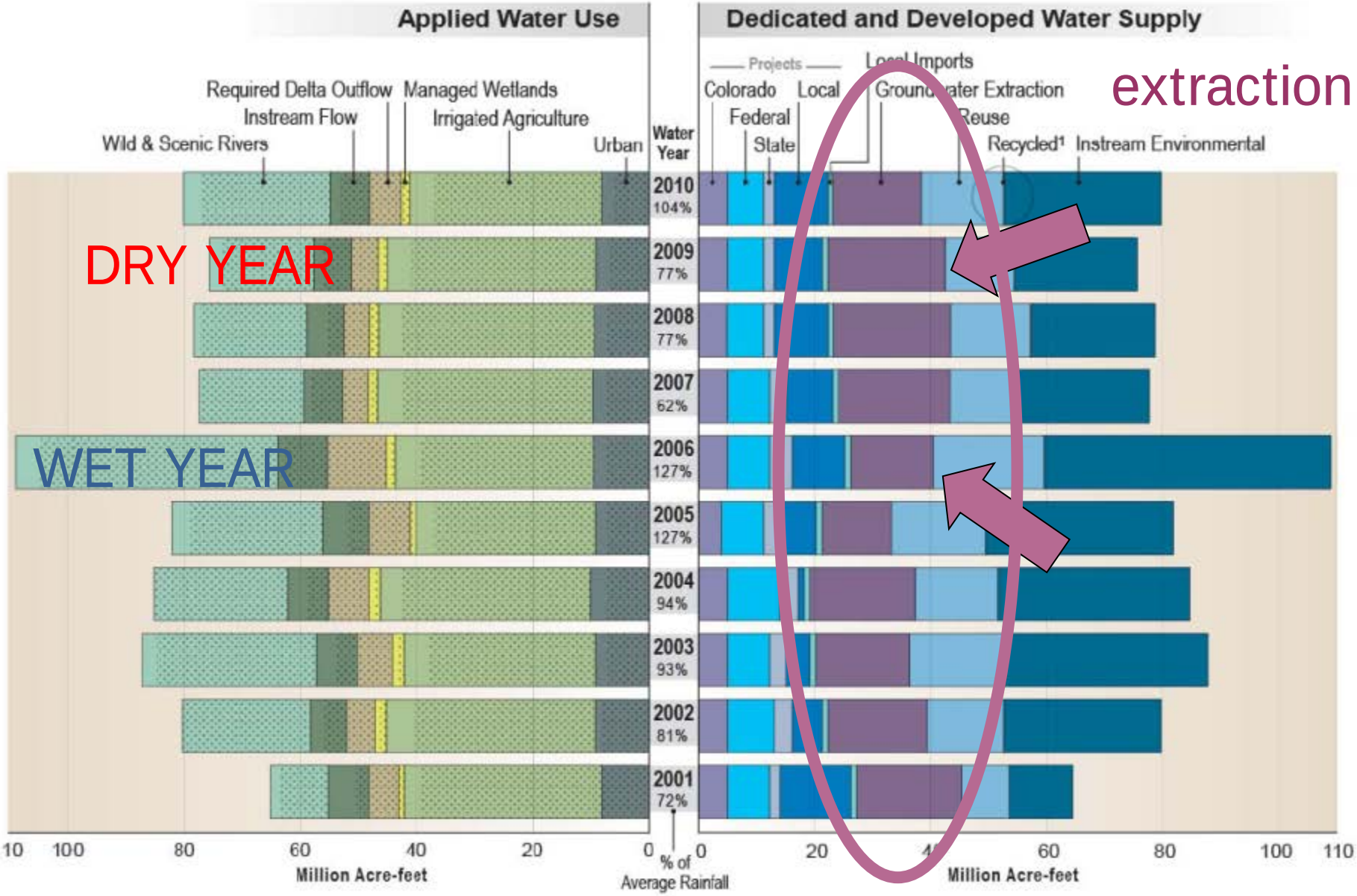
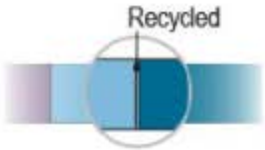
Ruud, Harter et al., 2003, 2004



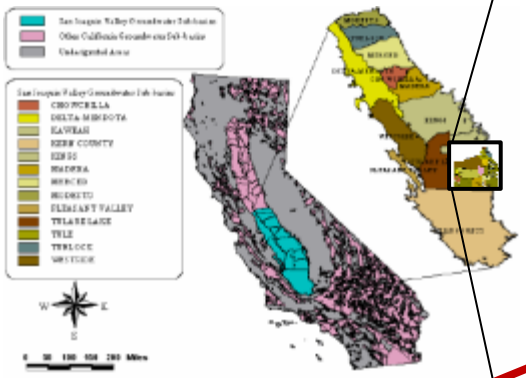
Stippling in bars **indicates depleted (irrecoverable) water use** *(water consumed through evapotranspiration, flowing to salt sinks like saline aquifers, or otherwise not available as a source of supply)*

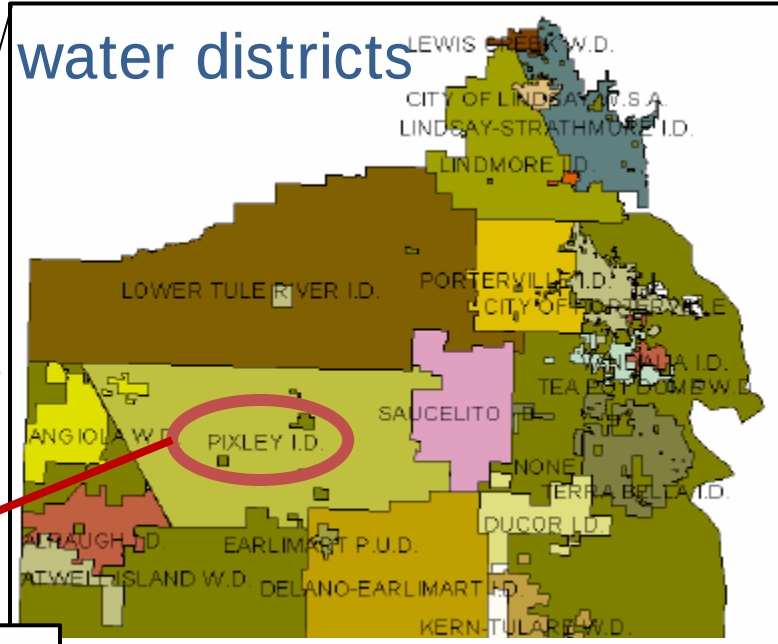


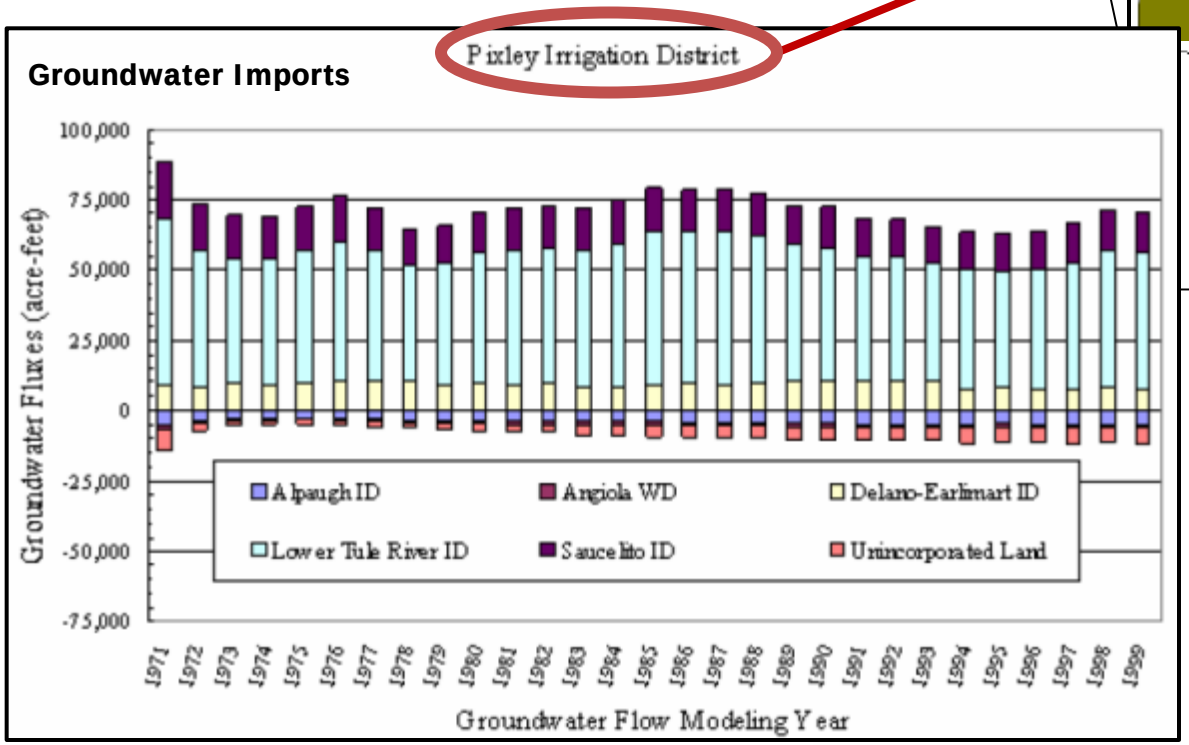
[1] **Detail of bar graph:** *For water years 2001-2010, recycled municipal water varied from 0.2 to 0.5 MAF of the water supply .*

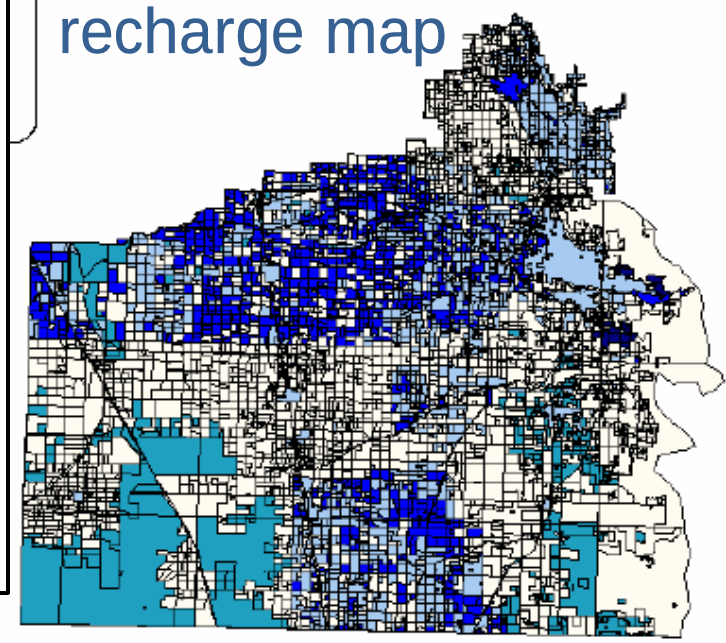
From: DWR California Water Plan 2013 - Draft (Bulletin 160-2013)

Estimating Groundwater Flows Across Subbasin / Political Boundaries



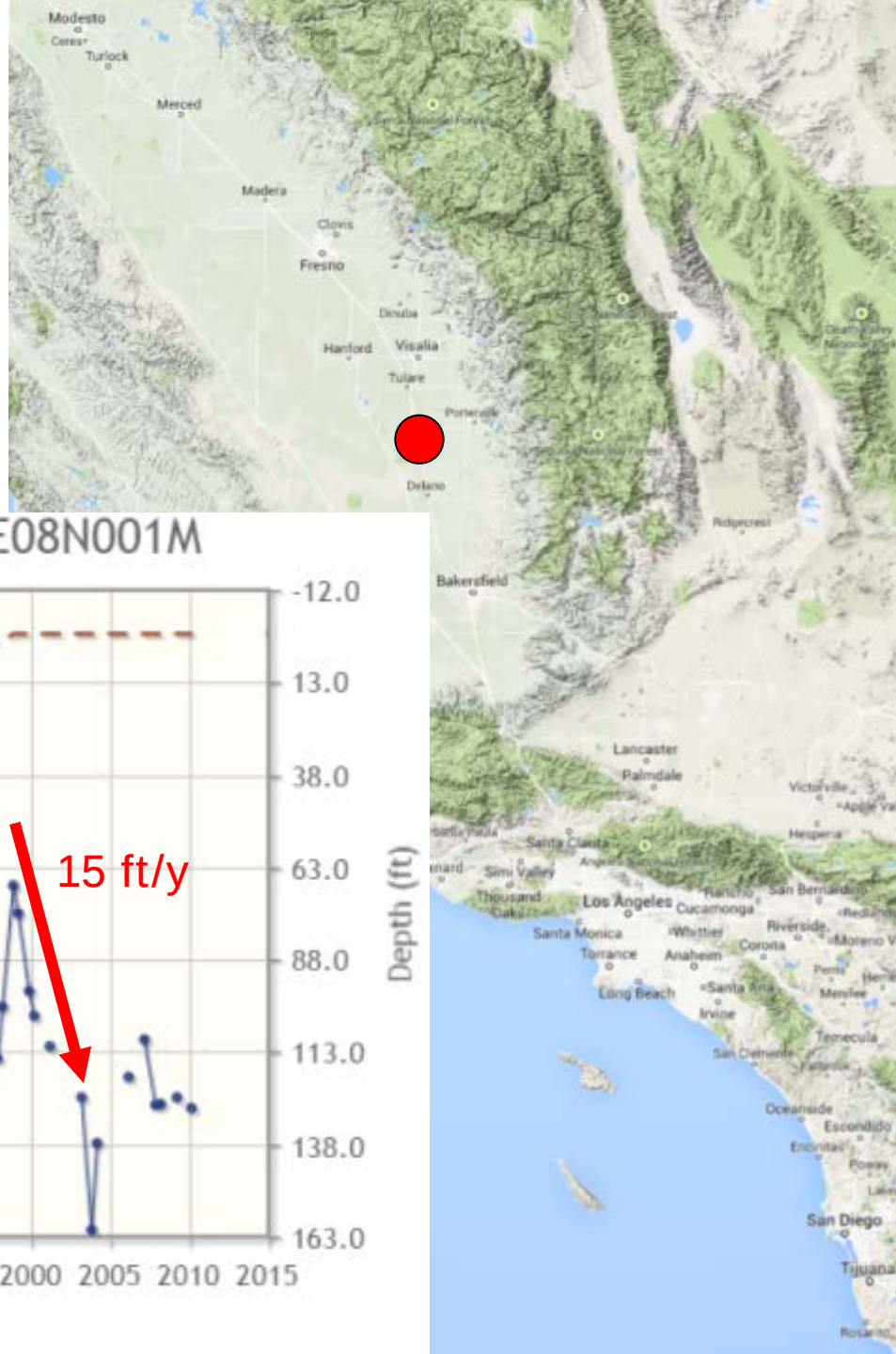


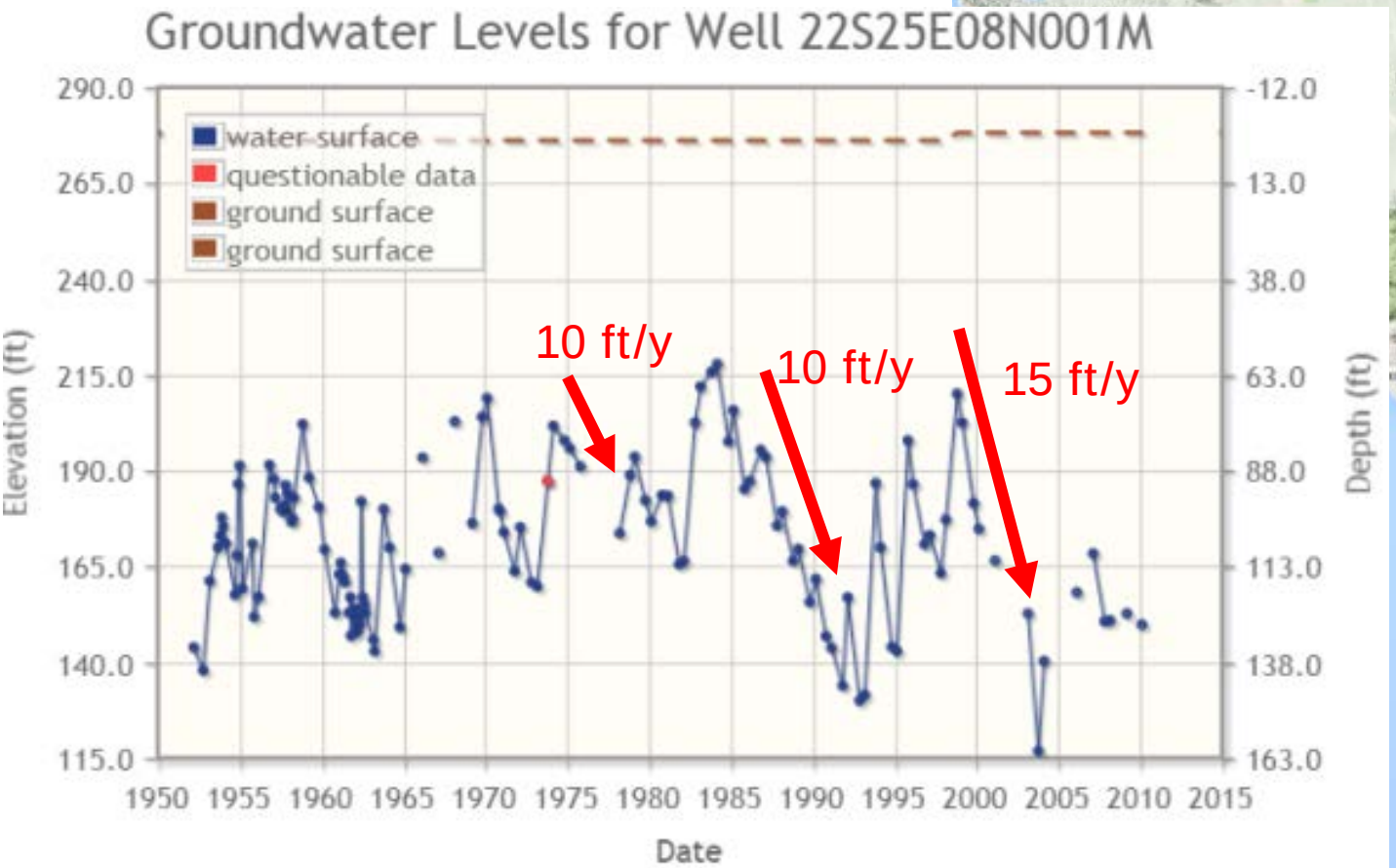




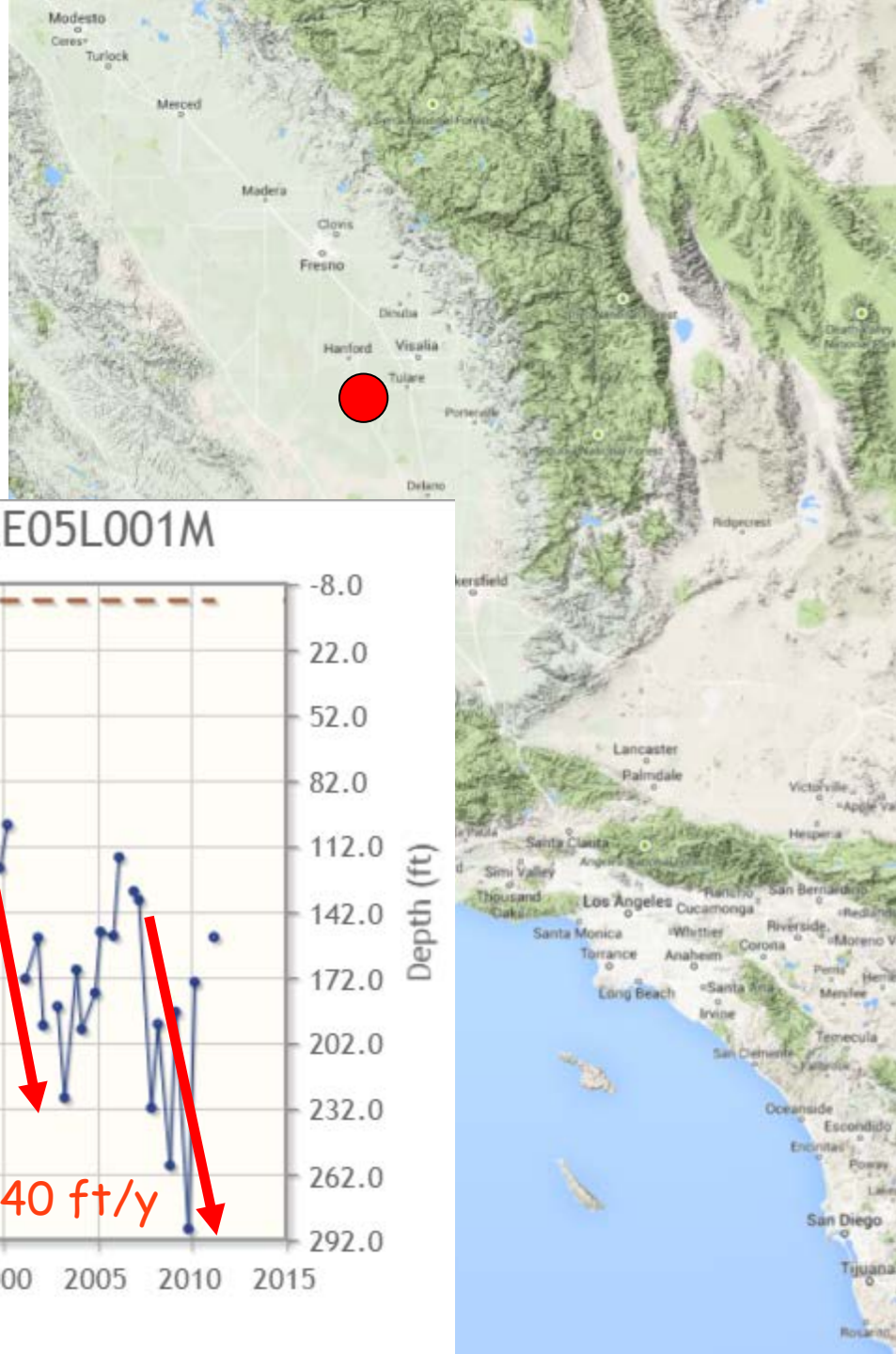
Ruud et al,. 2003; http://groundwater.ucdavis.edu/files/136420.pdf

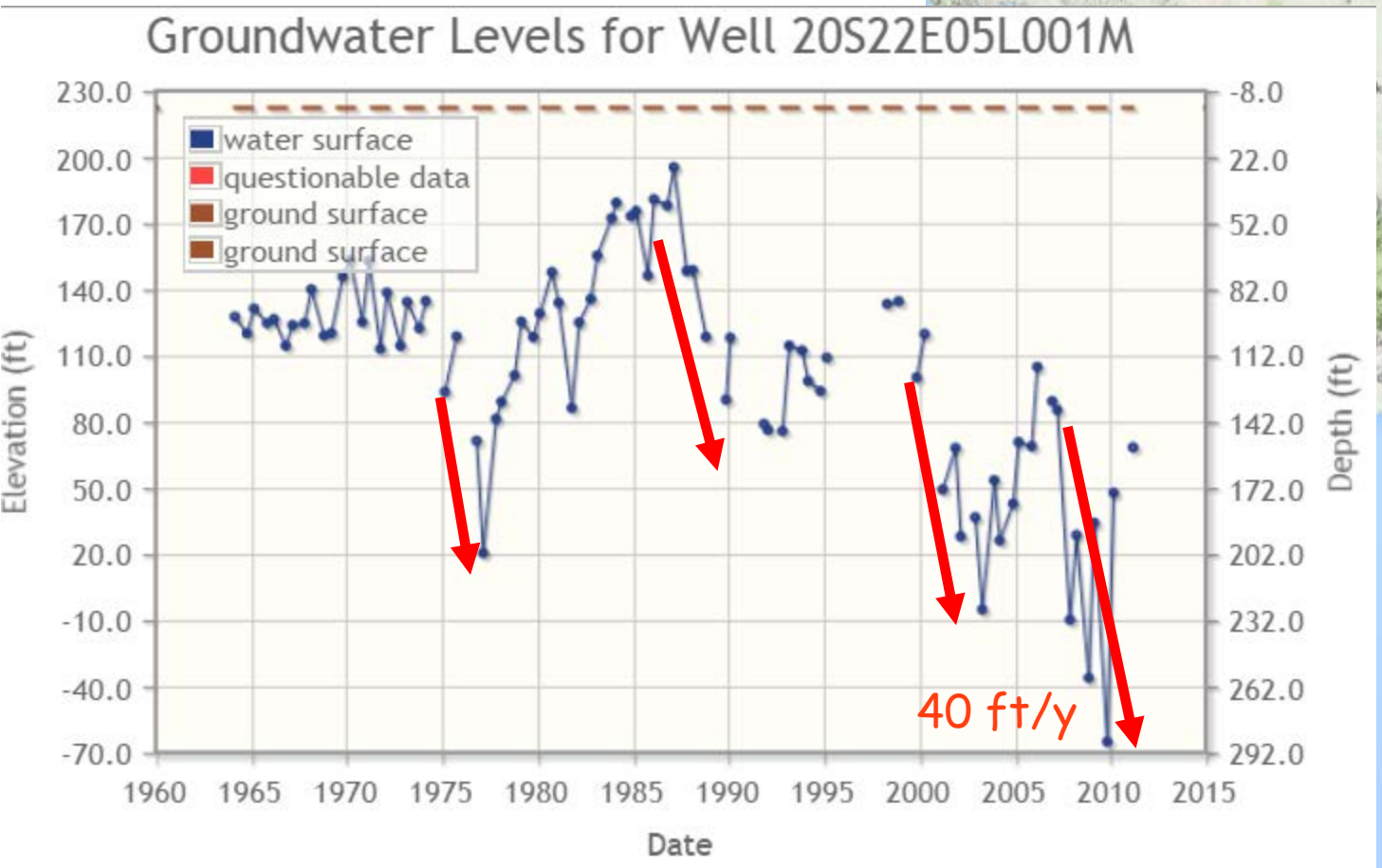
Groundwater Levels during Drought

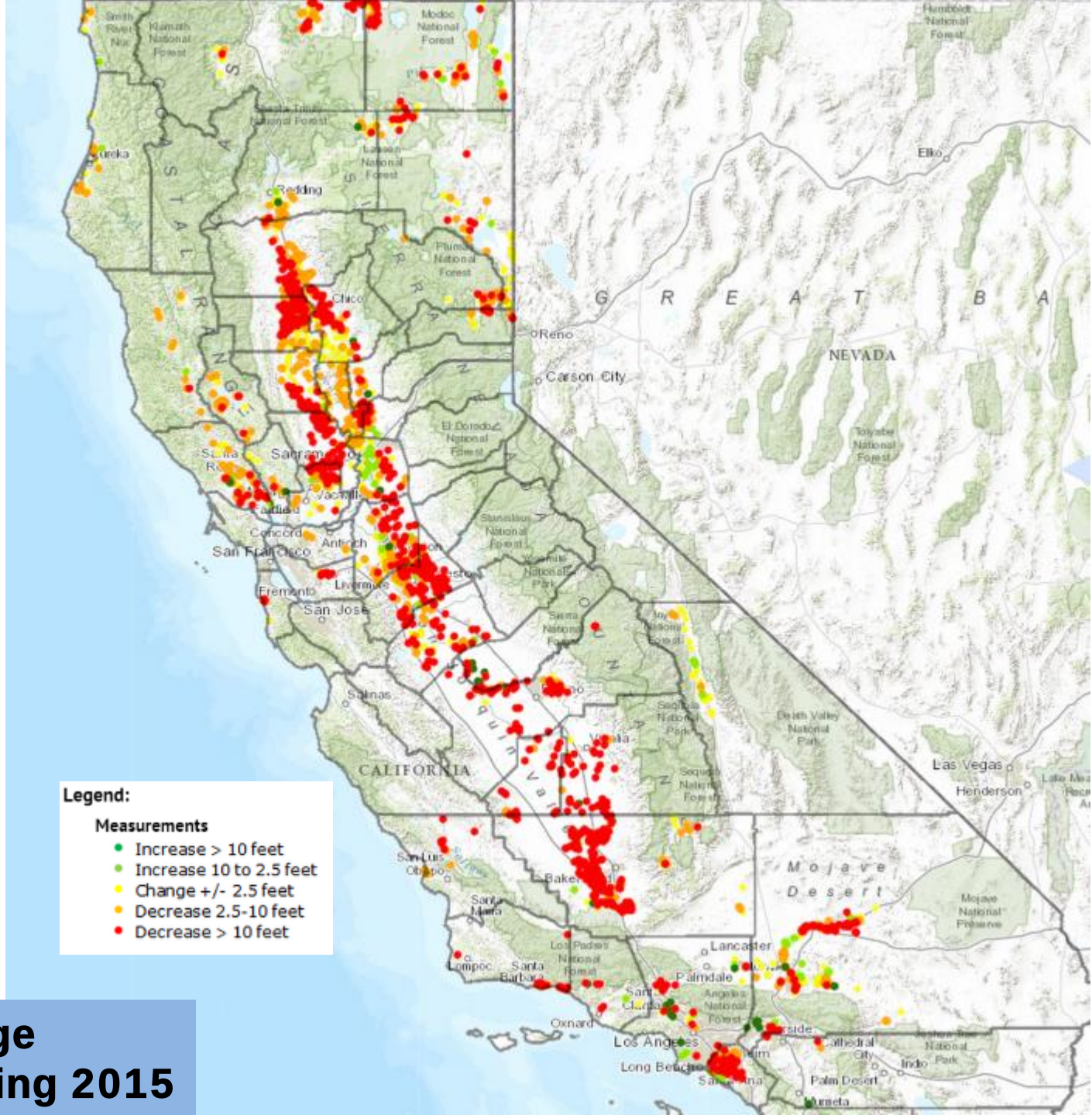




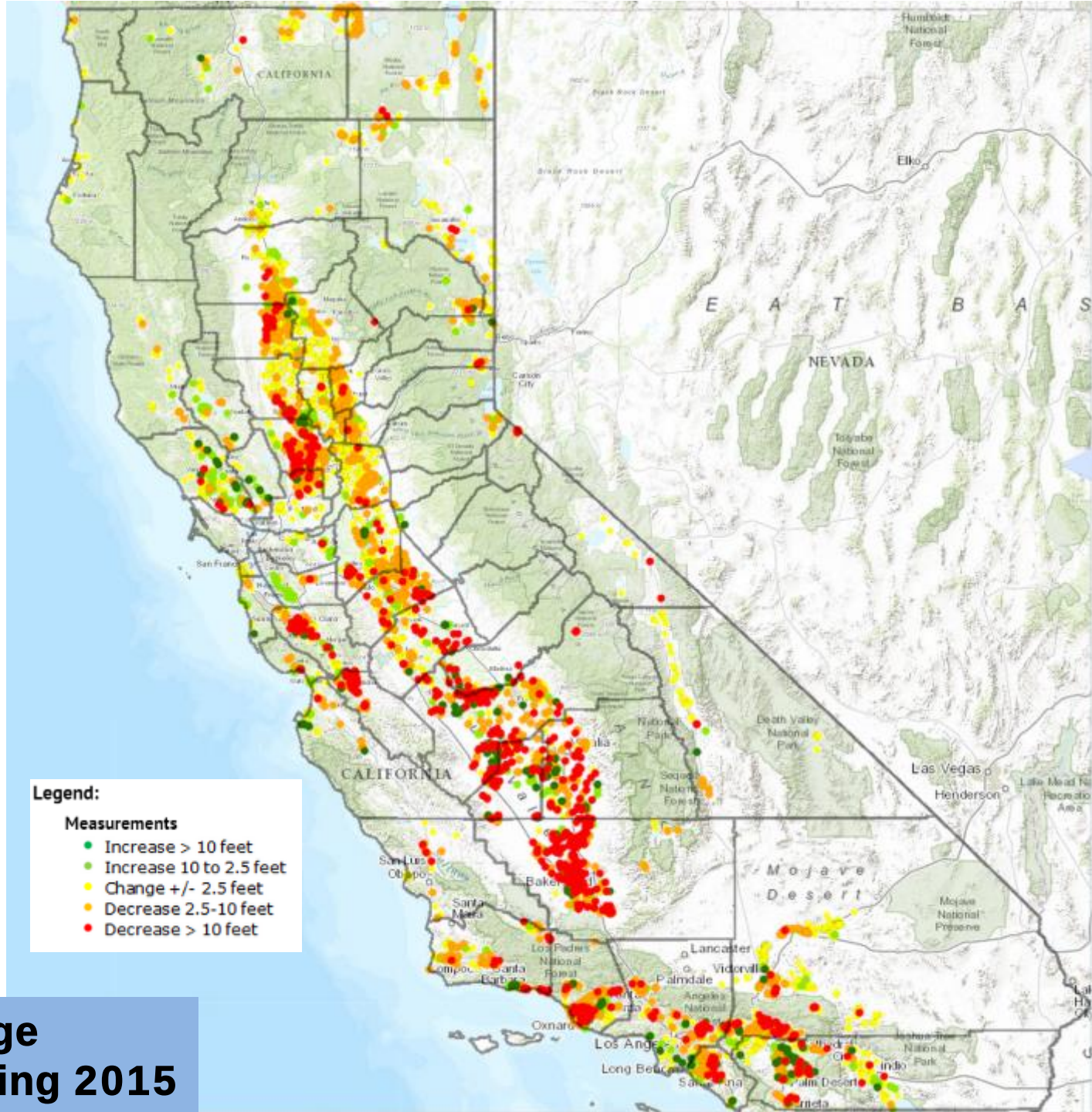
Groundwater Levels during Drought







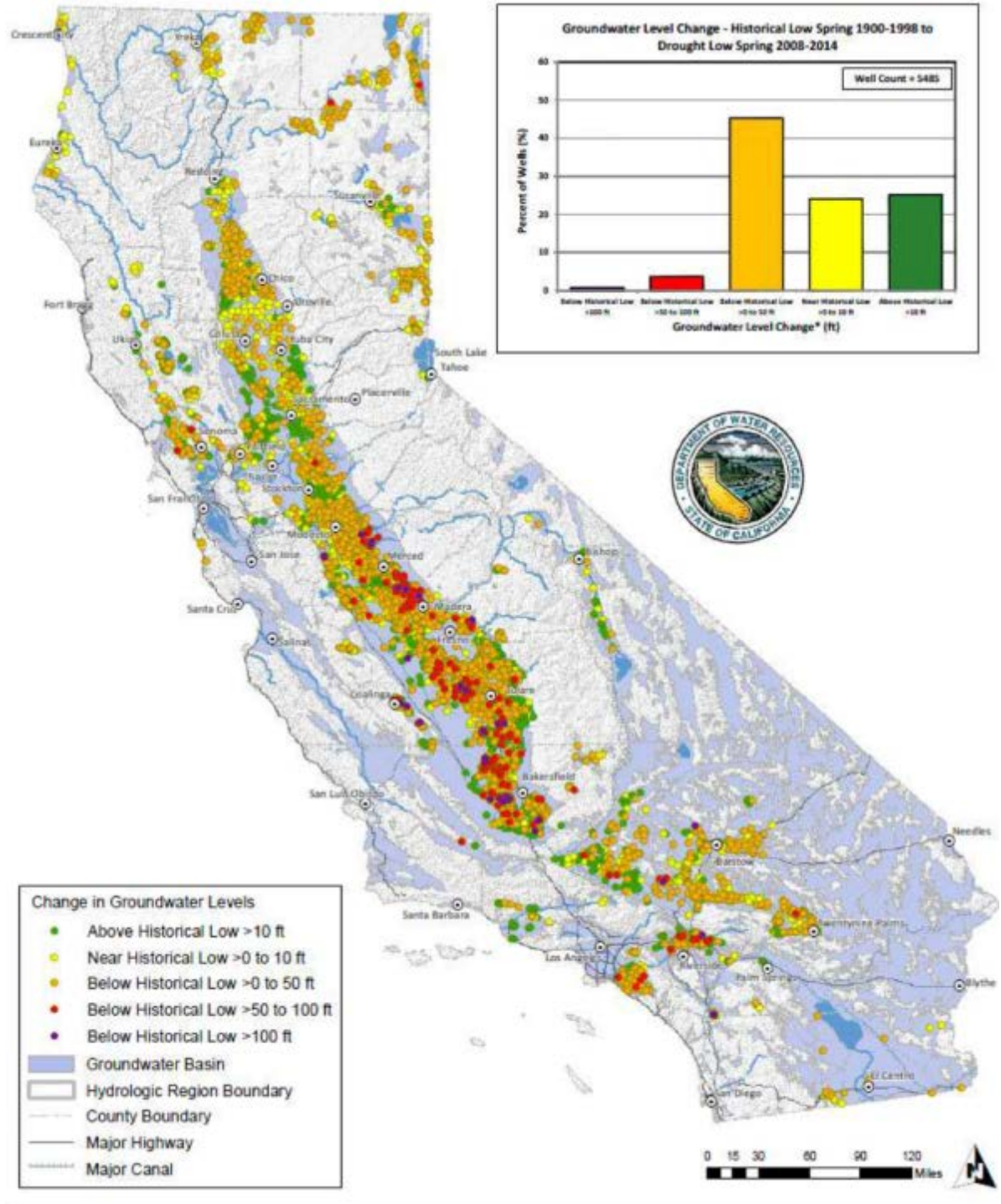
Water Level Change
Spring 2005 – Spring 2015



Water Level Change
Spring 2014 – Spring 2015

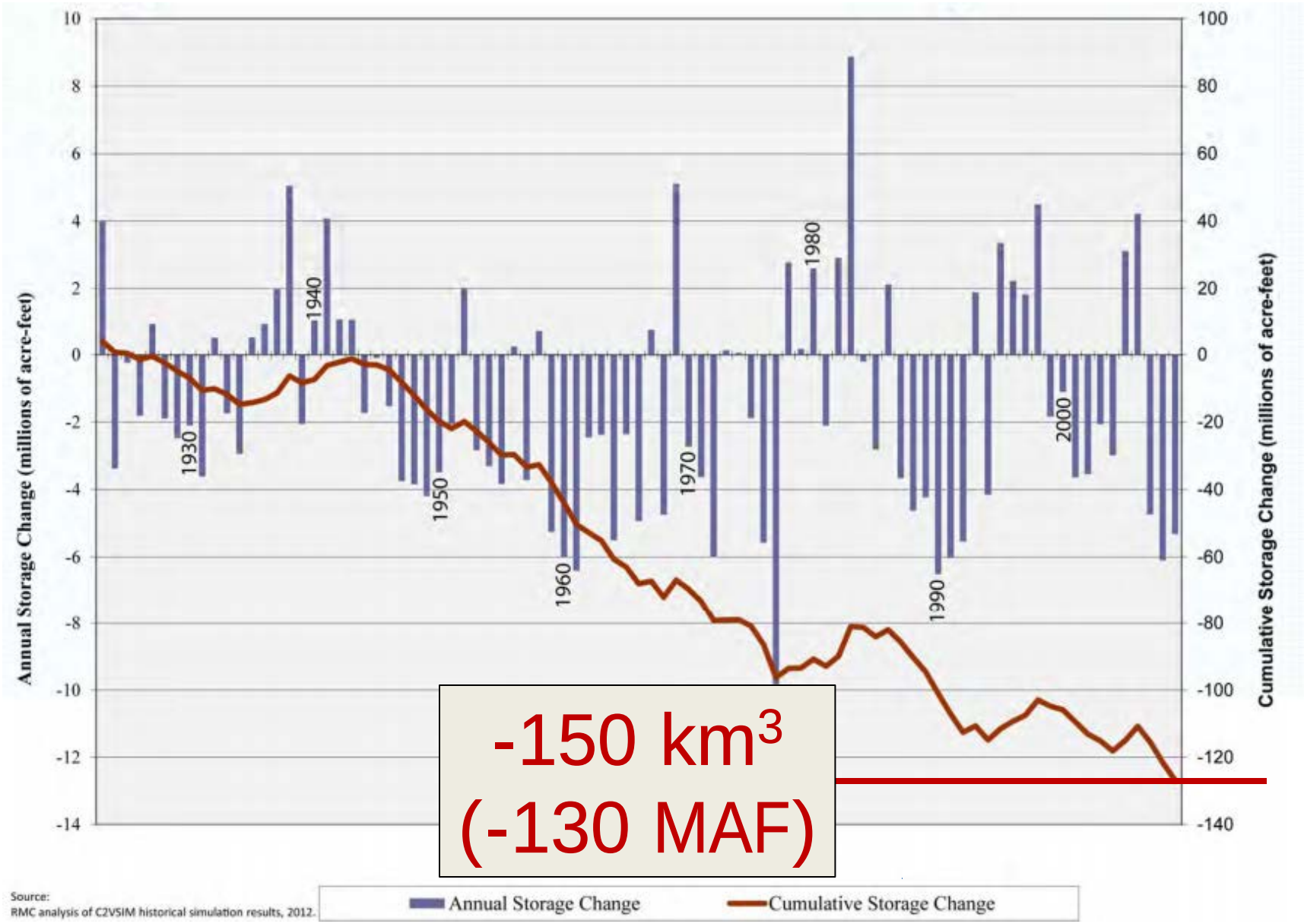
Change in Groundwater Level

Record Low 20th Century to Drought 2008-2014



http://www.water.ca.gov/waterconditions/docs/Drought_Response-Groundwater_Basins_April30_Final_BC.pdf

Change in Groundwater Storage in the Central Valley, 1920 - 2010

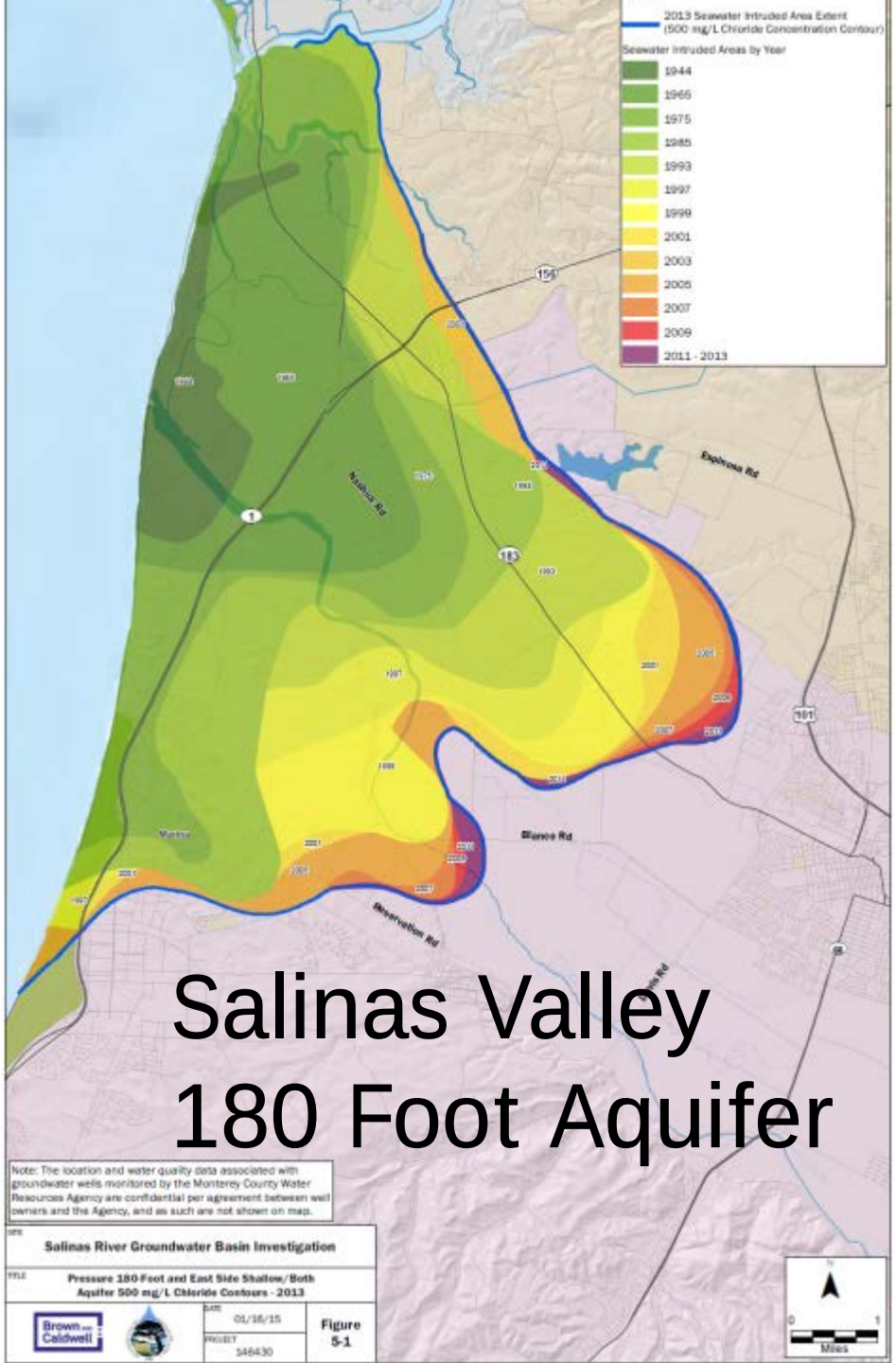


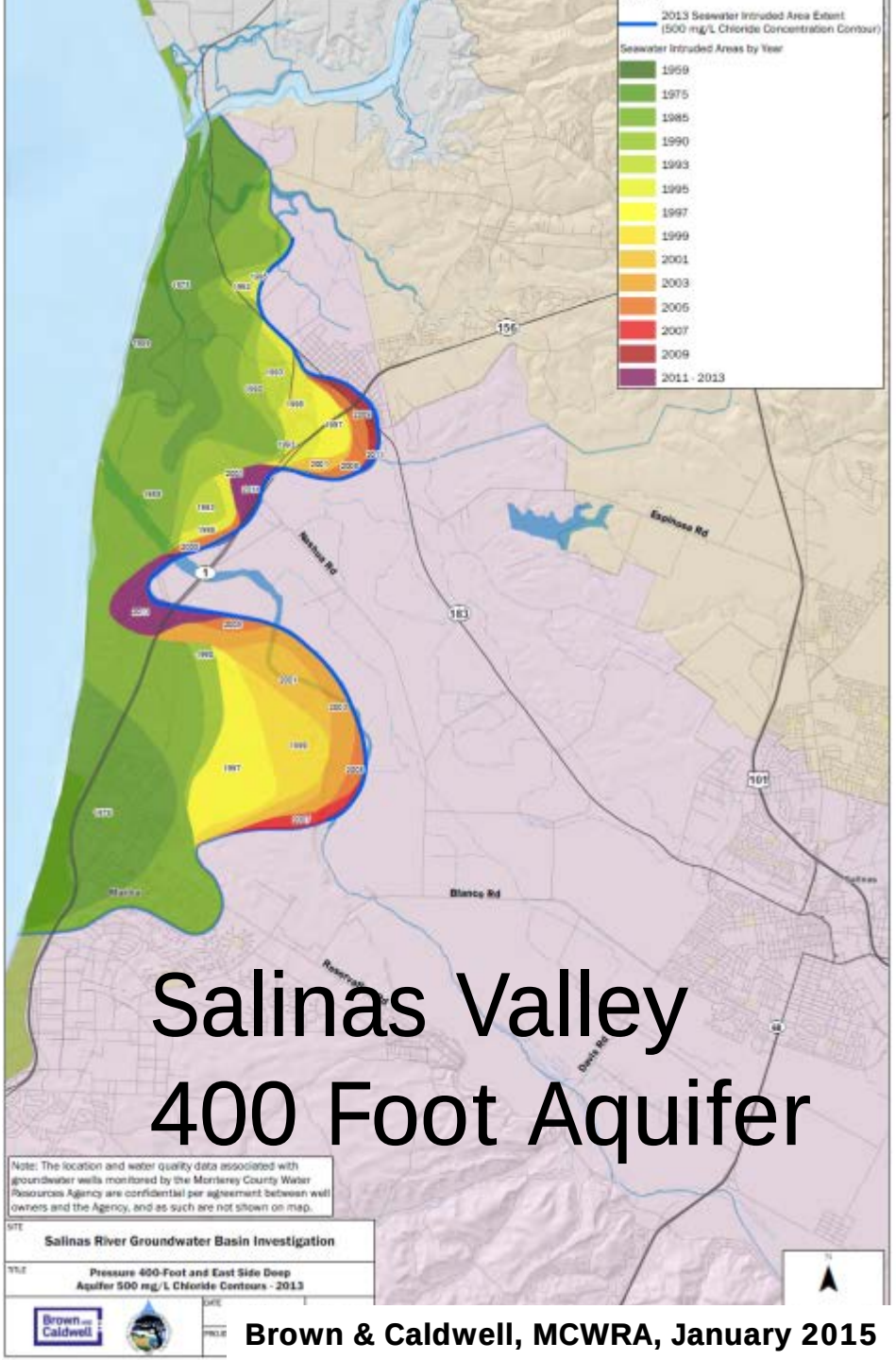
from: Lester Snow, CA Water Foundation

Consequences of Groundwater Overdraft…

- Seawater intrusion
- Increased pumping cost & cost of drilling new wells
- Land subsidence
- Water quality degradation
- Surface water depletion
- Impact to groundwater dependent ecosystems

…Long Before Running Out of Groundwater!





Brown & Caldwell, MCWRA, January 2015

California Groundwater Rights: Background

- Correlative Rights Doctrine – safe yield of groundwater basin shared by overlying users
  - Katz v. Wilkinshaw, 1908
- California constitutional mandate for beneficial use (1928)
- Special districts (20 different types, about 2,300 districts)
  - Water districts, irrigation districts, private water companies, reclamation districts, water conservation districts, water replenishment districts, water storage districts, etc.
- County police power – controls groundwater exports
  - Baldwin vs. Tehama County, 1994
- The Courts: basin adjudication / "physical solution" – controls extraction
  - Many Southern California (sub)basins, mid 20th century
  - City of Barstow vs. Mojave Water Agency, 2000:
    - Right of water users to negotiate physical "equitable, practical" solution, regardless of water rights
    - Individual water rights holders cannot be forced into a voluntary agreement

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    - Right of water users to negotiate physical "equitable, practical" solution, regardless of water rights
    - Individual water rights holders cannot be forced into a voluntary agreement
- State groundwater management:
  - Voluntary local groundwater management plans: AB 3030 (1992)
  - Financial incentives for local groundwater management: SB 1938 (2002)
  - **Sustainable Groundwater Management Act of 2014: mandatory & expanded local control**

Sustainable Groundwater Management Act of 2014

SEC. 2.

Section 113 is added to the Water Code, to read:

113.

It is the policy of the state that **groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits** for current and future beneficial uses.

Sustainable groundwater **management is best achieved locally** through the development, implementation, and updating of plans and programs based on the best available science.

[emphasis added]

Sustainability = No “Undesirable Results”

10721. Unless the context otherwise requires, the following definitions govern the construction of this part:

(u) “Sustainable groundwater management” means the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.

(w) **“Undesirable result” means one or more of the following** effects caused by groundwater conditions occurring throughout the basin (Section 10721 (w)):

(1) **Chronic lowering of groundwater levels** indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

(2) Significant and unreasonable **reduction of groundwater storage**.

(3) Significant and unreasonable **seawater intrusion**.

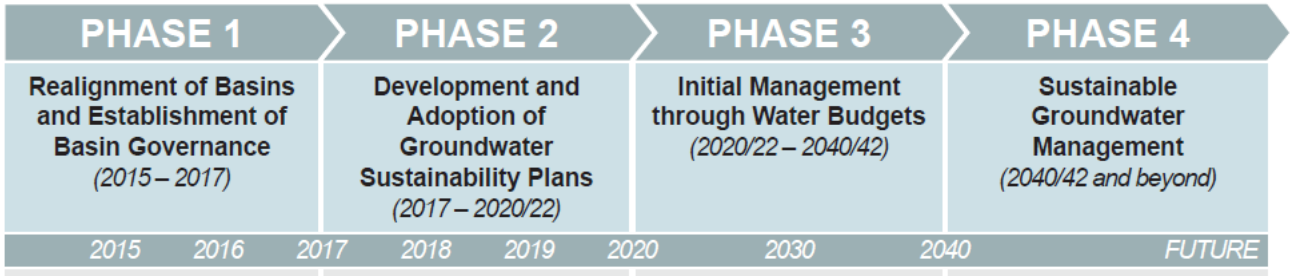
(4) Significant and unreasonable **degraded water quality**, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable **land subsidence** that substantially interferes with surface land uses.

(6) **Surface water depletions** that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

[emphasis added]

So What Exactly Will Happen?



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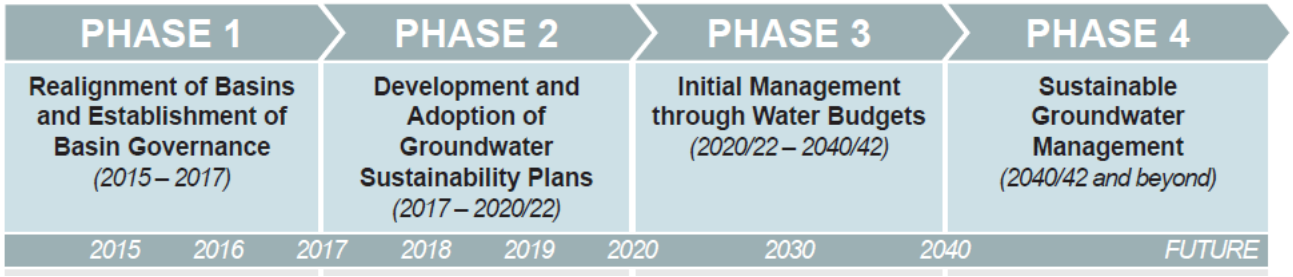
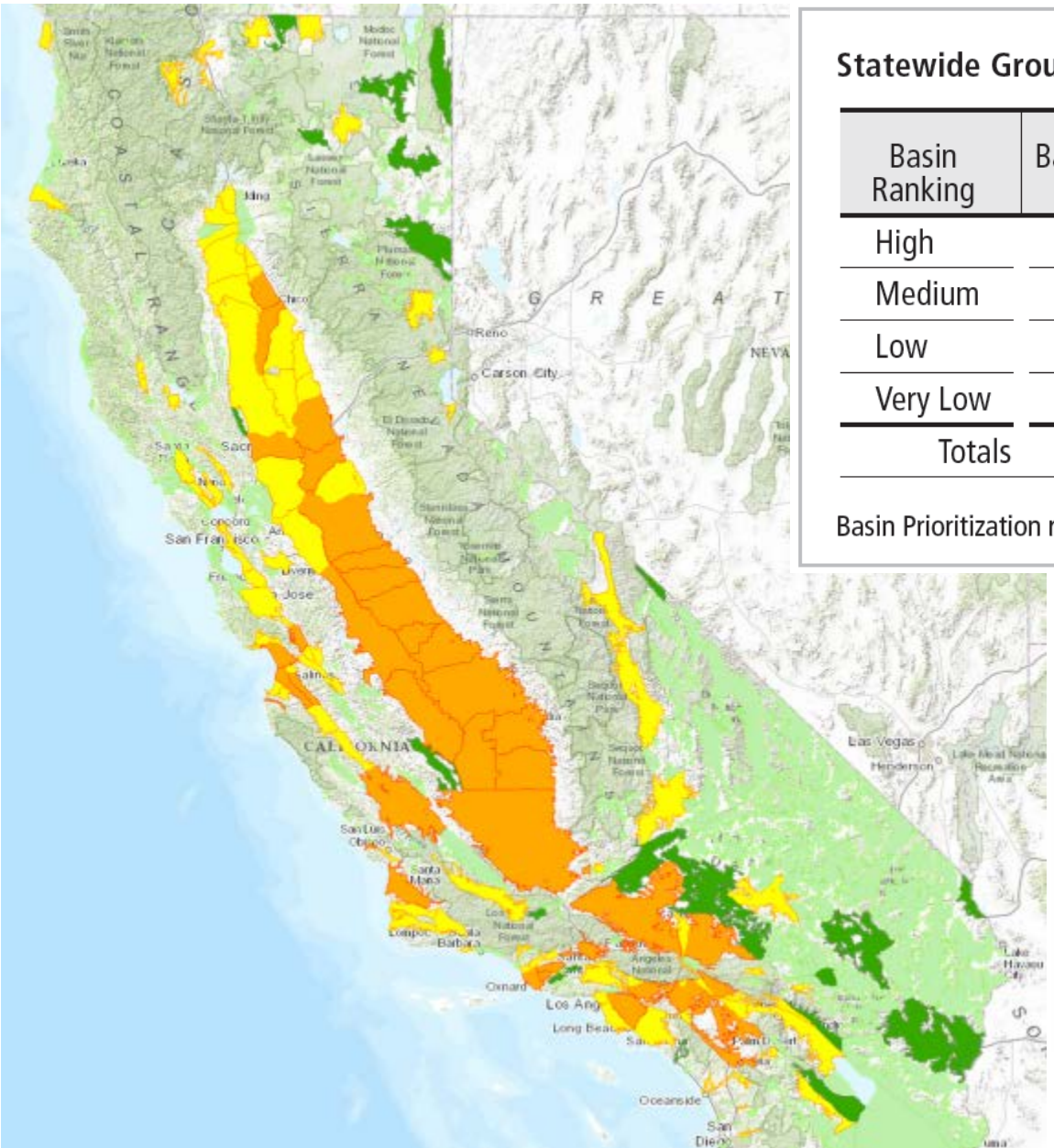


- **First Step: forming a Groundwater Sustainability Agency (GSA)**
  - By June 2017

Medium and High Priority Groundwater Basins



Statewide Groundwater Basin Prioritization Summary

Basin Ranking	Basin Count per Rank	Percent of Total for State	
		GW Use	Overlying Population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

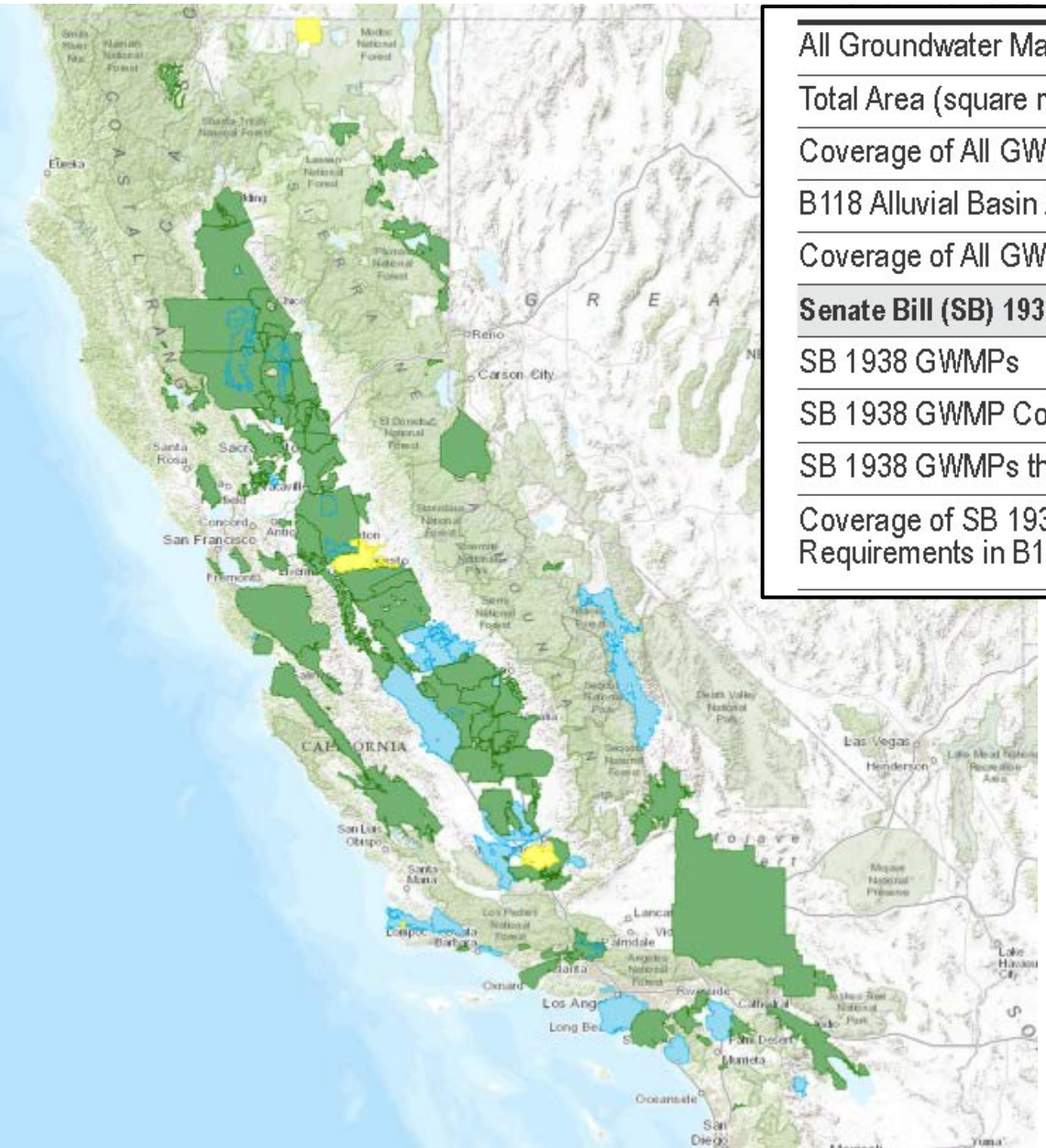
Basin Prioritization results – June 2, 2014

CASGEM Groundwater Basin Prioritization

- High
- Medium
- Low
- Very Low

California Department of Water Resources, 2015

Existing Groundwater Management Plans: Inventory and Assessment (No or Limited Implementation)



All Groundwater Management Plans (GWMP)	119
Total Area (square miles)	158,600
Coverage of All GWMPs (%)	20%
B118 Alluvial Basin Area (square miles)	61,900
Coverage of All GWMPs in B118 Basins Area (%)	42%
Senate Bill (SB) 1938 GWMPs Overlying B118 Alluvial Basins	
SB 1938 GWMPs	83
SB 1938 GWMP Coverage in B118 Basin Area (%)	32%
SB 1938 GWMPs that include all CA Water Code Requirements	35
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	17%

Groundwater Management Plans

- AB 359
- SB 1938
- AB 3030

California Department of Water Resources, 2015

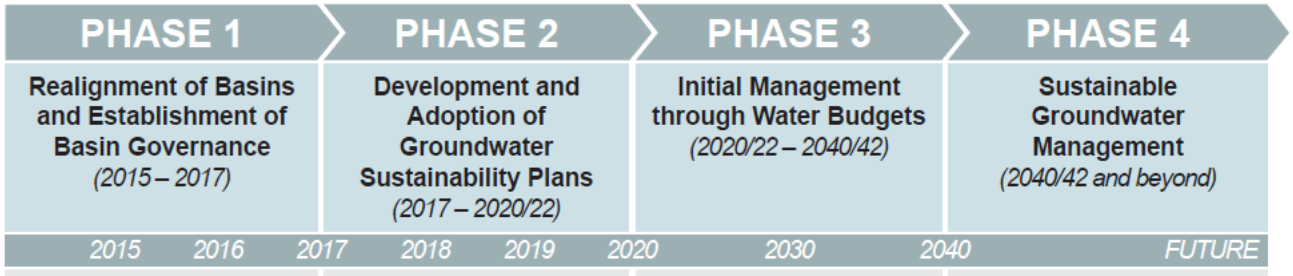
Who can be a GSA?

- Exempt:
  - Adjudicated basins (mostly in southern CA)
  - Functional equivalent of a GSA, adjudicated basin
- Any local public agency
  - Cities
  - Counties
  - Water / irrigation districts
  - Other public agencies with responsibility for:
    - water supply,
    - water management, or
    - land use
  - NEW special acts districts (created by legislature, then CEQA, LAFCO, public vote) => Paso Robles

GSA Formation: Next Steps

- County: Groundwater Advisory Committee
- Stimulate dialogue / communication among local agencies, key stakeholders (e.g., Farm Bureau)
- Engage broad range of interested parties
- Gather information about the basin / find out where the information is / what is available
- Understand what Groundwater Sustainability Planning entails
- Look over the fence and see what's happening elsewhere
- Transparency, transparency, transparency
- DEADLINE: June 30, 2017

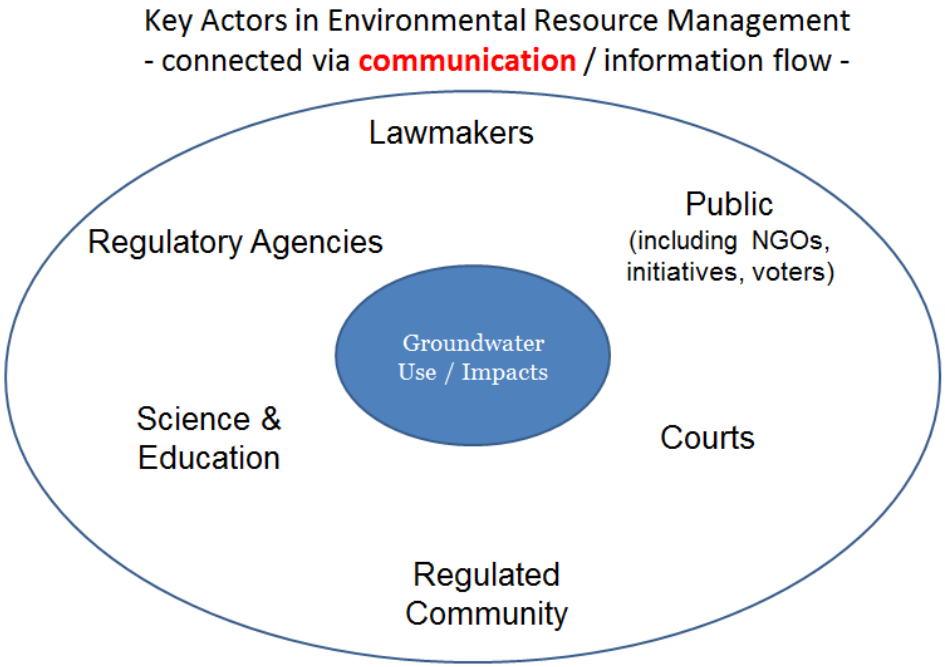
So What Exactly Will Happen?



- First Step: forming a Groundwater Sustainability Agency (GSA)
  - By June 2017
- **Second Step: developing a Groundwater Sustainability Plan (GSP)**
  - Within 5 years of GSA formation

Key Elements of (Local/regional) California Groundwater Management Plans

- Context / Basin Description
- Public and agency involvement
- Basin management objectives
- Monitoring
- Accountability and review



Sustainable Groundwater Mgmt Act:

- Enforcement mandate
- Empowerment for demand management (in addition to supply management)
- Integration with surface water management
- Integration with water quality management (source control, remediation, containment)
- Integration with landuse planning
- Local control / enforcement, with state oversight / enforcement

Groundwater Management Portfolio: Overview

- Data collection, monitoring, modeling, assessment
- Supply management
- Demand management
- Stakeholder engagement and management

Monitoring and Assessment

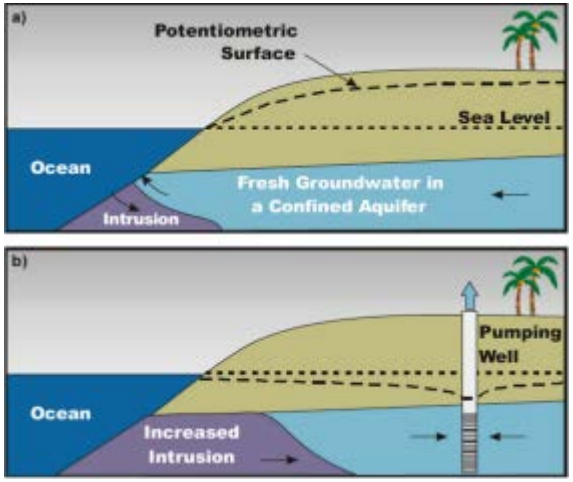
Groundwater Sustainability Agencies have *discretionary* authority to:

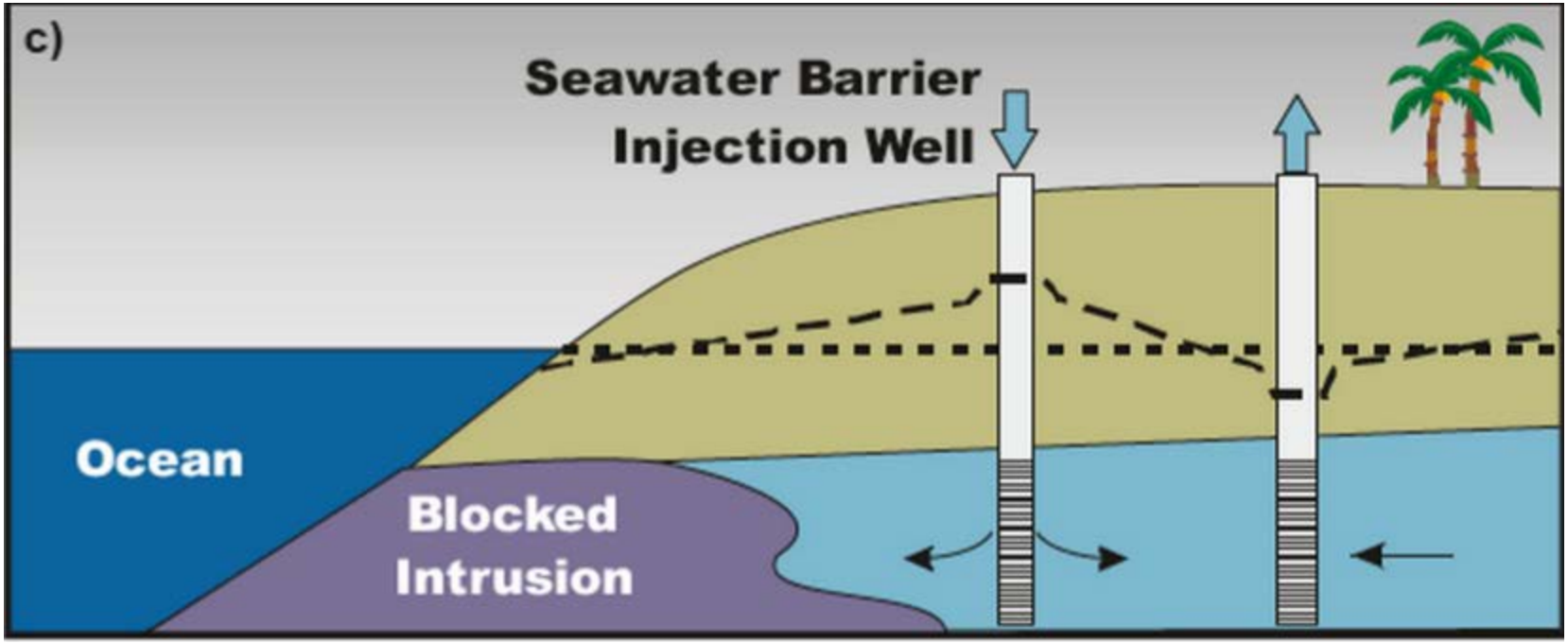
- Conduct studies
- Register & monitor wells
- Set well spacing requirements
- Require extraction reporting
- Regulate extractions
- Implement capital projects
- Assess fees to cover costs

Some exemptions for smaller private well owners

COURTESY - Marcus Trotta, Sonoma County Water Agency, 2015

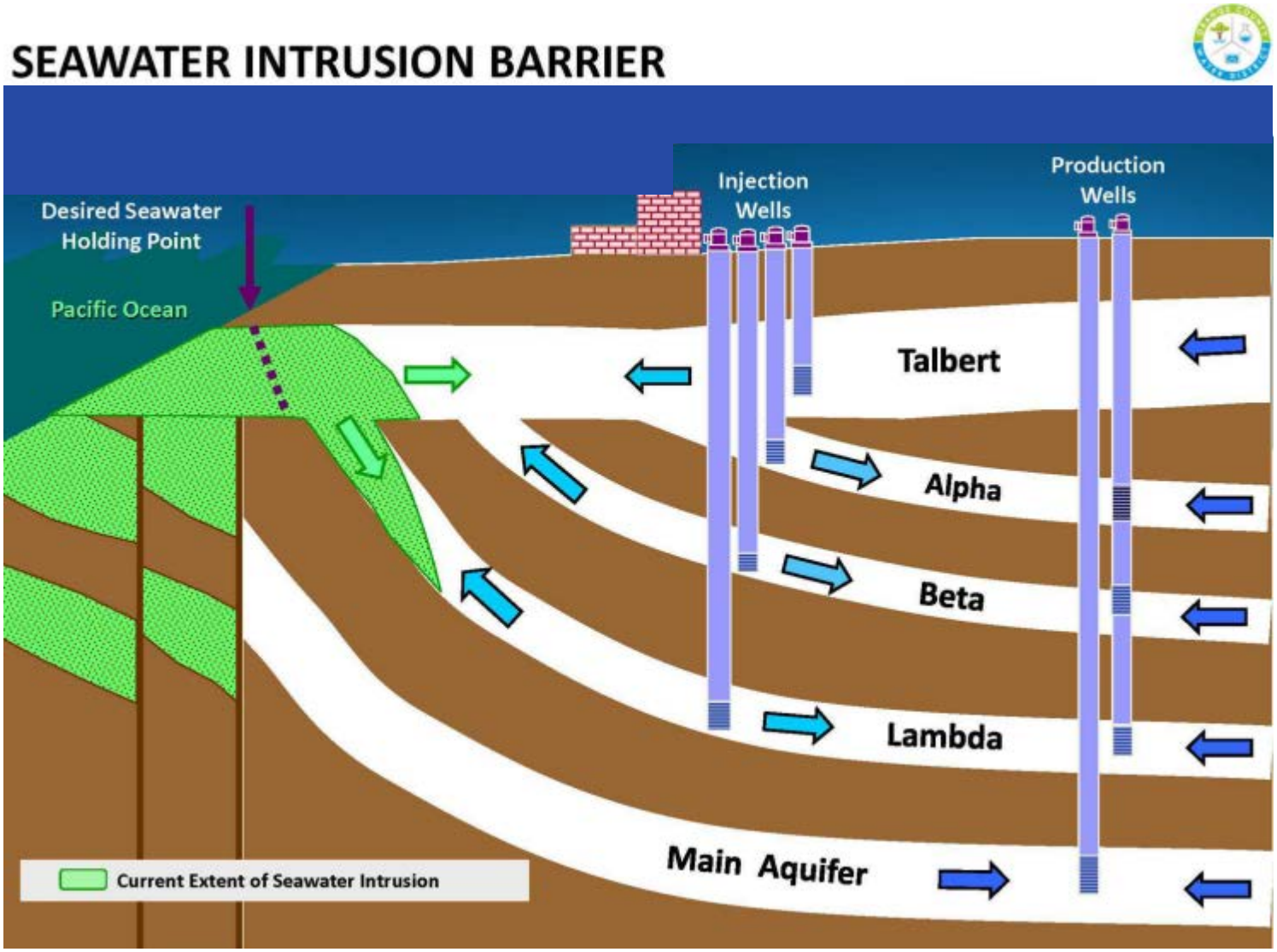
Supply Management:
Seawater Intrusion Barriers





Ted Johnson, Water Replenishment District, 2007

Seawater Intrusion



Orange County Water District, 2014

Recycled Water Reuse
- Pajaro Valley -

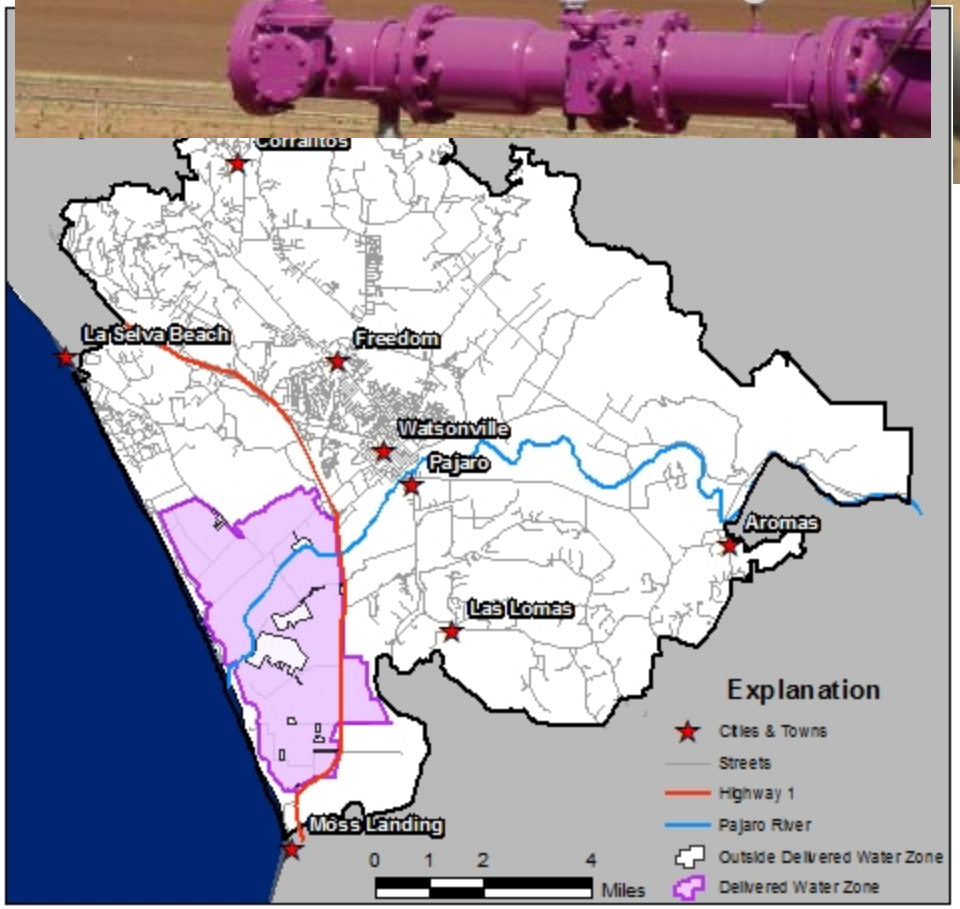
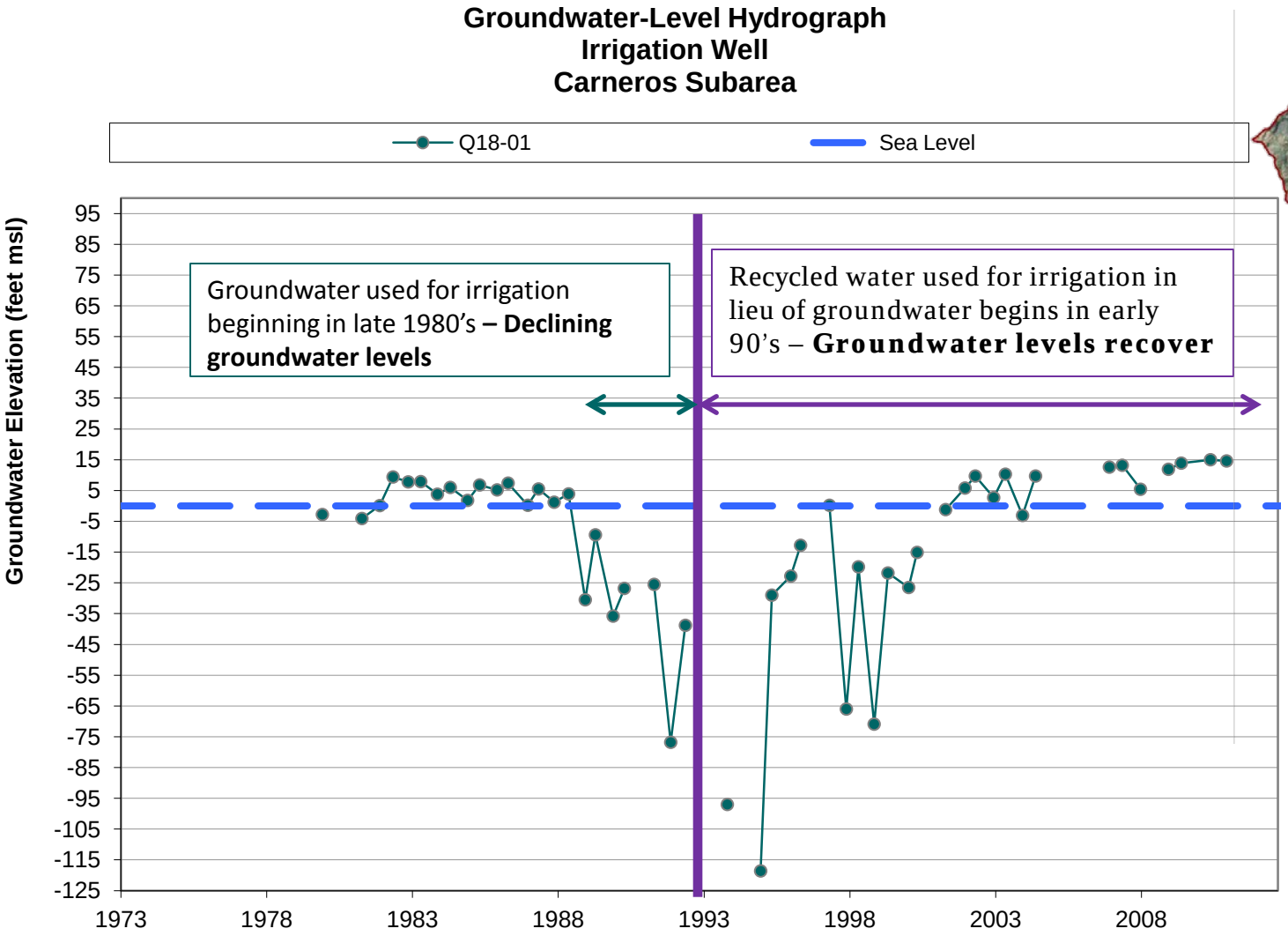
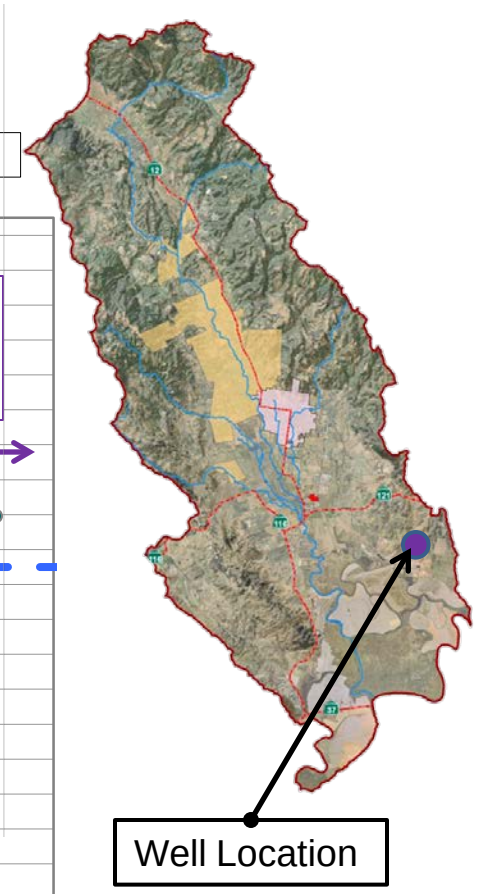


Photo: Californian Salinas

Photo: J.D. Hillard

Irrigation with Recycled Water to Offset Groundwater Pumping



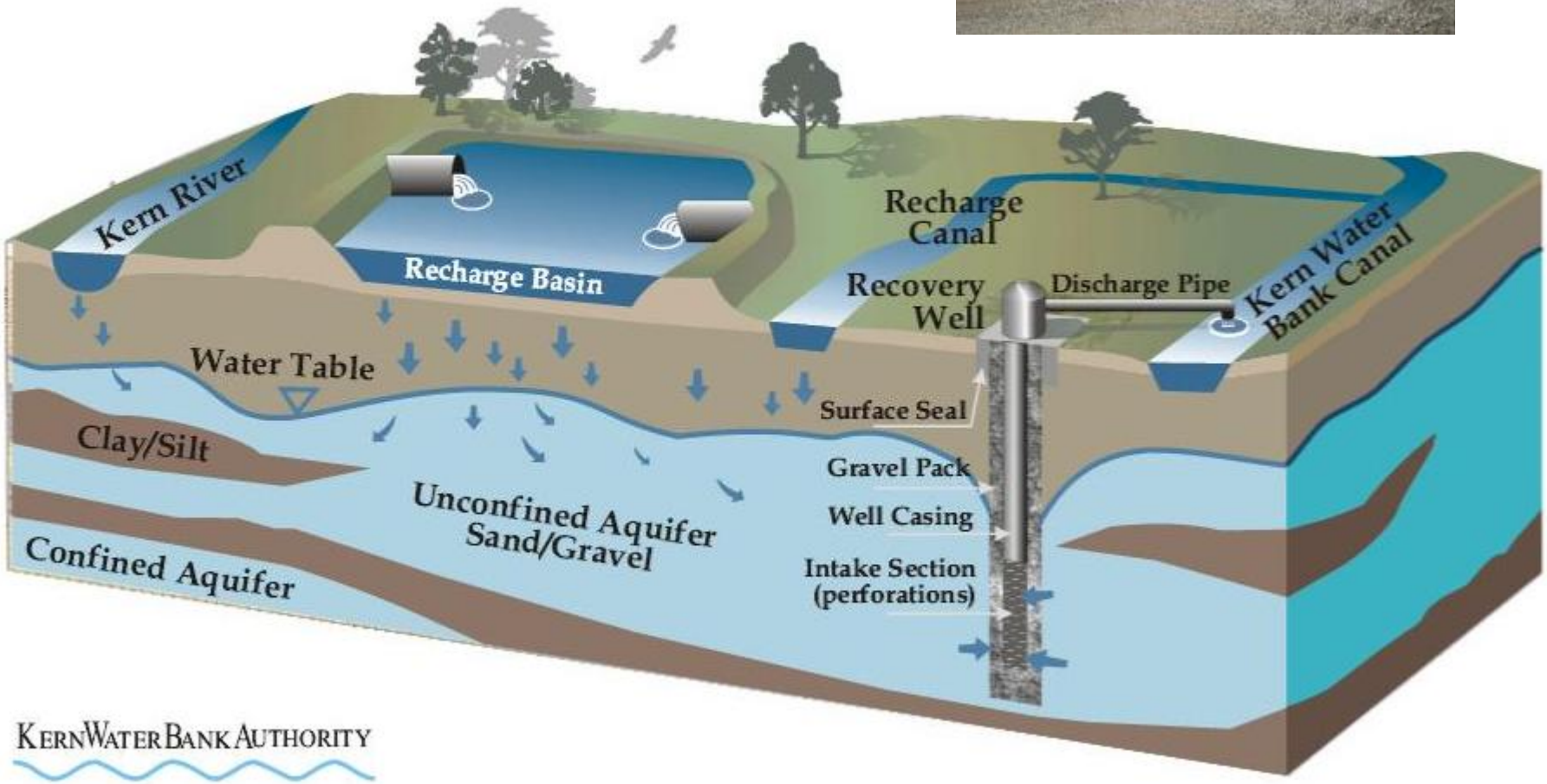


COURTESY - Marcus Trotta, Sonoma County Water Agency, 2015

Water Banking

From: Ted Johnson, WRD 2013

DWR, California Water Plan Update 2013



KERNWATERBANKAUTHORITY

Local Recharge Basins/ Managed Aquifer Recharge

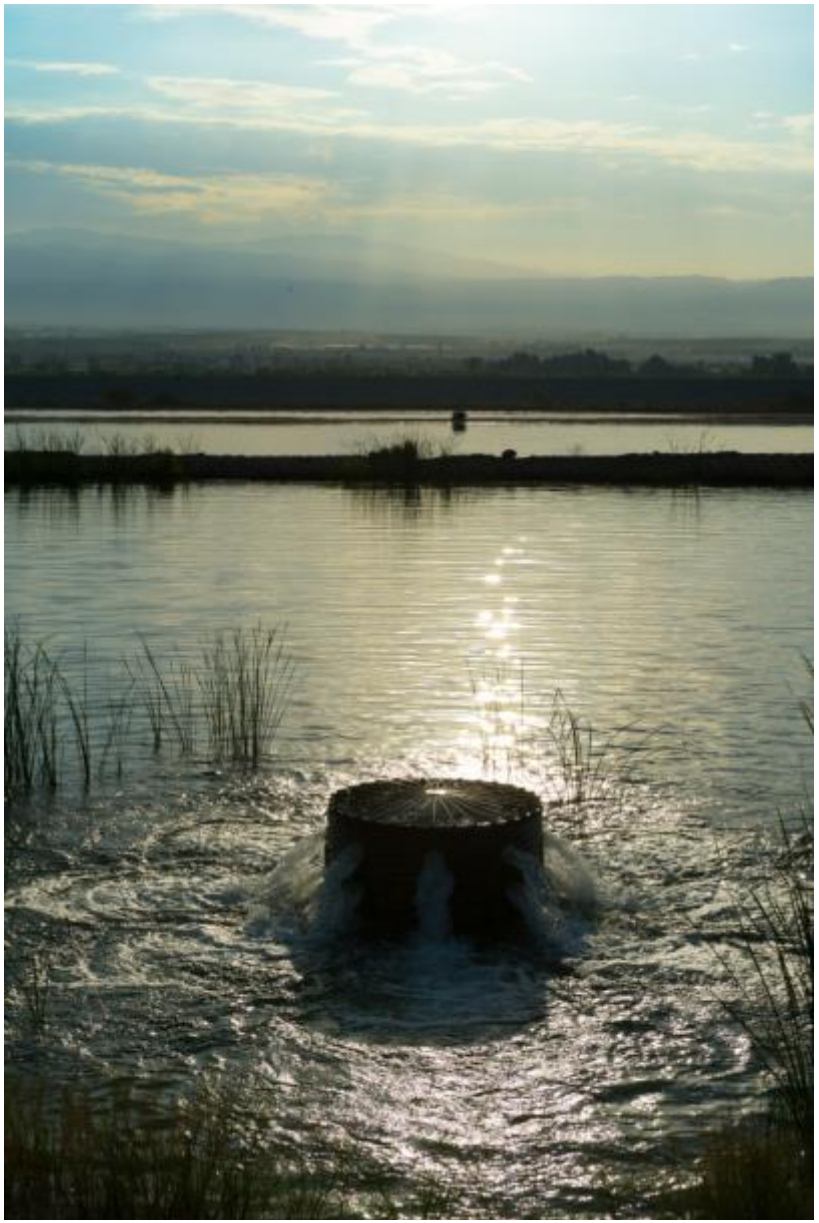


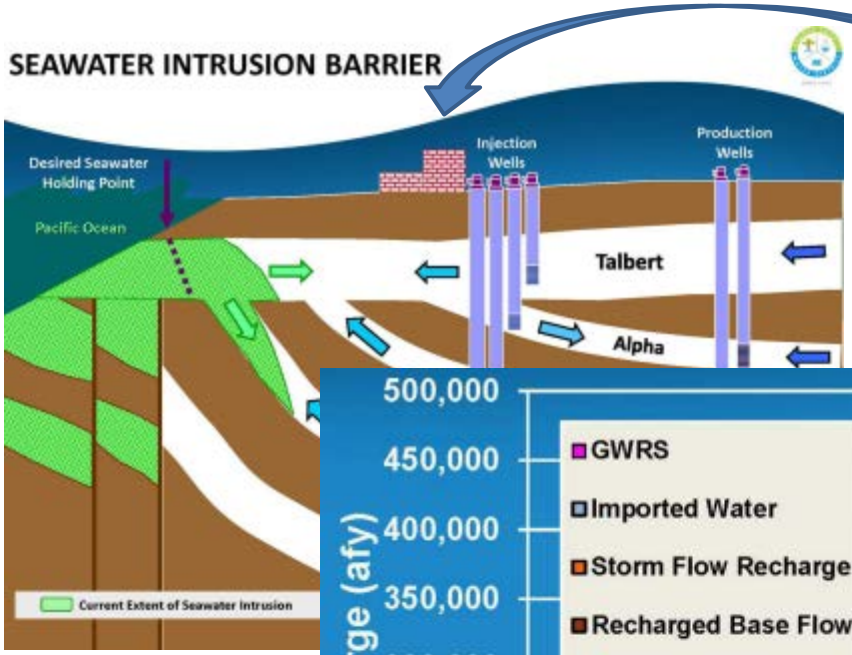
Photo: Kelly M. Grow, Dept Water Resources

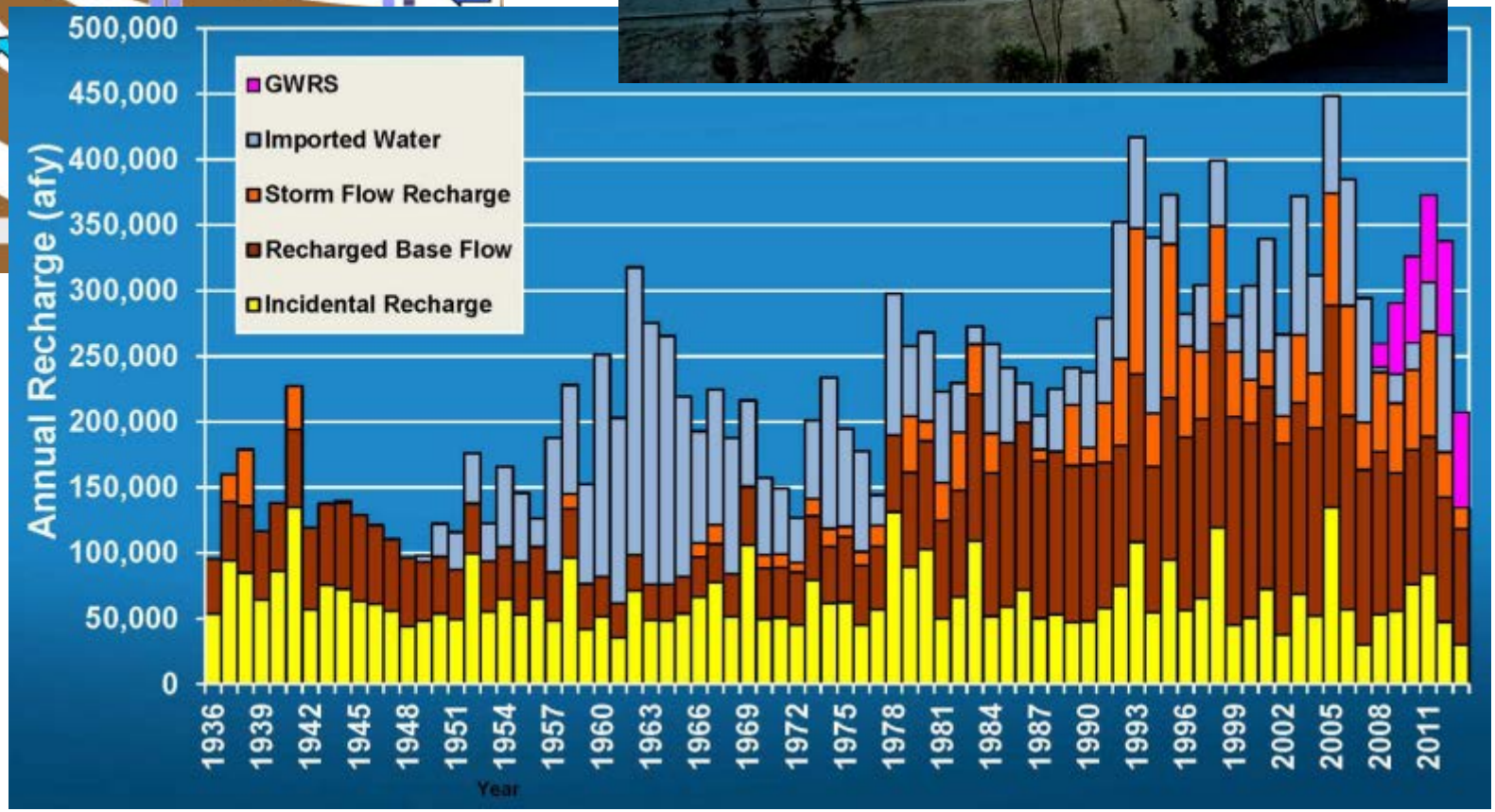
Coachella Valley (Colorado River water)

Santa Clara County

Photos : George Sakkestad, Mercury News, 2015

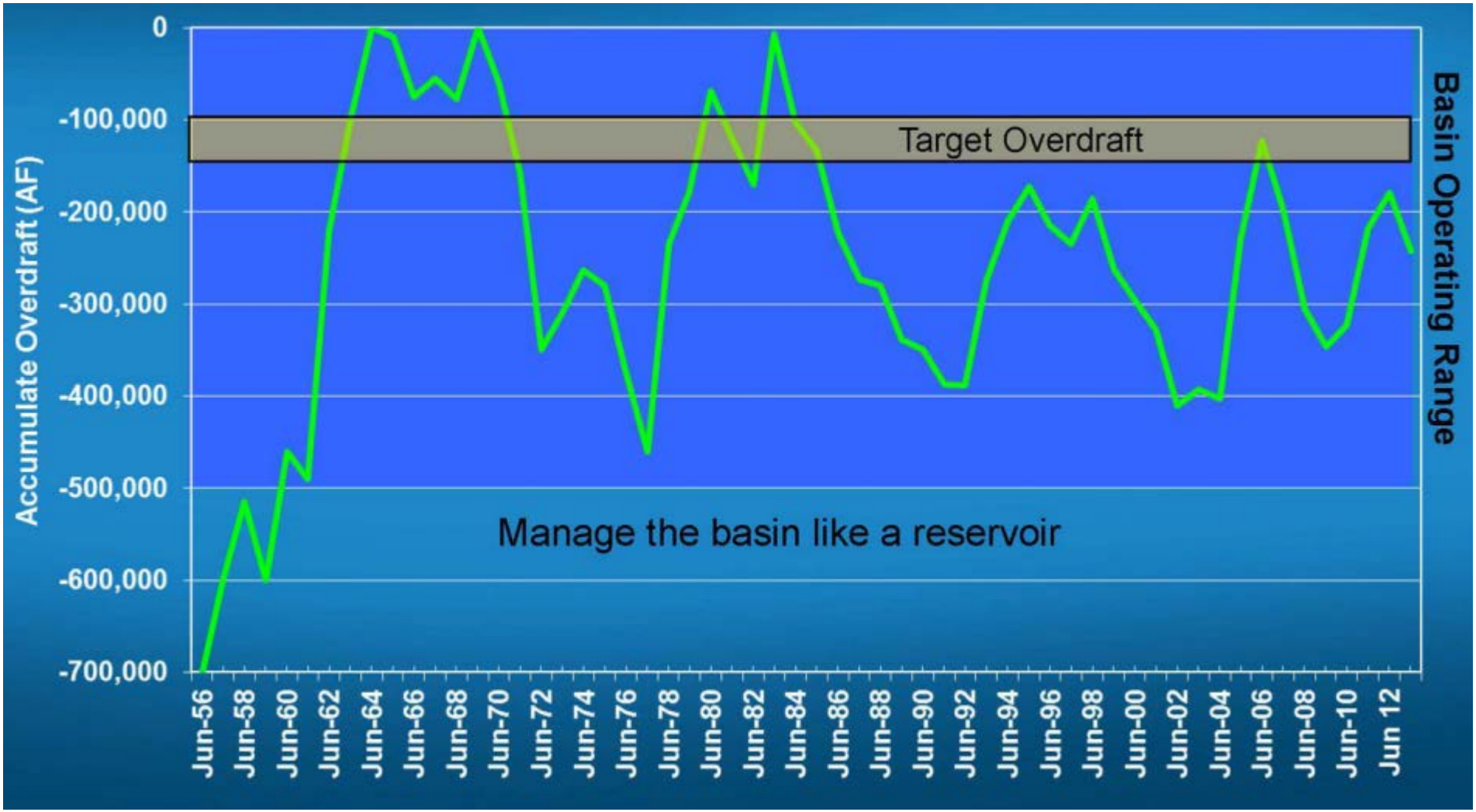
Orange County: Groundwater Recharge Portfolio





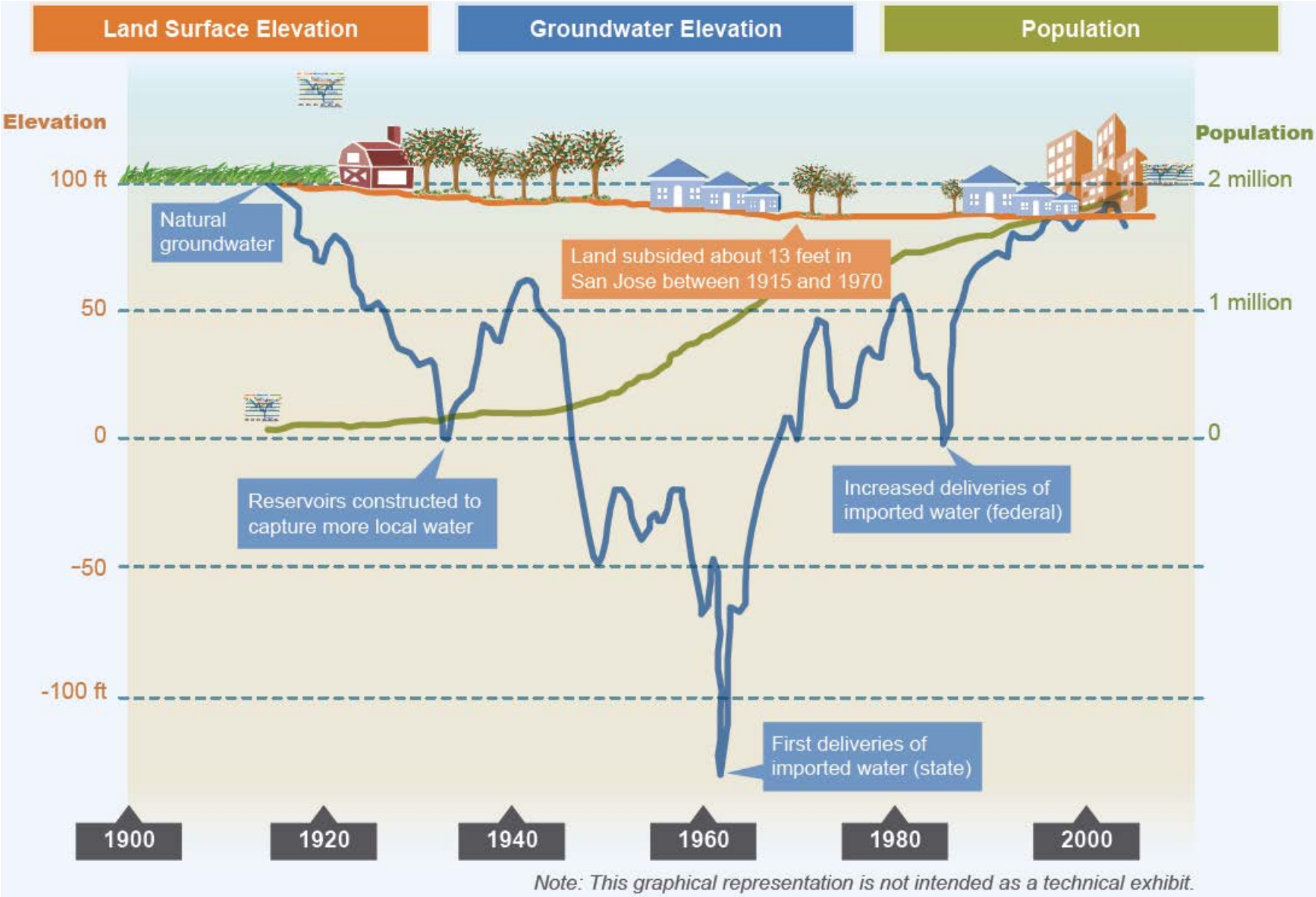
Orange County Water District, 2014

Seawater Intrusion

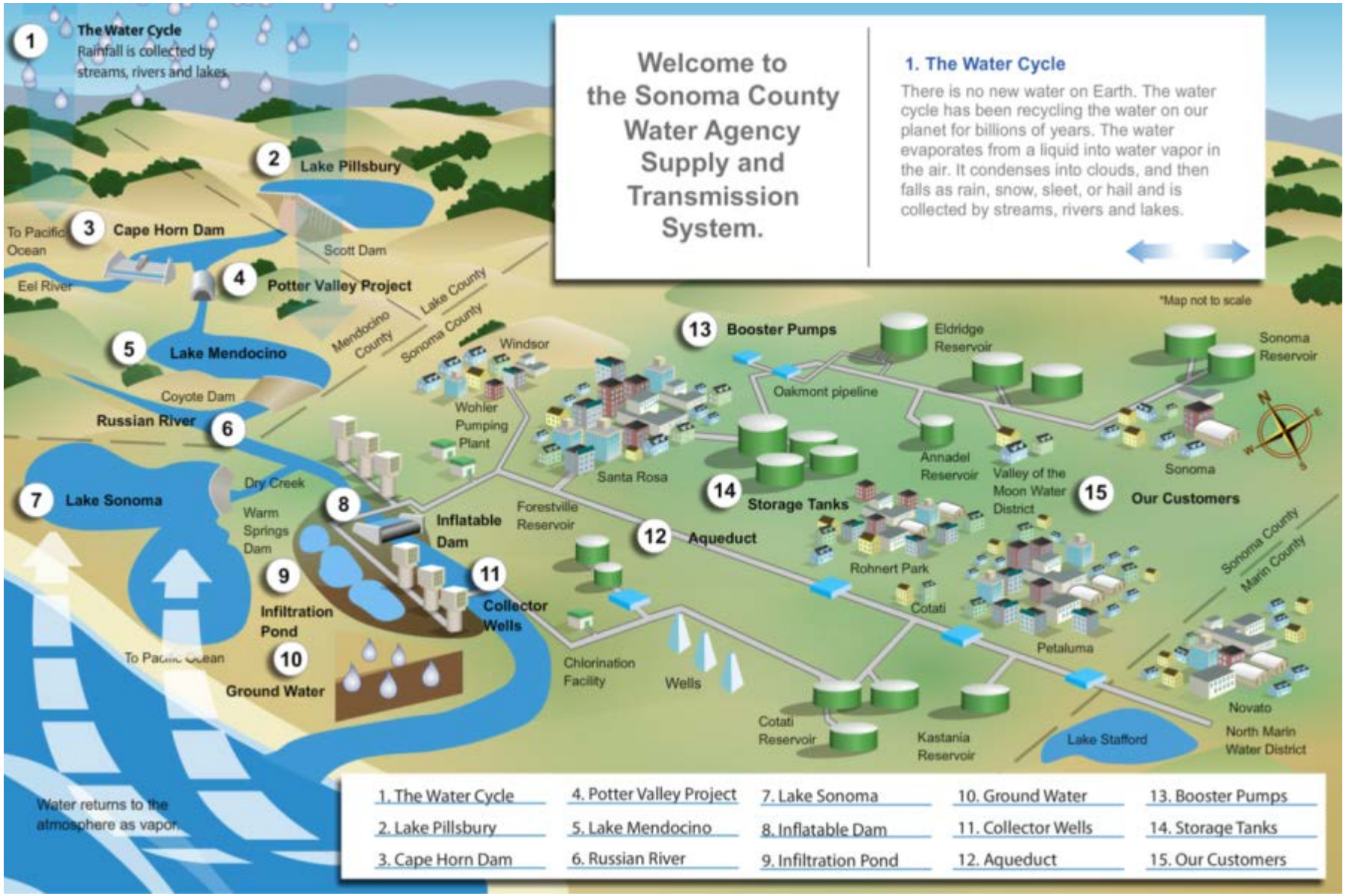


Orange County Water District, 2014

Storage for Local Use: Santa Clara Valley Water District



Sonoma County: Integrated Water Management Portfolio



- Healthy

Health Maintenance
- Nutrition
- Exercise
- Relationships/social engagement
- Monitoring & Assessment

- Sustainable Groundwater

Groundwater Management
- Adaptive supply management
- Adaptive demand management
- Stakeholder engagement
- Monitoring & Assessment

METRIC

TRIGGER(s)

- Ill

Treatment Mode
- Medication / therapy
- Additional monitoring & Doctor's assessment

- Reversible undesirable impacts

Extraordinary Measures
- Supply enhancement / demand reduction
- Additional monitoring & assessment

THRESHOLD(s)

- Critically ill

Emergency Mode
- Emergency Room
- Surgery

- Major undesirable impacts

Emergency Mode
- SGMA Chapter 11
- Probationary Status

- Death

- Groundwater unusable/unavailable

Thomas Harter, Univ. of California, 2015

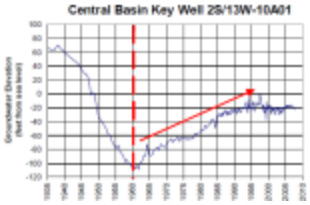
Undesirable Result & Measurable Objective	Metric	Possible Threshold
Chronic lowering of groundwater levels: maintain desired range	Water level at key locations	• No less than at any time AFTER earlier mitigation of undesirable results and PRIOR to 2015, OR • No less than at any time prior to 2015, OR • No less than at any time prior to 2042, OR • Any fixed level arrived at through local/state political consensus about "significant and unreasonable", driven by economic cost: • Significant and unreasonable increase in pumping cost • Significant and unreasonable cost of new well installation / well deepening
Reduction in groundwater storage: maintain desired range	Water level at key locations	
Seawater intrusion: Stop or reverse water quality degradation	Water level at key locations or GW Salinity	Identify seawater intrusion threat via geologic and geochemical characterization & modeling => define safe water level thresholds for land subsidence. Threshold: • Higher than land subsidence-driven threshold or any of the above, whichever is higher
Degraded water quality: no harm to SWRCB regs	Porter-Cologne/ anti-degradation	• set by current and future RWB regulations • Use modeling and assessment to link groundwater management actions to RWB objectives
Land subsidence: stop or minimize subsidence	Water level at key locations	Identify subsidence threat via geologic characterization & modeling => define safe water level thresholds for land subsidence. Threshold: • Higher than land subsidence-driven threshold or any of the above, whichever is higher
Depletion of interconnected surface water & adverse impacts on SW beneficial uses: minimum required streamflow	Water level at key locations (within 1 mile of stream?), surface critical low flows at key locations & times	Use modeling and assessment to link impact of groundwater management/use to beneficial uses of surface water => set thresholds • No less than at any time AFTER earlier mitigation of undesirable results and PRIOR to 2015 => no further assessment needed • Higher than surface water beneficial use-driven thresholds or any of the above, whichever is higher

Thomas Harter, Univ. of California, 2015

Relationship between
Measurable Objectives (MO) and Management Practices

M E T R I C

THRESHOLD (s)



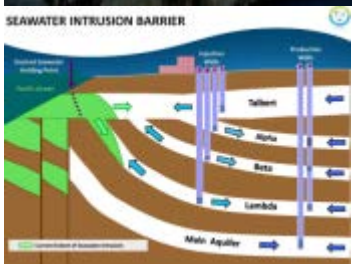
Measurement / Monitoring

Certainty

Groundwater Sustainability Plan
- Monitoring & Assessment
- Stakeholder engagement
- Adaptive supply management
- Adaptive demand management

Management Impact

Uncertainty



Thomas Harter, Univ. of California, 2015

Relationship between
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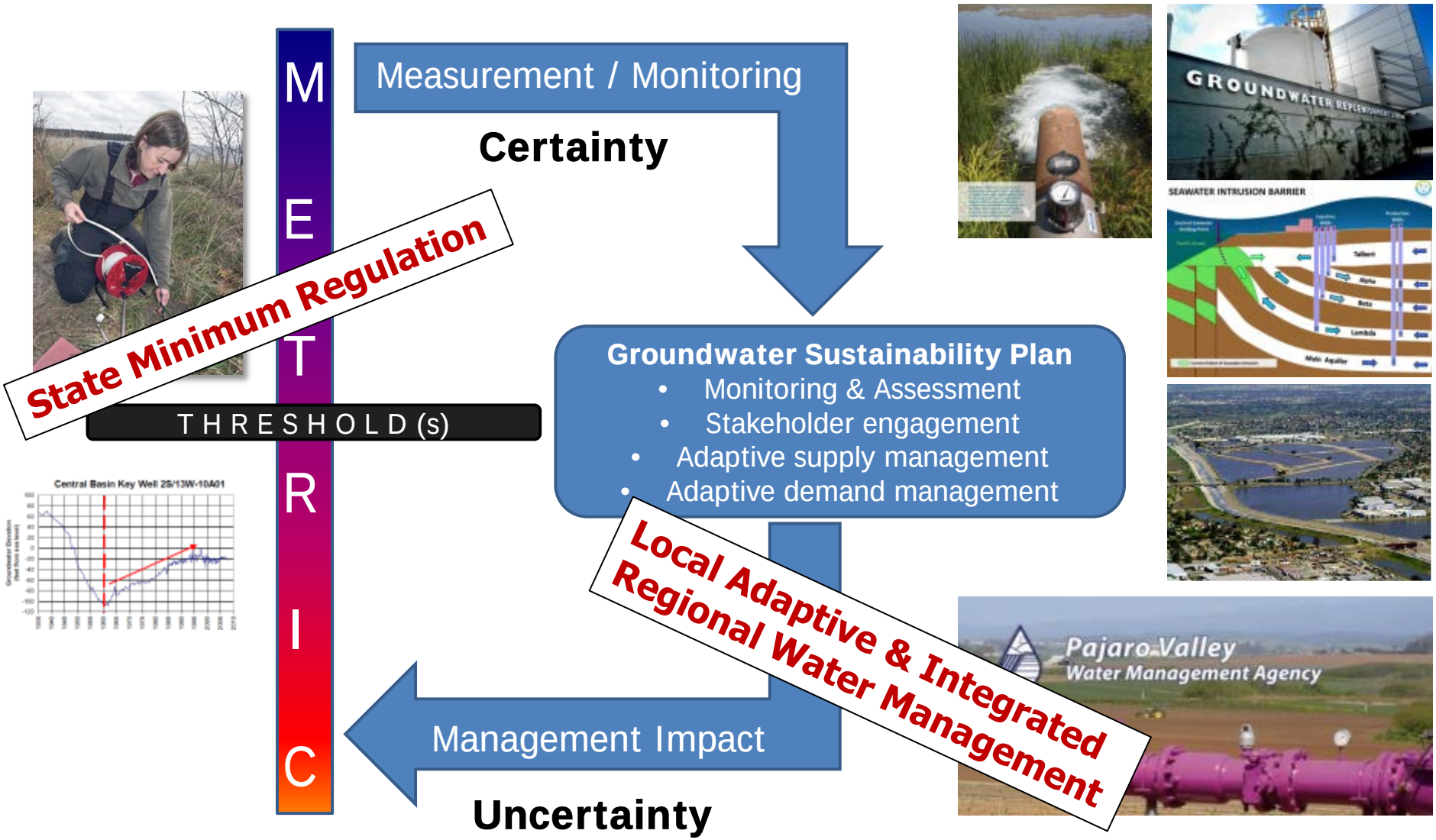
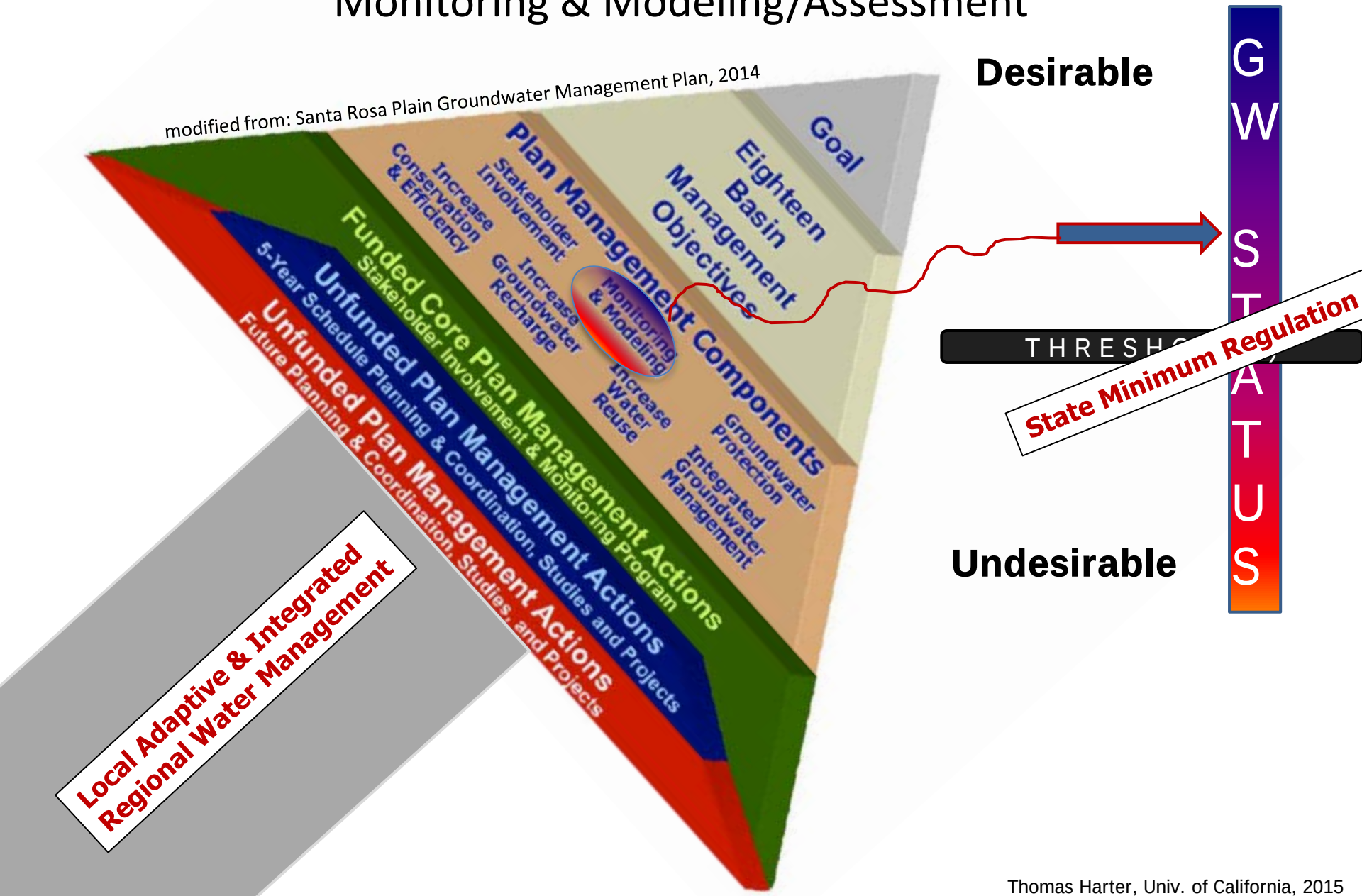


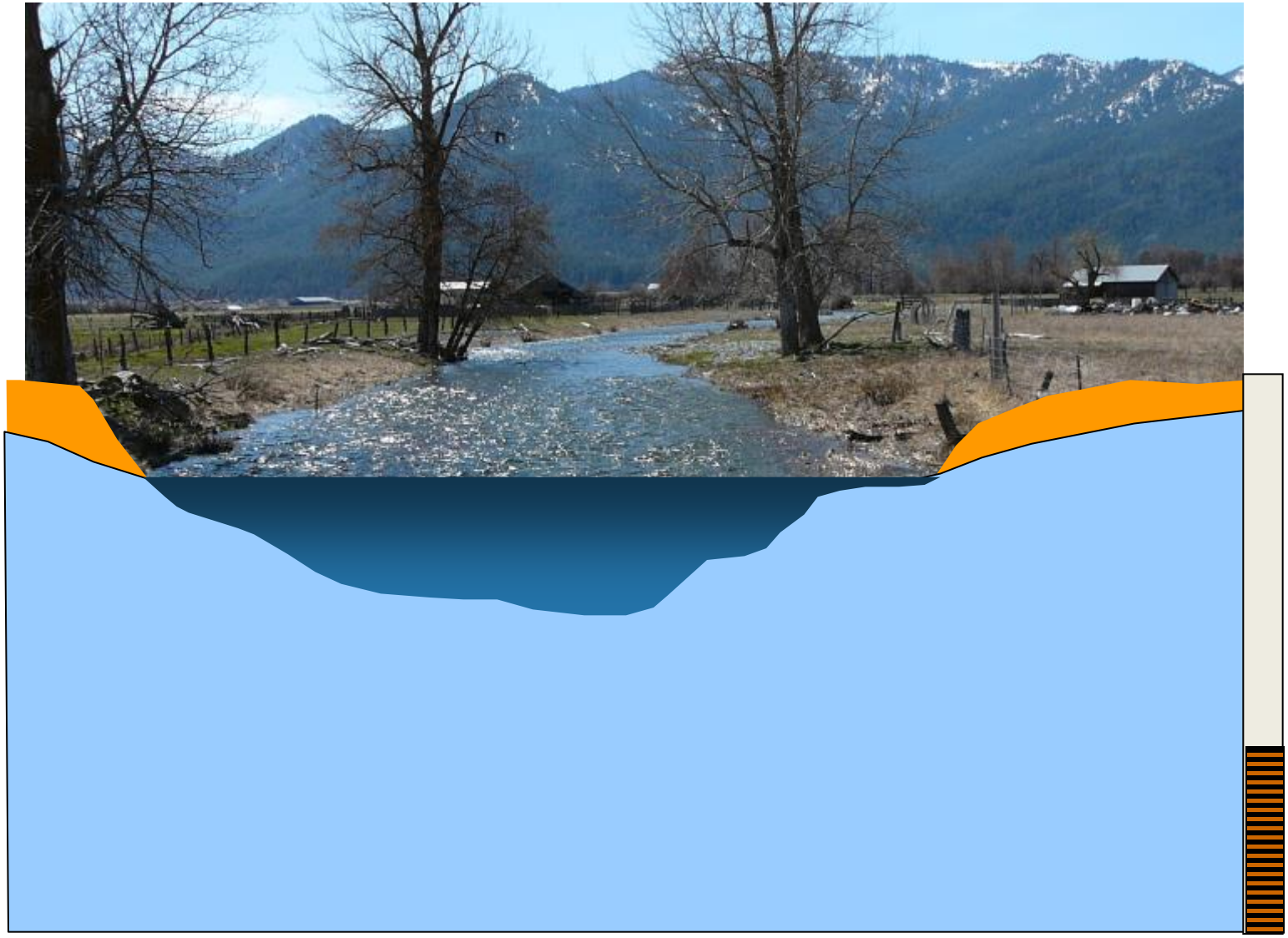
Thomas Harter, Univ. of California, 2015

Core Link between Local Planning Effort and State Oversight: Monitoring & Modeling/Assessment



Thomas Harter, Univ. of California, 2015

Well Near a Stream



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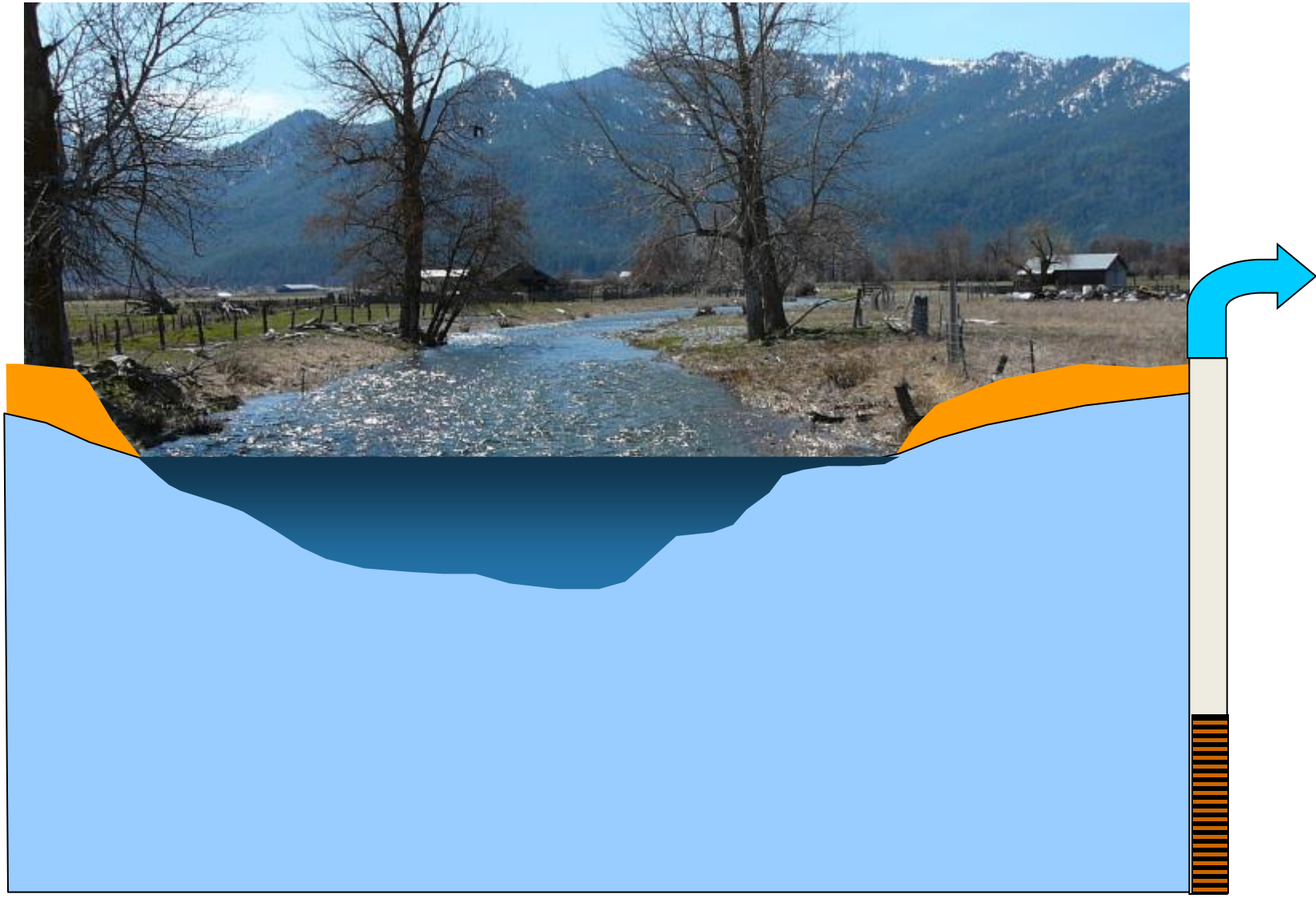

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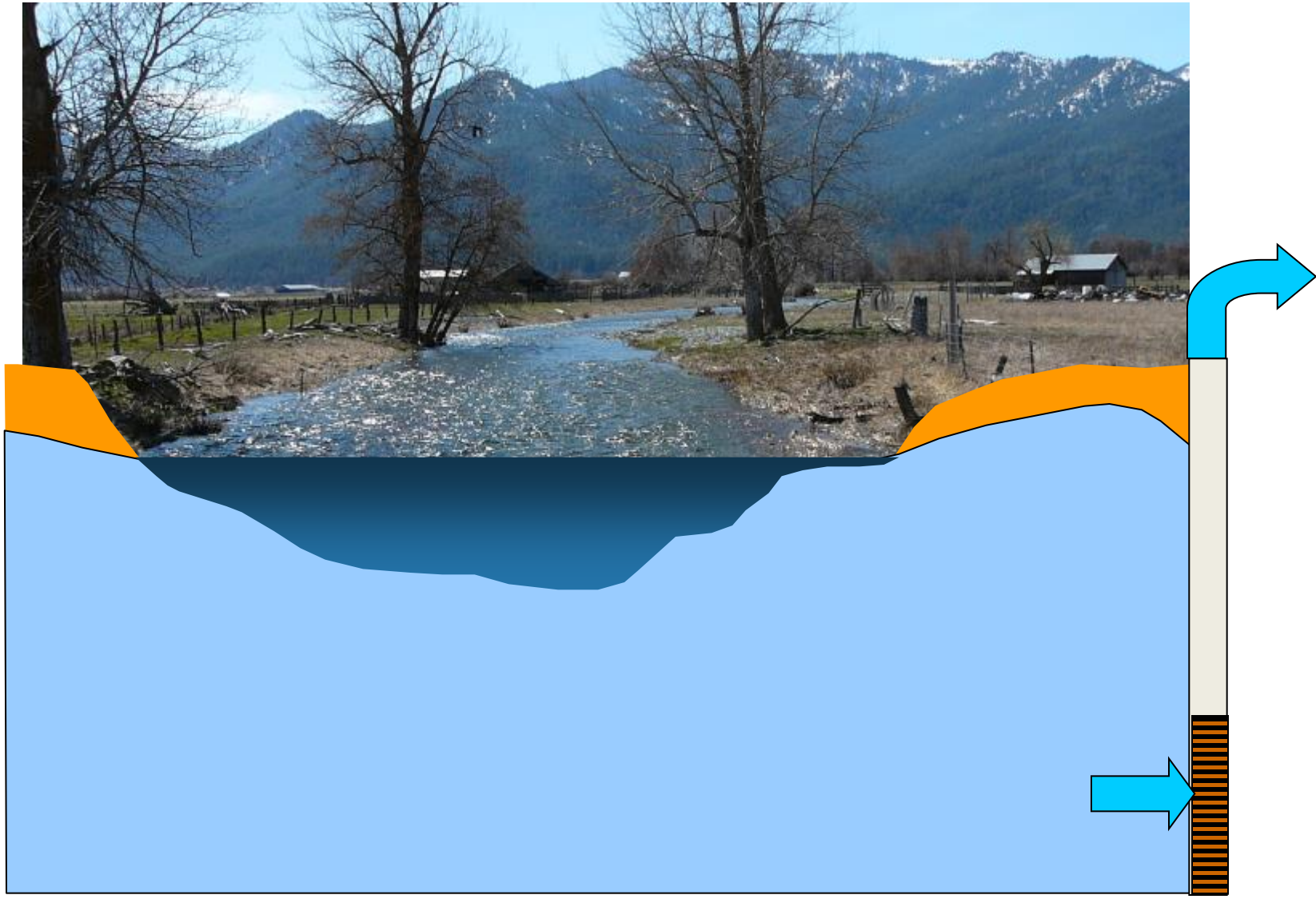

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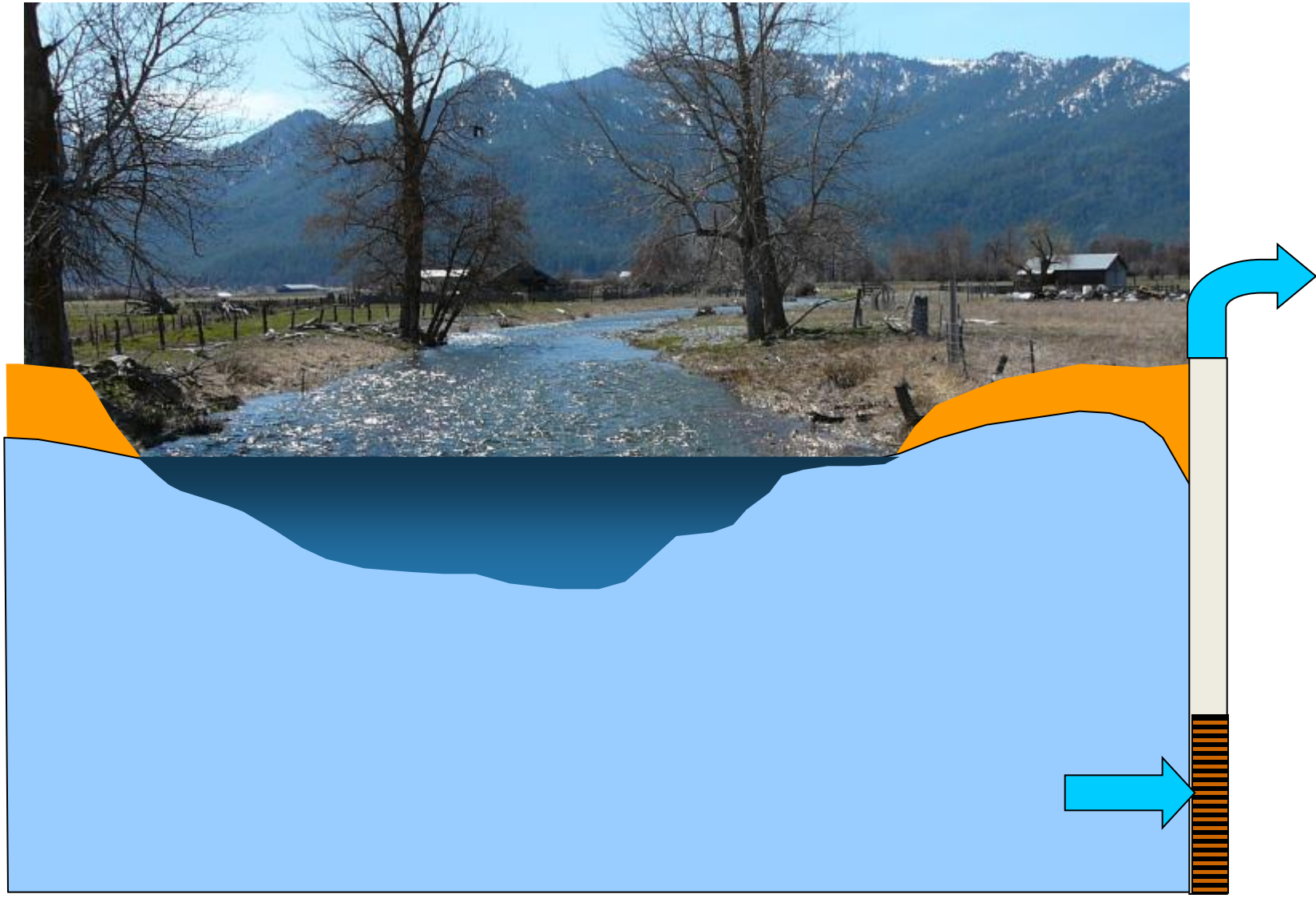

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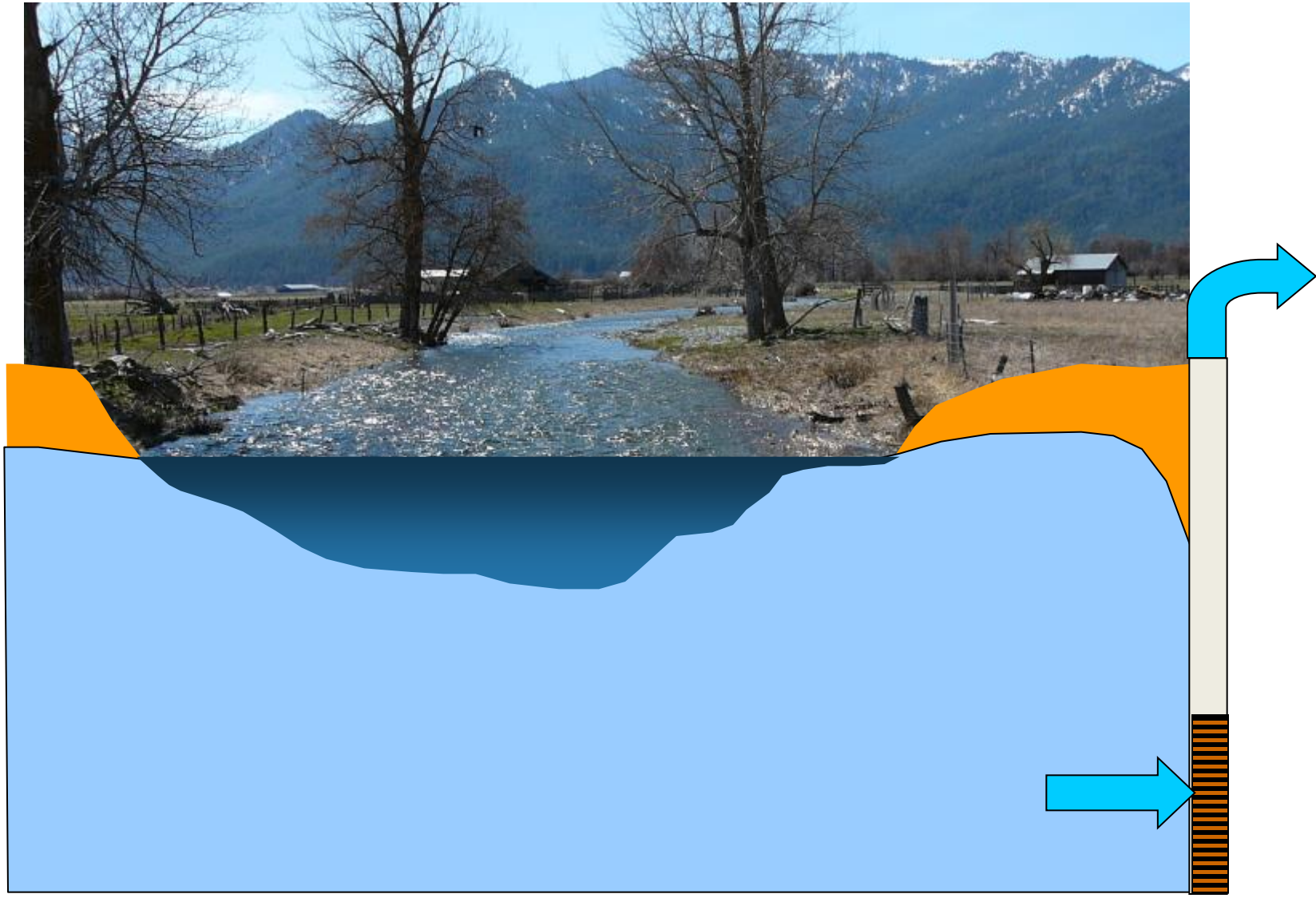

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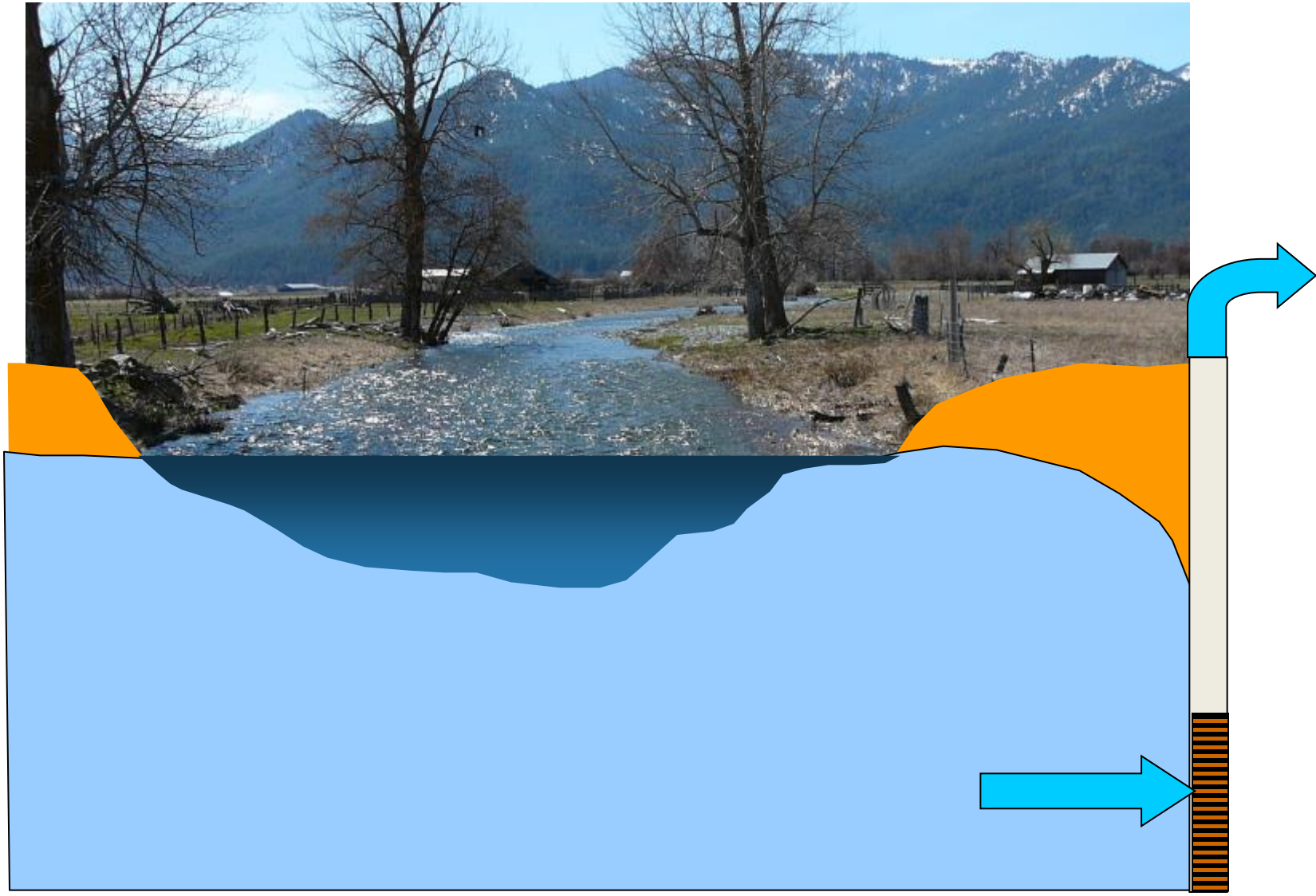

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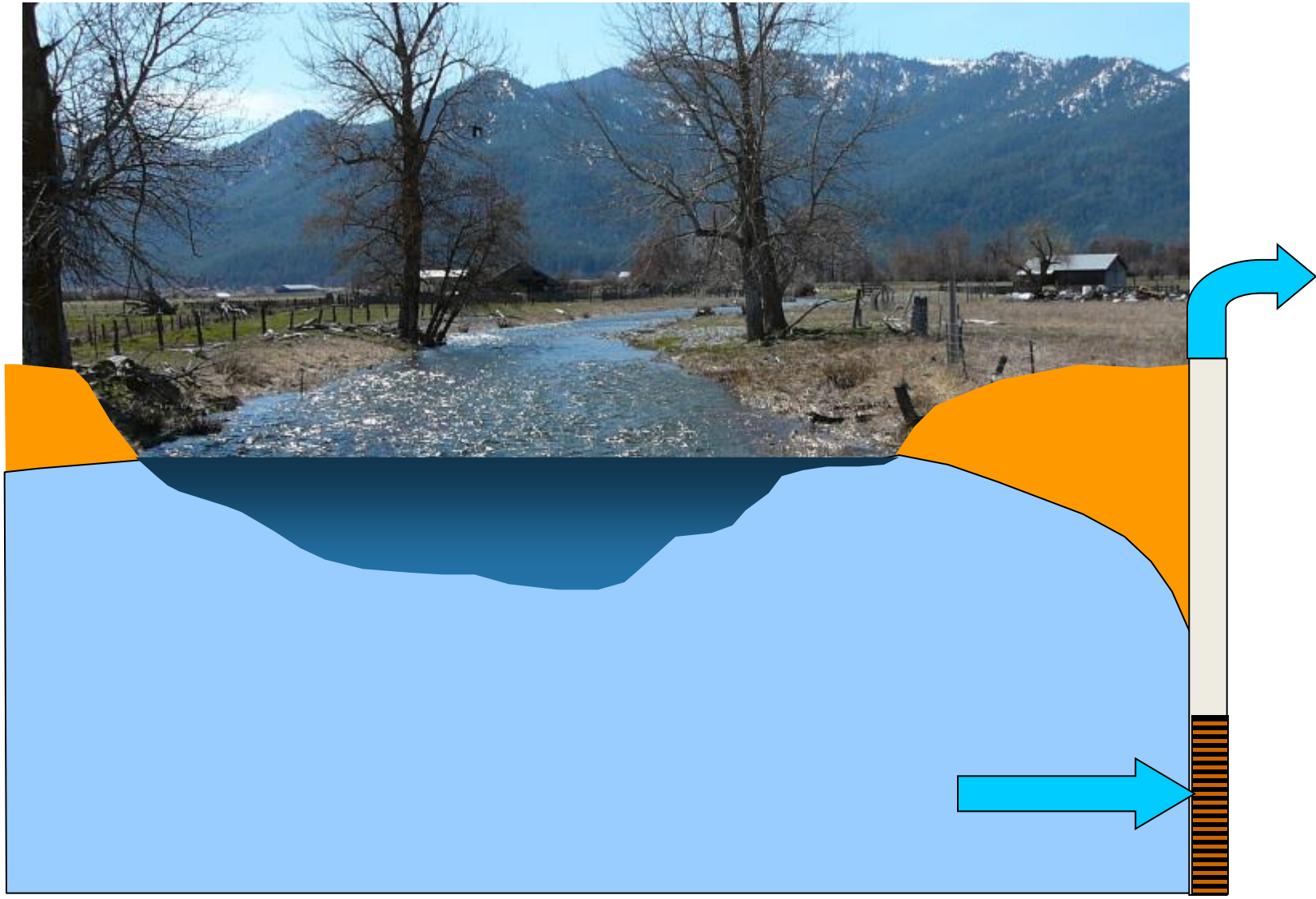

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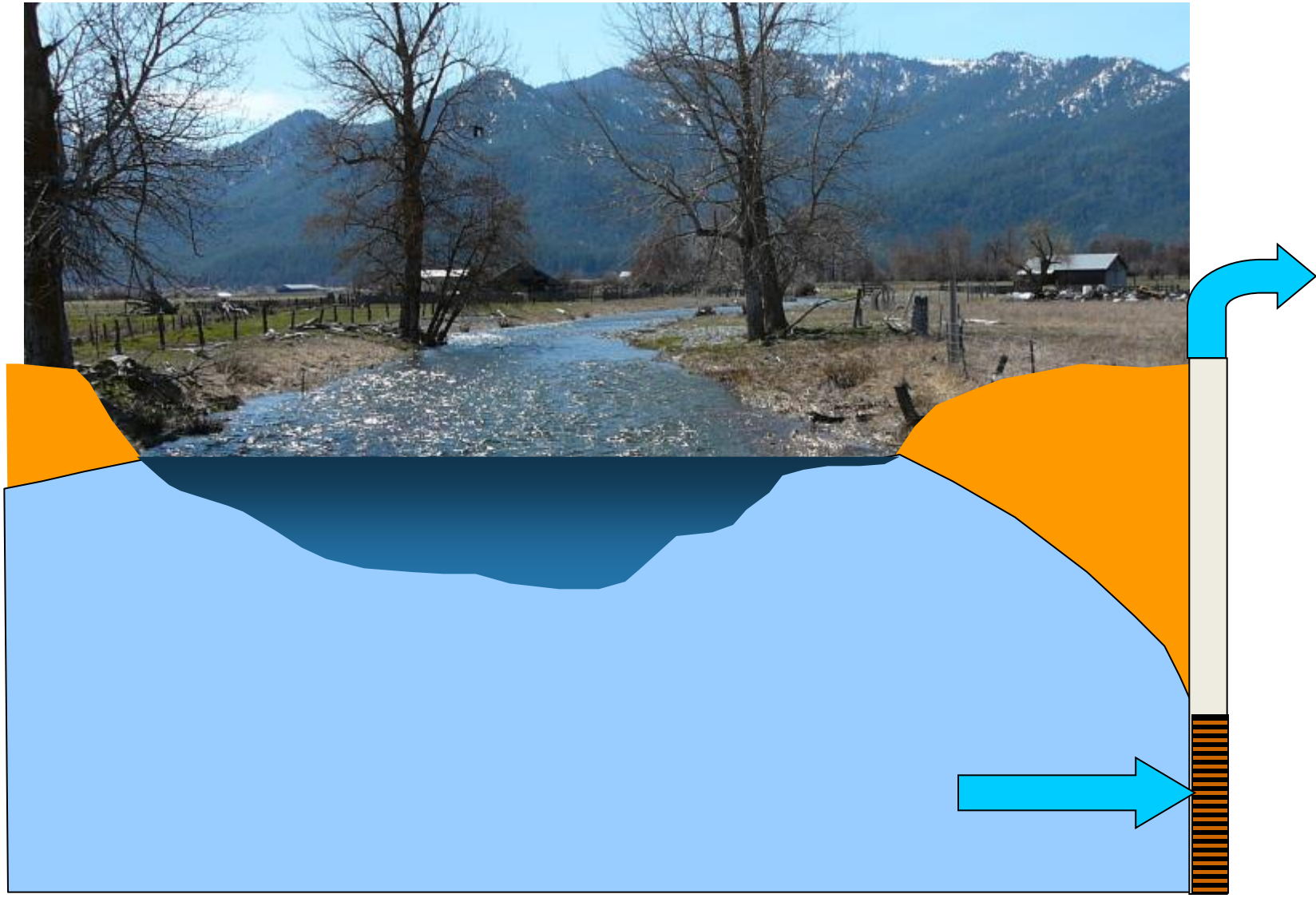

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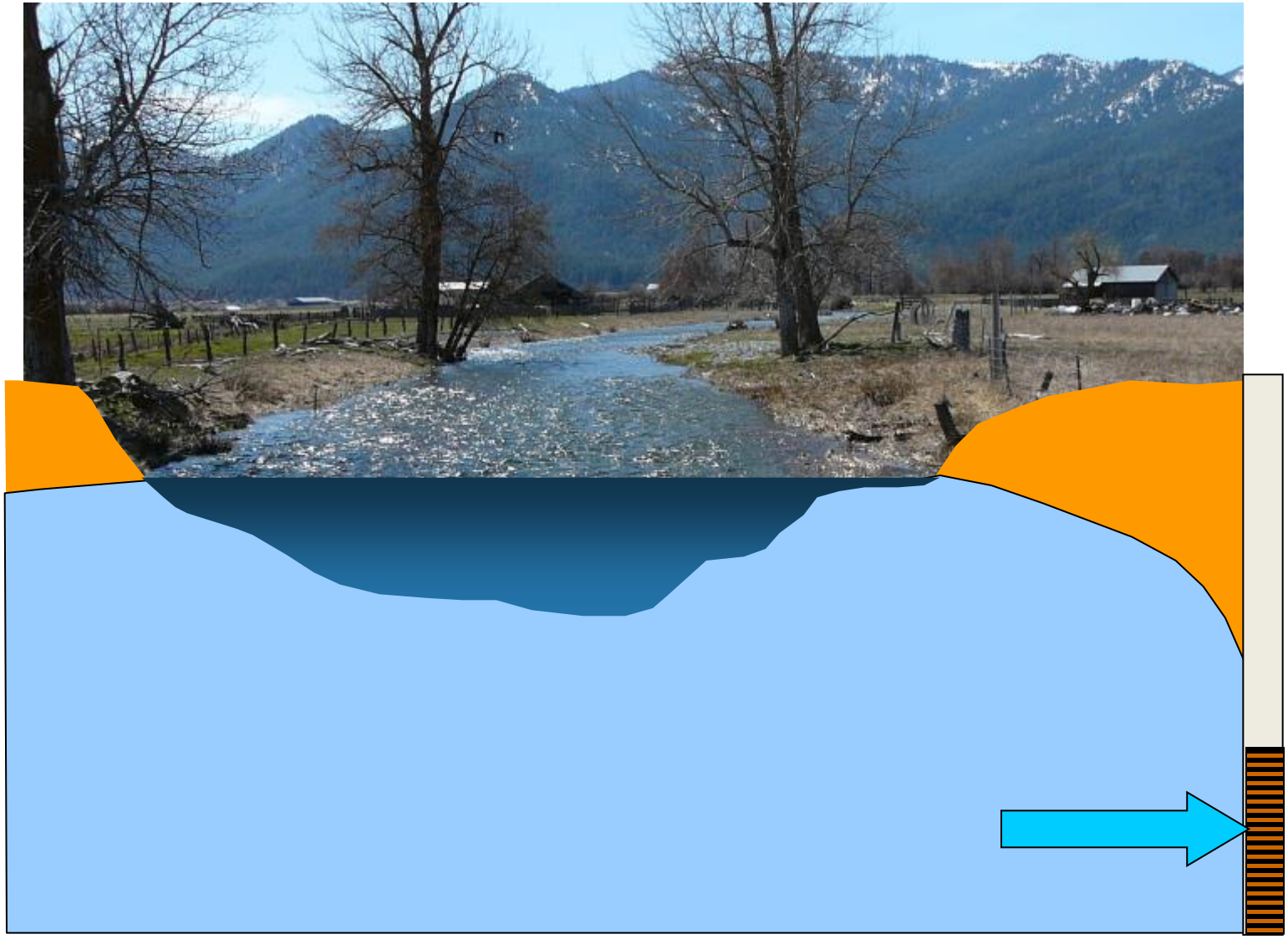

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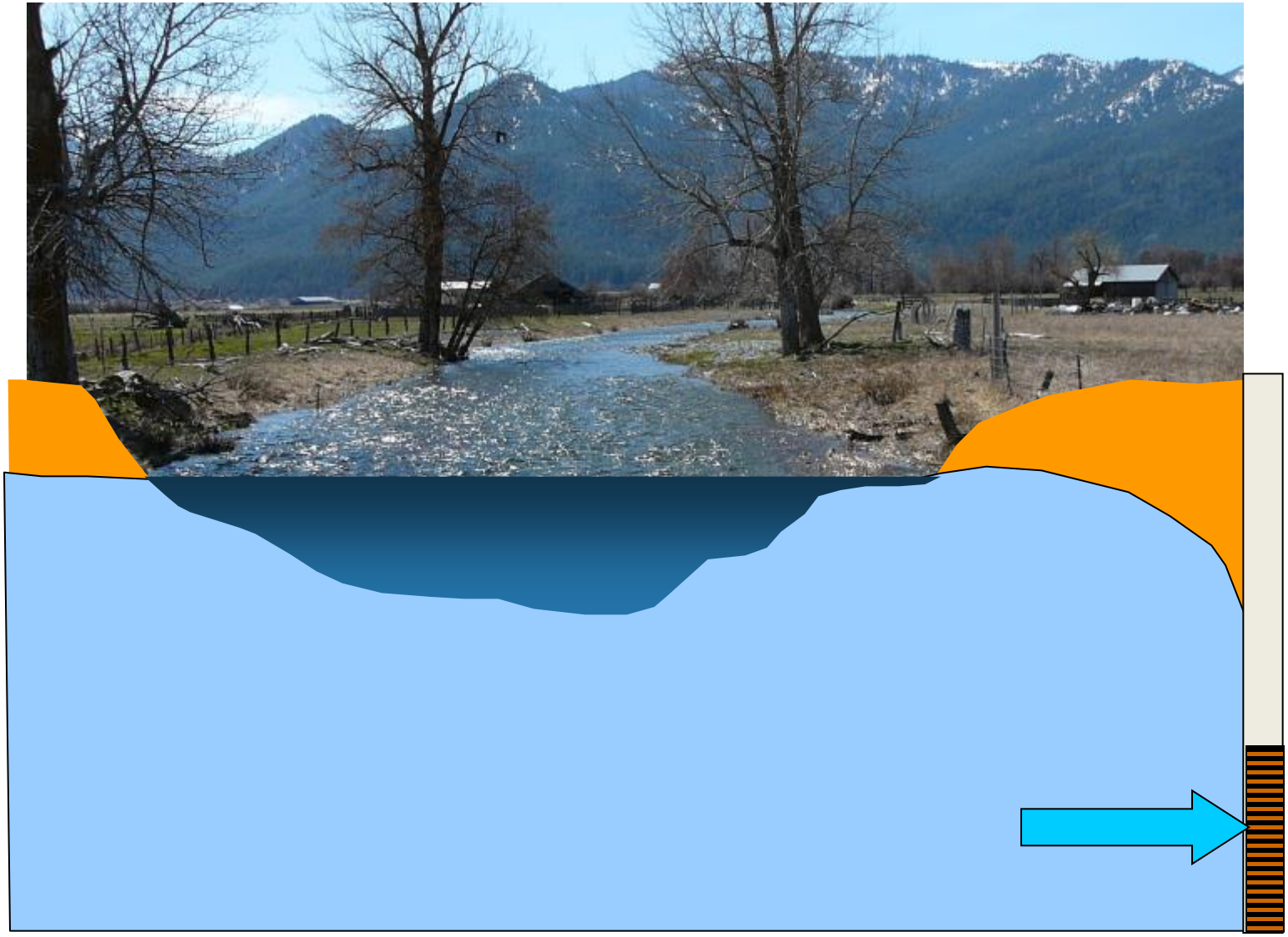
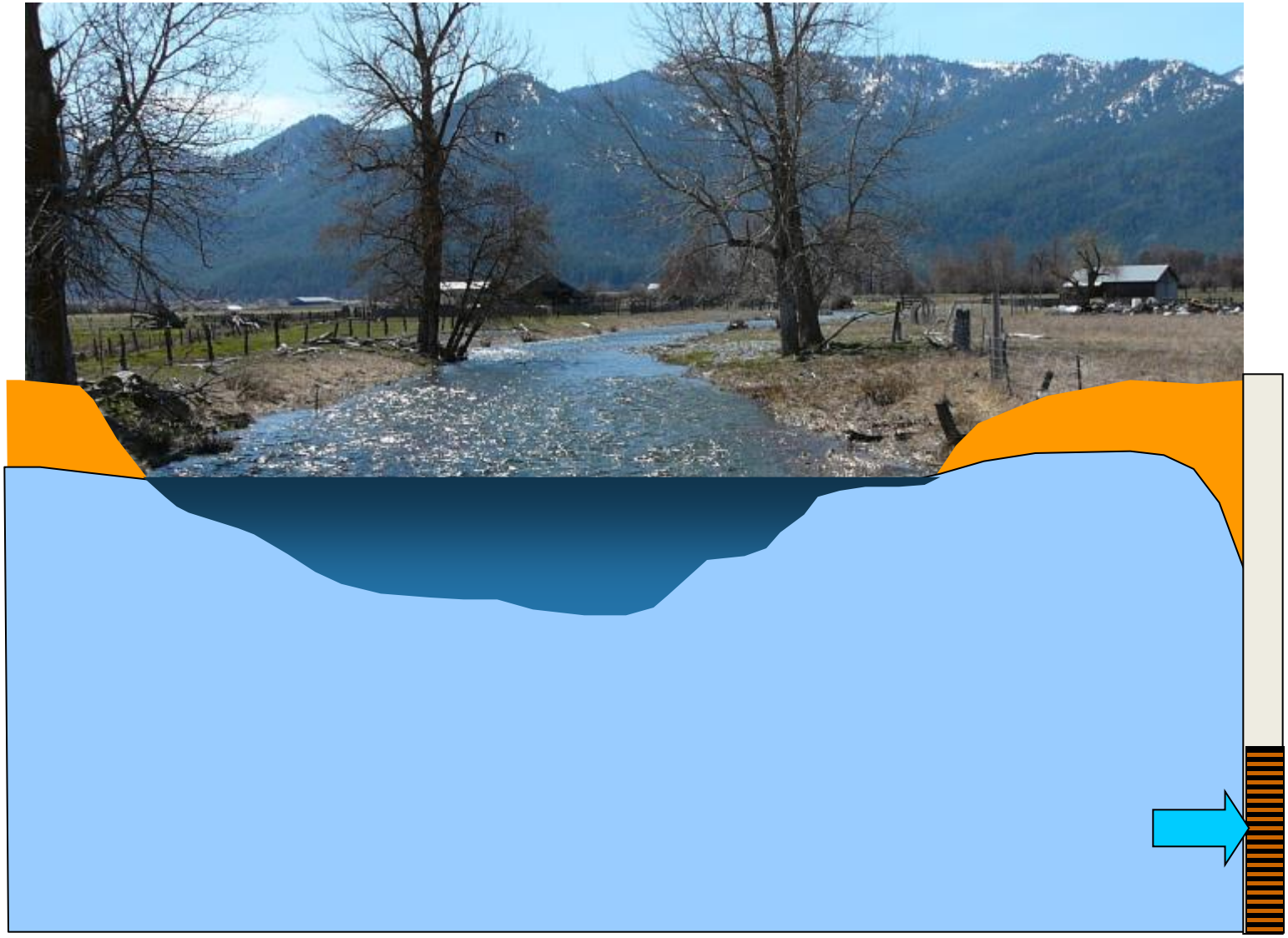
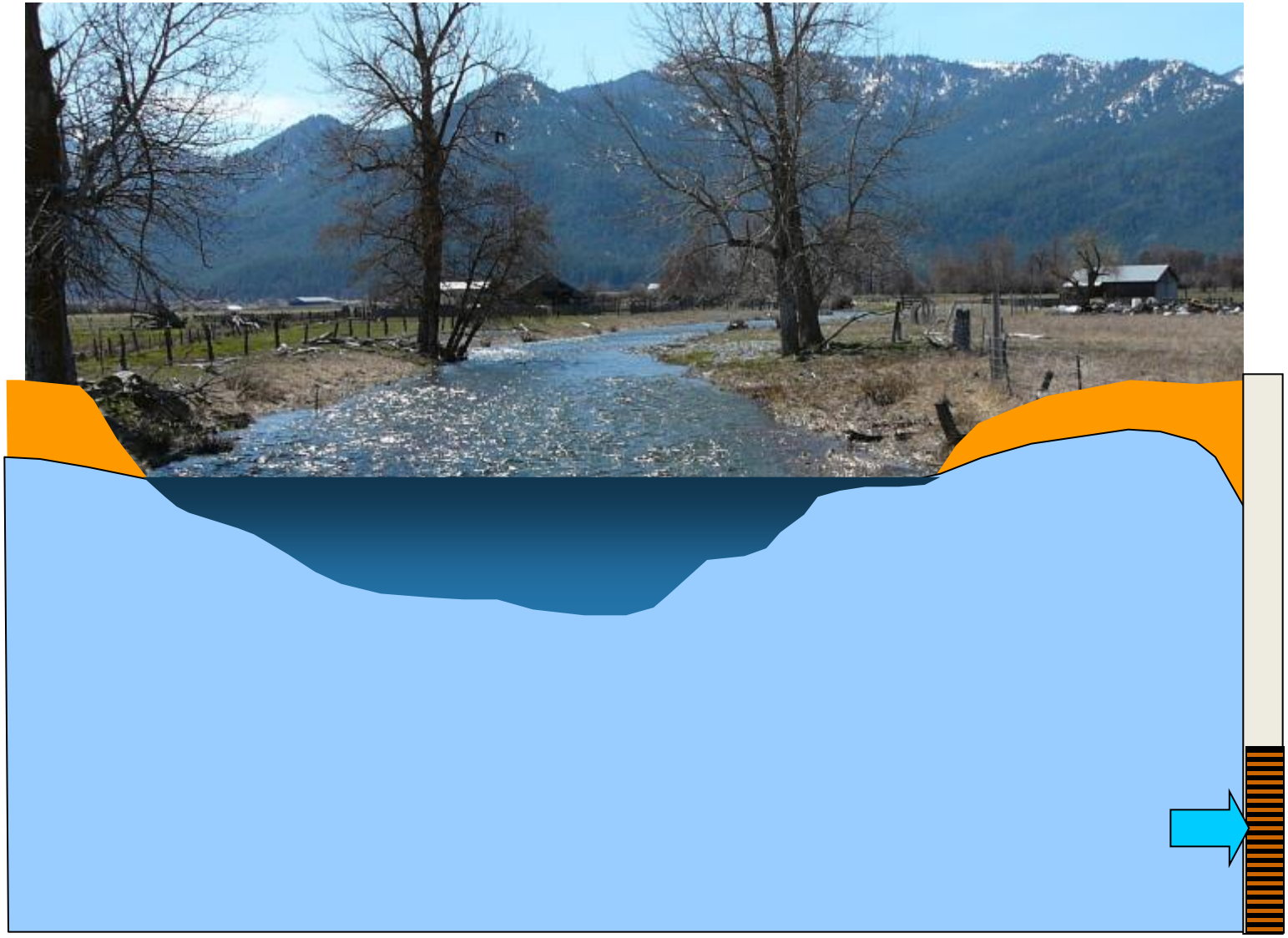


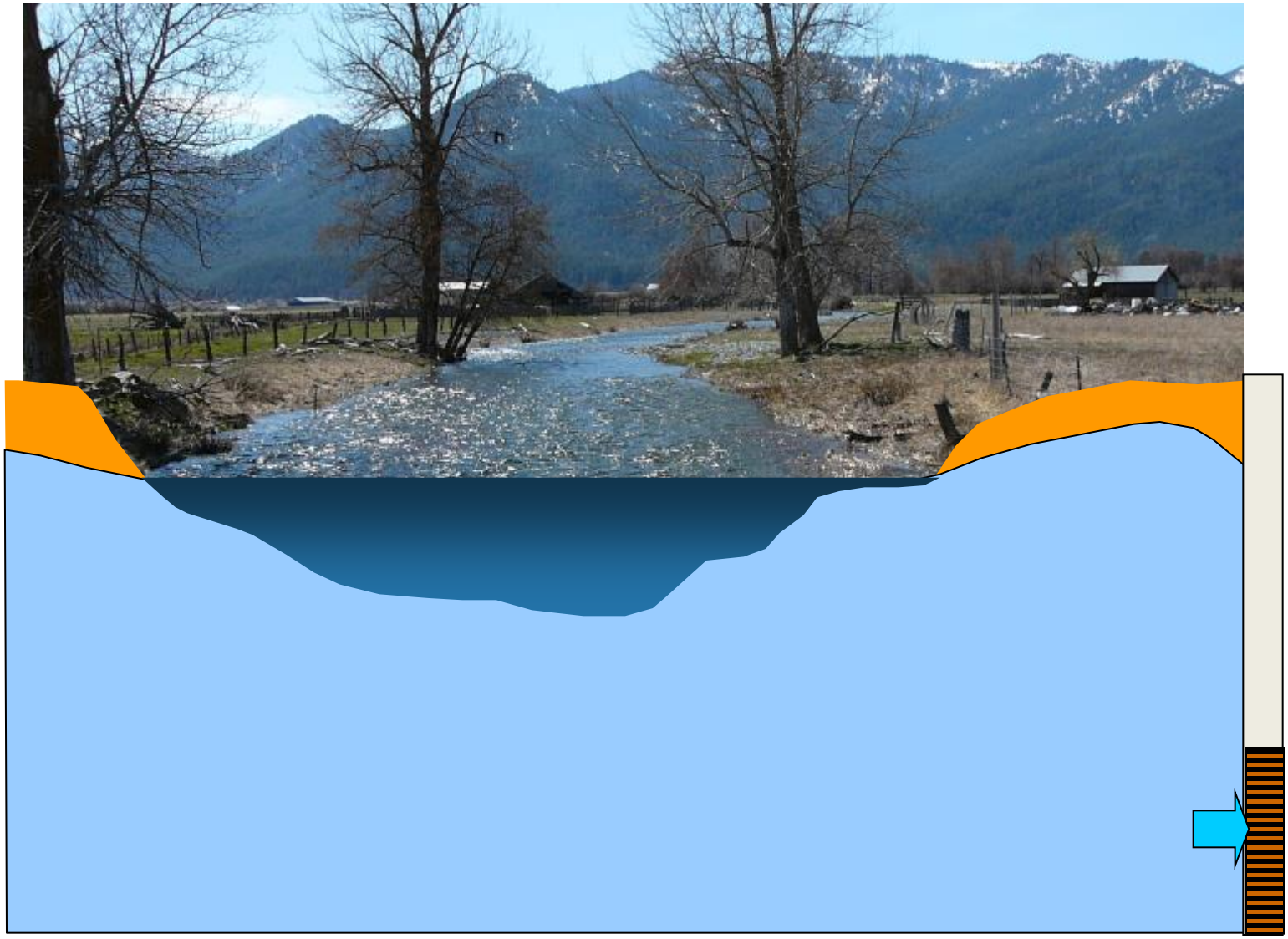
Well Near a Stream



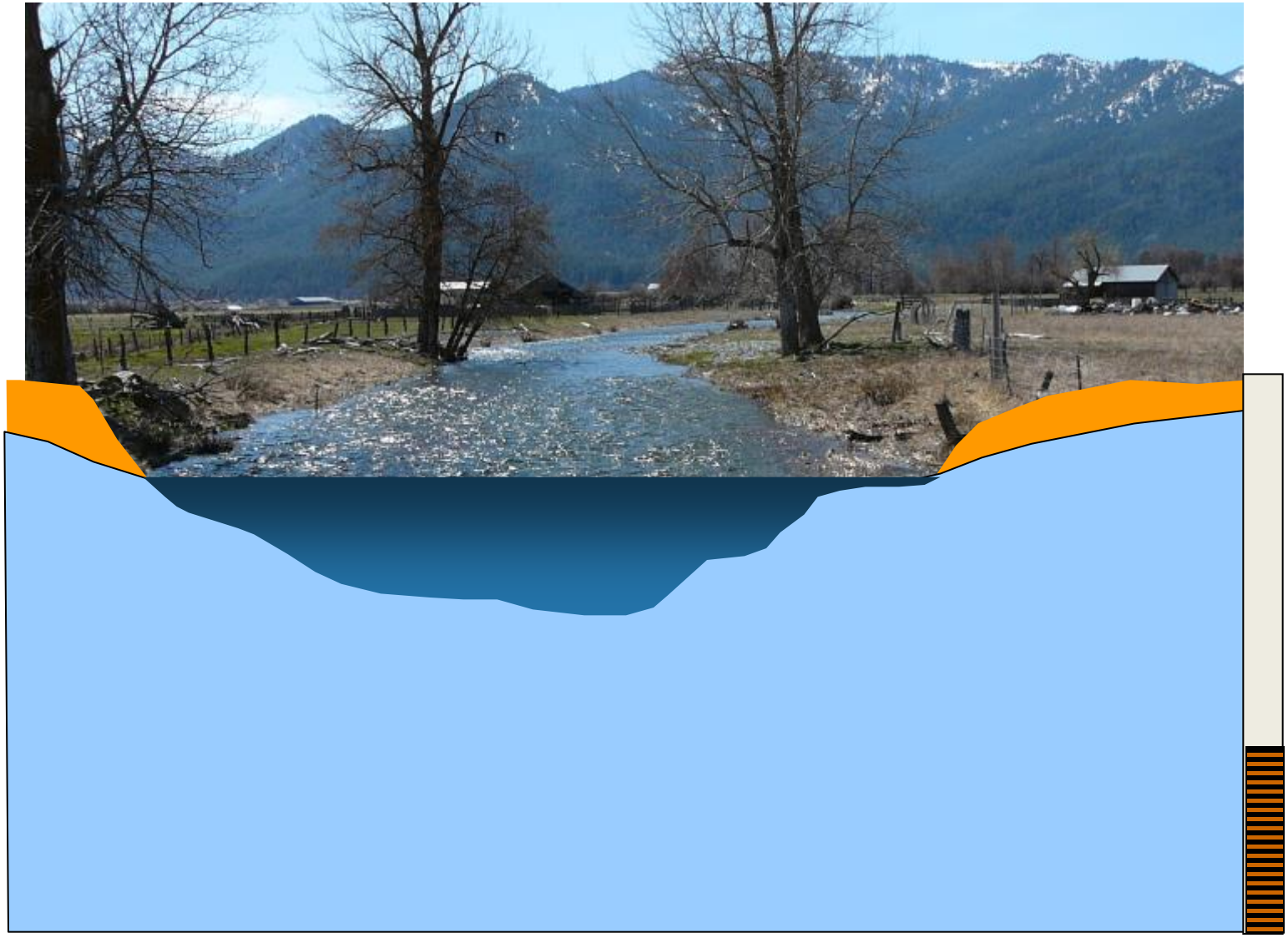
Well Near a Stream



Well Near a Stream



Well Near a Stream



Groundwater Banking for Environmental Flows: Scott Valley, Siskiyou County

Groundwater Management Tools for Regional Organization

- Limiting Groundwater Use / Mandates:
  - Limit extraction
  - Mandate reductions in current pumping
  - Limit construction of new wells
  - Requiring water conservation measures
  - Fees to support management/infrastructure/communication efforts
- Infrastructure measures:
  - Water efficiency projects
  - Wastewater treatment and recycling
  - Importing water
  - Conjunctive use of surface water and groundwater
  - Groundwater banking
  - Monitoring networks, data collection, and data analysis/modeling
- Communication and networking measures
  - Facilitate stakeholder participation
  - Education
  - Data analysis and reporting
  - Secure funding (grants, project applications,….)
  - Inform landuse decisions by county or cities

Role of the State: **Carrot**

- Department of Water Resources has a key role:
  - Technical assistance and funding (Prop 1: $100 million for SGMA)
  - Regulation
    - Groundwater basin boundary adjustments
    - Minimum guidelines for appropriate GSP
  - Control
    - Review and approve GSPs
    - Review implementation

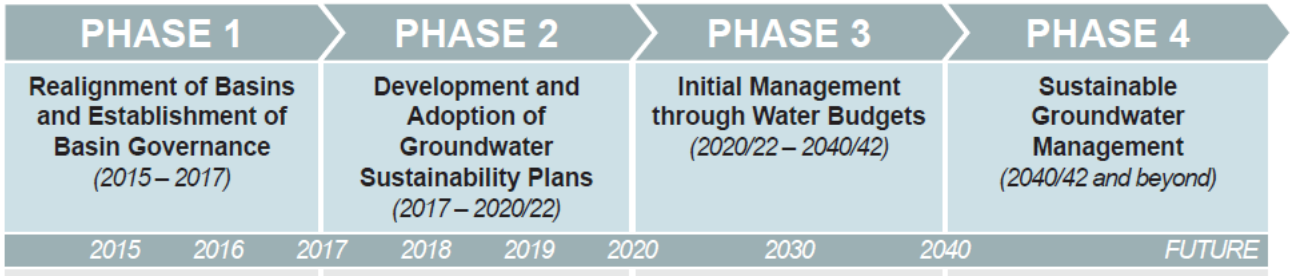
Role of the State: Carrot **& Stick**

- Department of Water Resources has a key role:
  - Technical assistance and funding (Prop 1: $100 million for SGMA)
  - Regulation
    - Groundwater basin boundary adjustments
    - Minimum guidelines for appropriate GSP
  - Control
    - Review and approve GSPs
    - Review implementation
- State Water Resources Control Board:
  - Enforcement where local control fails (after 2017)
    - "pobabationary status"
    - Public hearing and 180 days to fix the problem
  - After 180 days: SWRCB poses as interim GSA
    - Groundwater extraction reporting mandatory
    - Possibly temporary control of groundwater extraction
    - Development and implementation of interim GSP
  - When locals are ready: get authority back from state

California Groundwater Rights: Background

- Correlative Rights Doctrine – safe yield of groundwater basin shared by overlying users
  - Katz v. Wilkinshaw, 1908
- California constitutional mandate for beneficial use (1928)
- Special districts (20 different types, about 2,300 districts)
  - Water districts, irrigation districts, private water companies, reclamation districts, water conservation districts, water replenishment districts, water storage districts, etc.
- County police power – controls groundwater exports
  - Baldwin vs. Tehama County, 1994
- The Courts: basin adjudication / "physical solution" – controls extraction
  - Many Southern California (sub)basins, mid 20th century
  - City of Barstow vs. Mojave Water Agency, 2000:
    - Right of water users to negotiate physical "equitable, practical" solution, regardless of water rights
    - Individual water rights holders cannot be forced into a voluntary agreement
- State groundwater management:
  - Voluntary local groundwater management plans: AB 3030 (1992)
  - Financial incentives for local groundwater management: SB 1938 (2002)
  - Sustainable Groundwater Management Act of 2014: mandatory & expanded local control
- => if local/regional control fails: State Water Resources Control Board
- **The Courts**
  - **Streamlined adjudication (legislation in 2015: AB 1390 & SB 226)**

So What Exactly Will Happen?

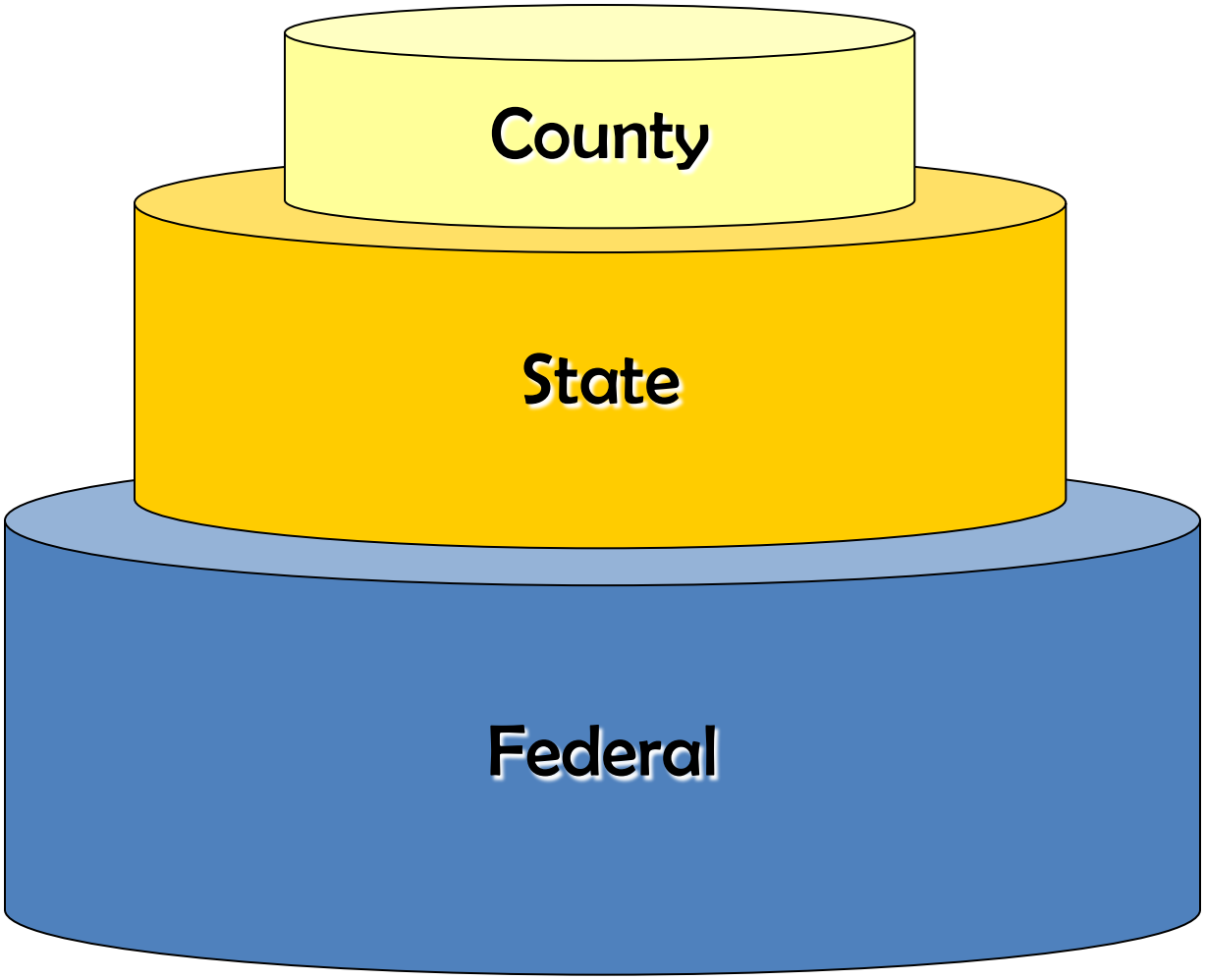


- First Step: forming a Groundwater Sustainability Agency (GSA)
  - By June 2017
- Second Step: developing a Groundwater Sustainability Plan (GSP)
  - Within 5 years of GSA formation
- **Third Step: implementing Groundwater Sustainability Plan**
  - **achieve sustainable management no later than 2042**
  - DWR may grant up to two 5-year extensions upon showing of good cause and progress

Legal Control of Water Resources

- Who owns how much water?
  - Surface water rights
  - Groundwater rights
- Water quality protection
  - Federal framework
  - California's implementation of the federal framework

The Babylonic Tower of Water Quality Regulations



Federal Framework

- National Environmental Policy Act (NEPA, 1970)
- Clean Water Act (CWA, 1972)
- Marine Protection Research and Sanctuaries Act (MPRSA, 1972)
- Safe Drinking Water Act (SDWA, 1974)
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, 1972)
- Toxic Substances Control Act (TSCA, 1976)
- Resource Conservation and Recovery Act (RCRA, 1974)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 1980) “Superfund Act”

The Federal Framework ….

…and the California Framework

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, 1972)

* registration of pesticides
* use of pesticides

Dep. Pesticide Regulations

Water Well Standards

Dep. Water Resources

California Environmental Quality Act, CEQA;

Porter-Cologne Act

SWRCB / RWQCB / local

Safe Drinking Water Act, 1974

* drinking water standards
* wellhead protection program
* source water assessment
* source water protection
* annual reporting to customers

Dep. Health Services

Clean Water Act, 1972

* point source (NPDES)
* nonpoint source regulation
* BMP mandate
* TMDL (total max. daily load)

State Water Resources Control Board
&
Regional Water Res. Control Boards

[Porter-Cologne Water Quality Control Act]

The Federal Framework ….

…and the California Framework

Superfund (CERCLA, 1980)

* cleanup and cost recovery program for contaminated groundwater sites

Dep. Toxic Subst. Control & Regional Water Res. Control Boards

Resource Conservation and Recovery Act (RCRA, 1976)

*cradle to grave monitoring of hazardous substances
* guidelines for managing nonhazardous waste facilities
* mandates standards for all handlers of hazardous waste (generators, transporters, and treatment, storage, and disposal facilities ("TSDFs"))

Dep. Toxic Substances Control

Toxic Substances Control Act (TSCA, 1976)

* registration program for toxic substances (other than pesticides)

Dep. Of Toxic Substances Control

Major Water Quality Regulations related to Farming

USDA:
Comprehensive Nutrient Management Plans
(guideline only)
farm / field scale

EPA:
Permit Nutrient Plans
(under revised NPDES regulations)
farm / field scale

CWA:
Effluent limitation guidelines
(under revised NPDES regulations)
farm scale

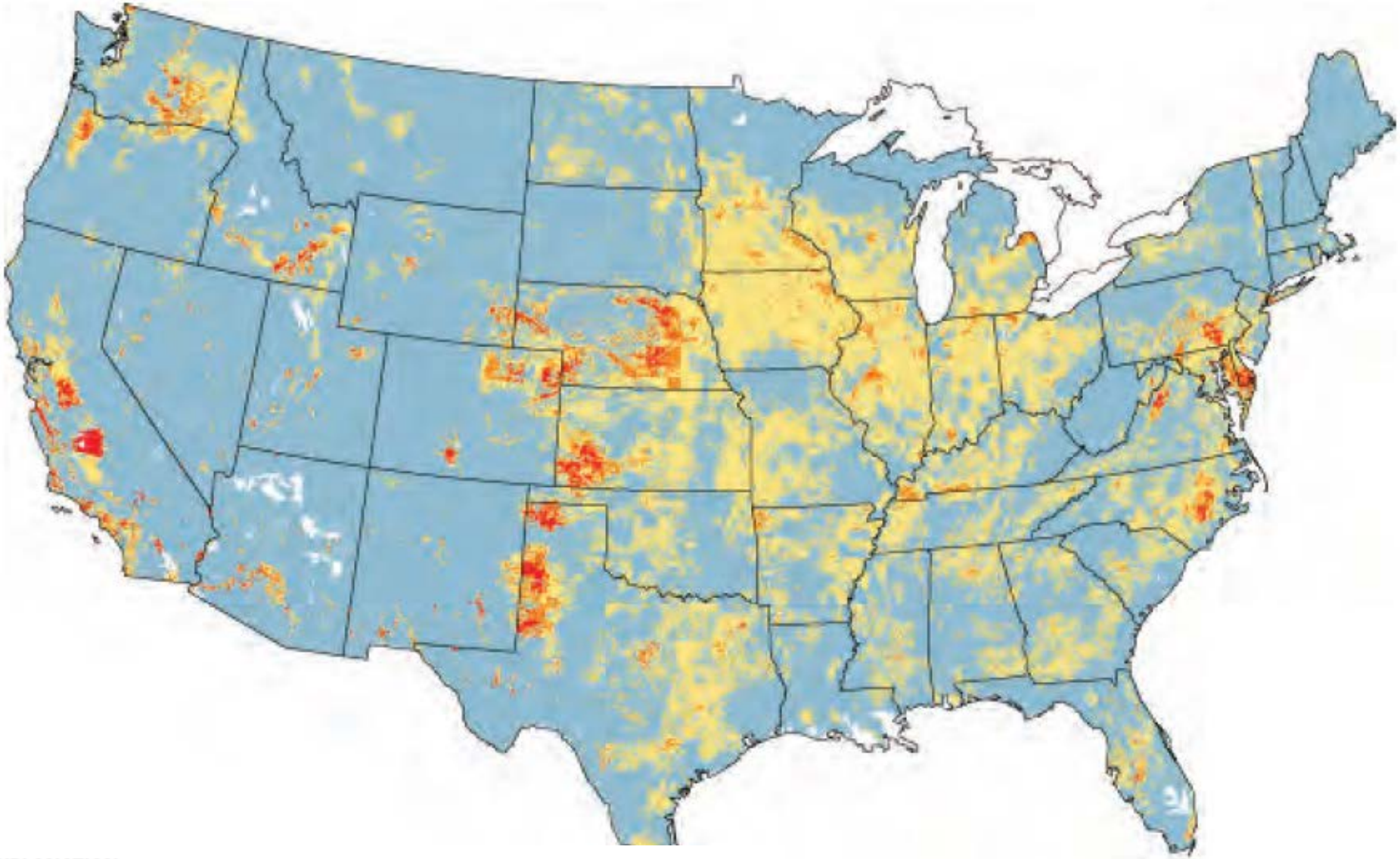
NEPA/CEQA:
EIR process for new permits
field / subfield scale

CWA: TMDLs
watershed scale

FIFRA:
pesticide use
farm / field scale

12/2002 sunset of 1982 CEQA ag effluent waiver (Porter-Cologne)
* waste dicharge requirements
(e.g. dairy WDR)
* waiver of waste discharge
(e.g. Irrigated Lands Conditional Waiver)
farm / field scale

Model for deep groundwater used as drinking water (50-m simulation depth)



EXPLANATION

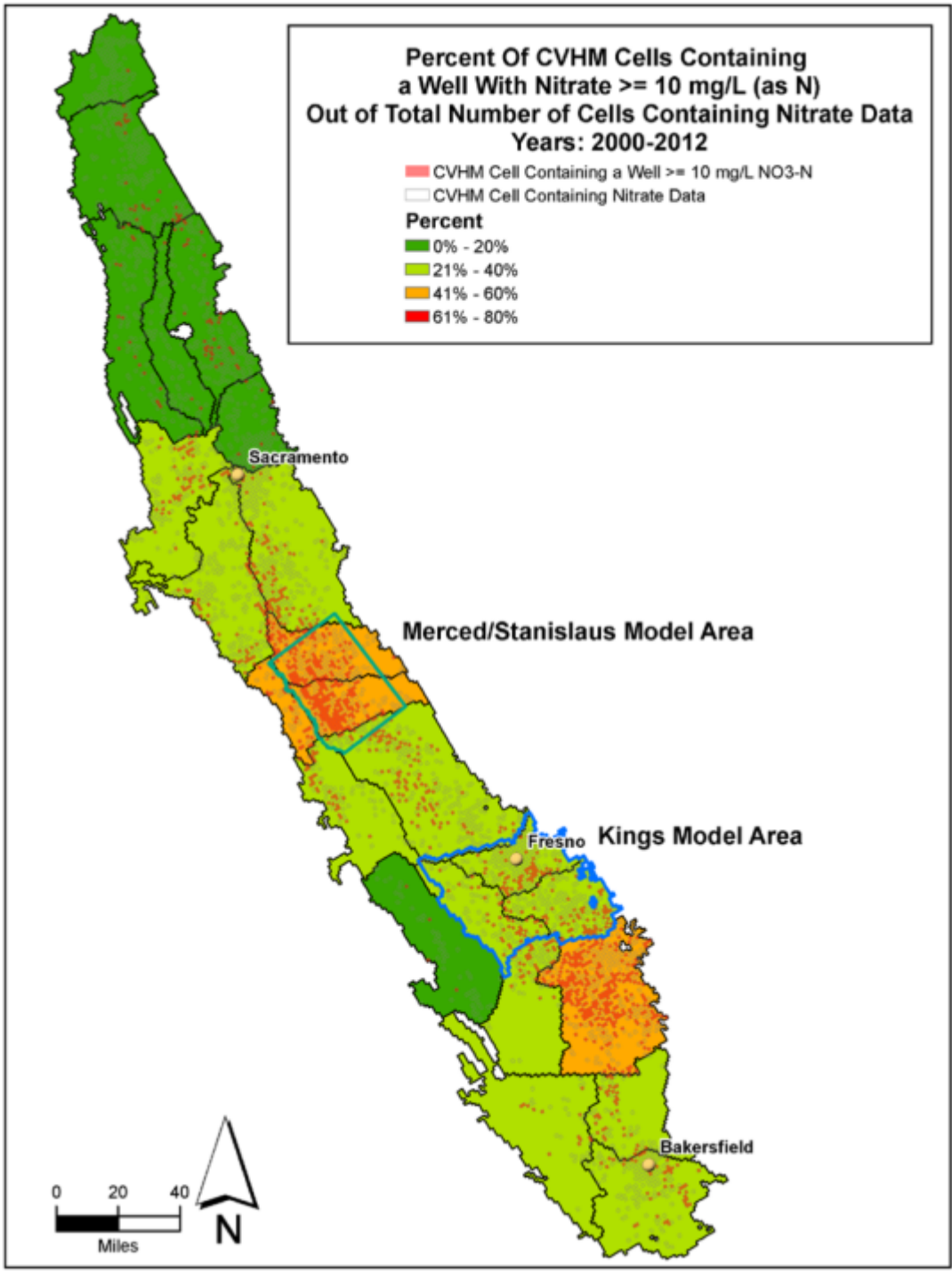
Predicted nitrate concentration, in milligrams per liter as N

≤1 | >1–5 | >5–10 | >10 | Missing data

Dubrovsky et al., USGS, 2010

Nitrate: Impacted regions within the Central Valley

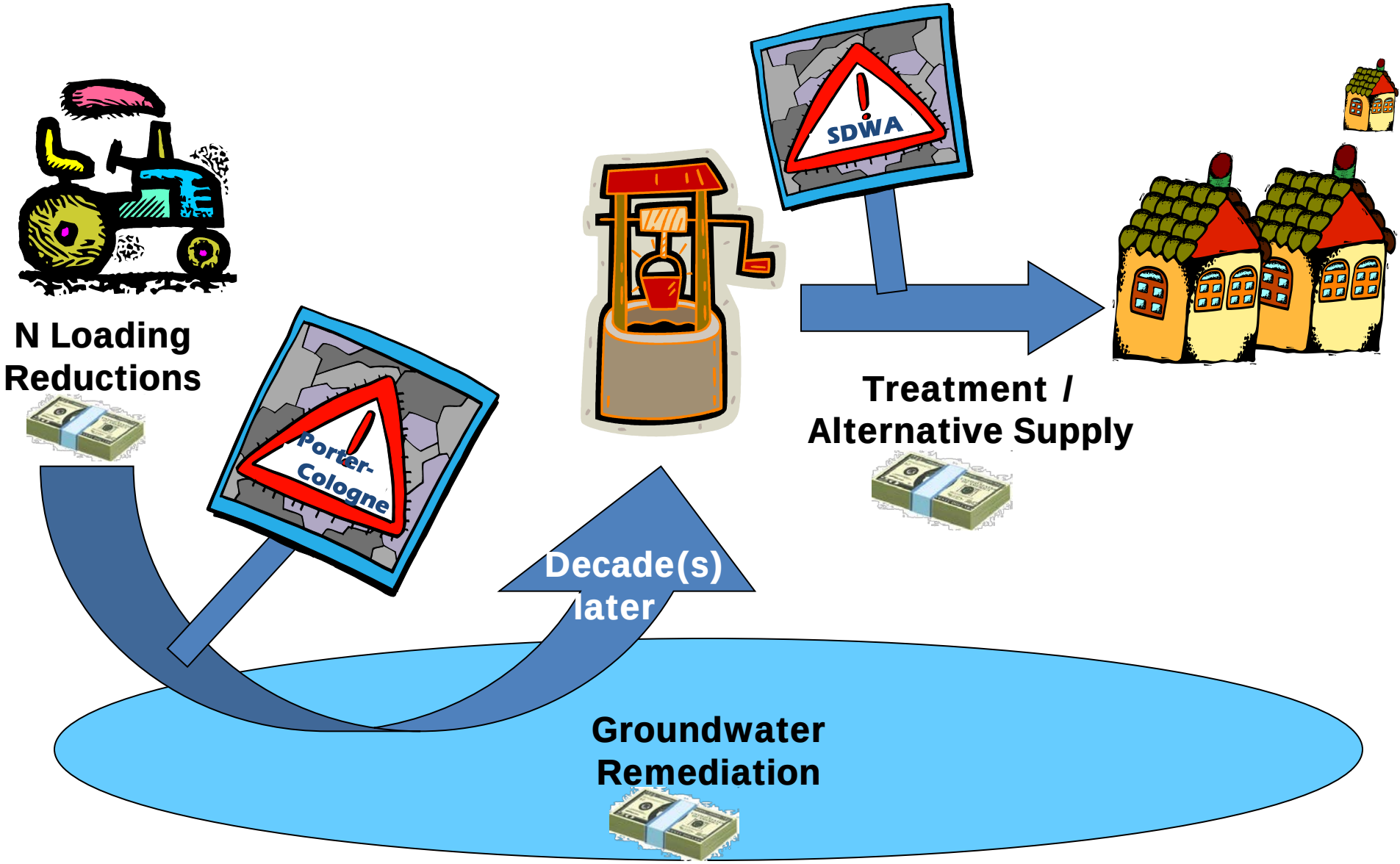
red dots: wells above MCL for nitrate



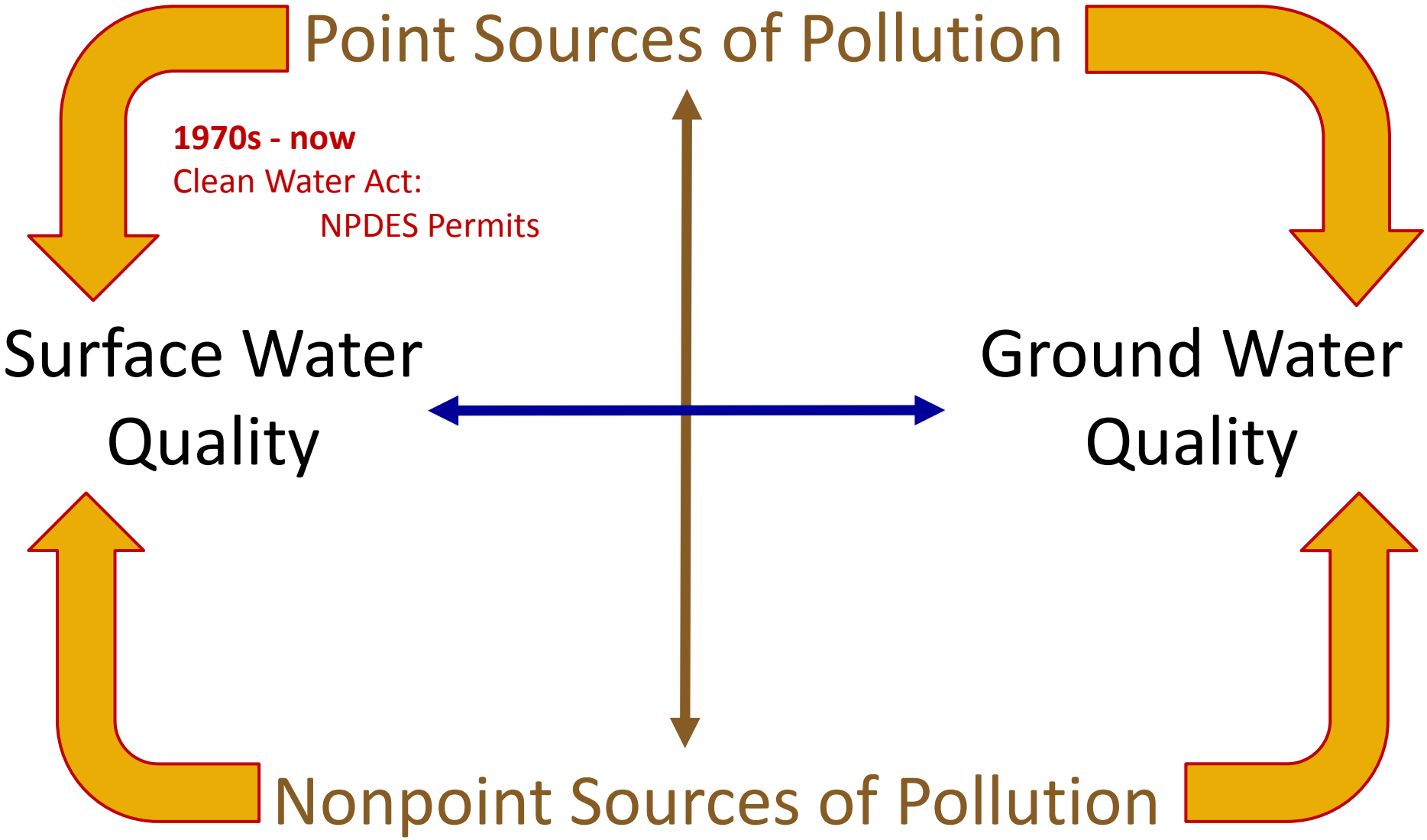
CVSALTS, Tasks 7 and 8 – Salt and Nitrate Analysis for the Central Valley Floor
Final Report, December 2013

Figure 7-14

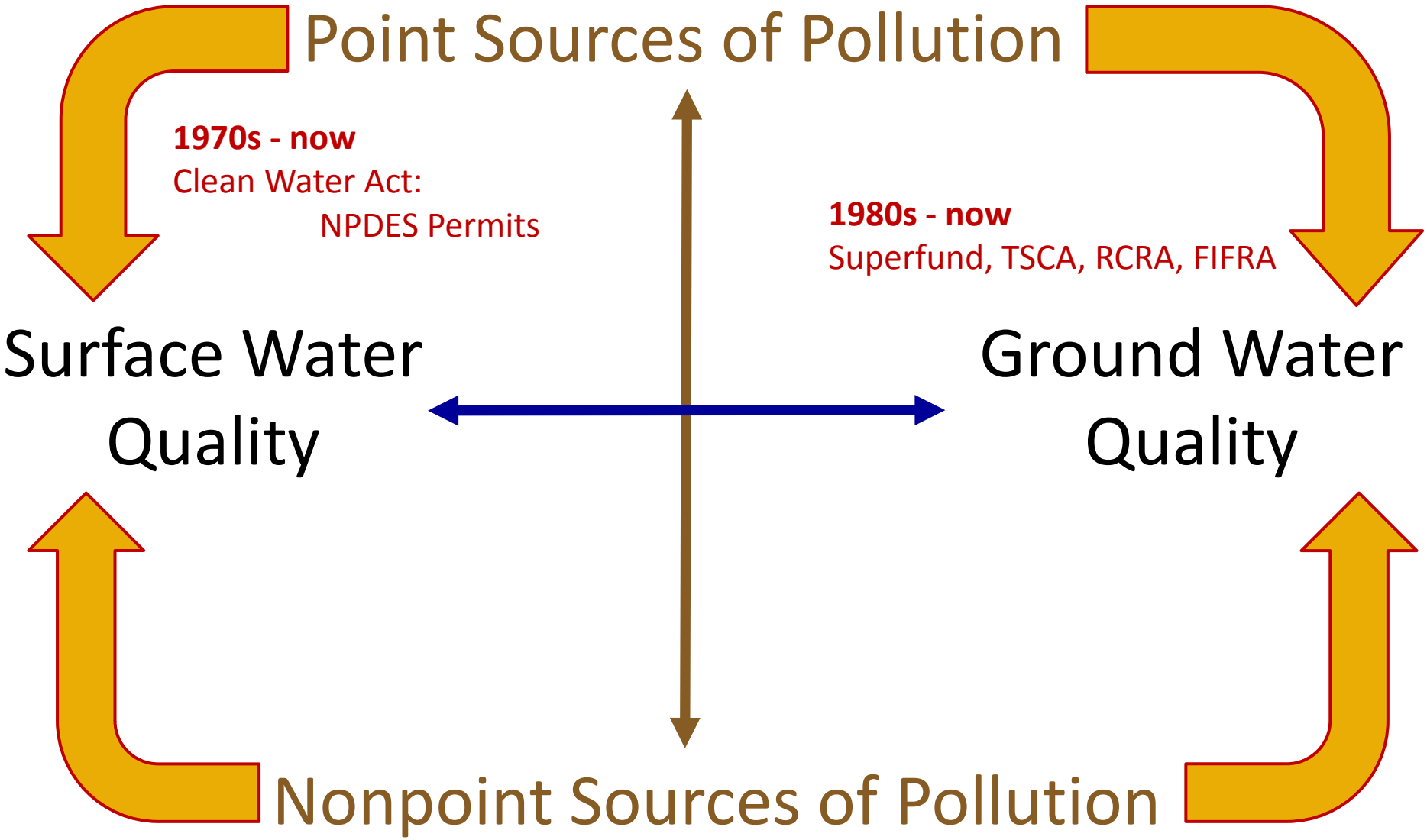
Nitrate: Funding and Regulatory Framework



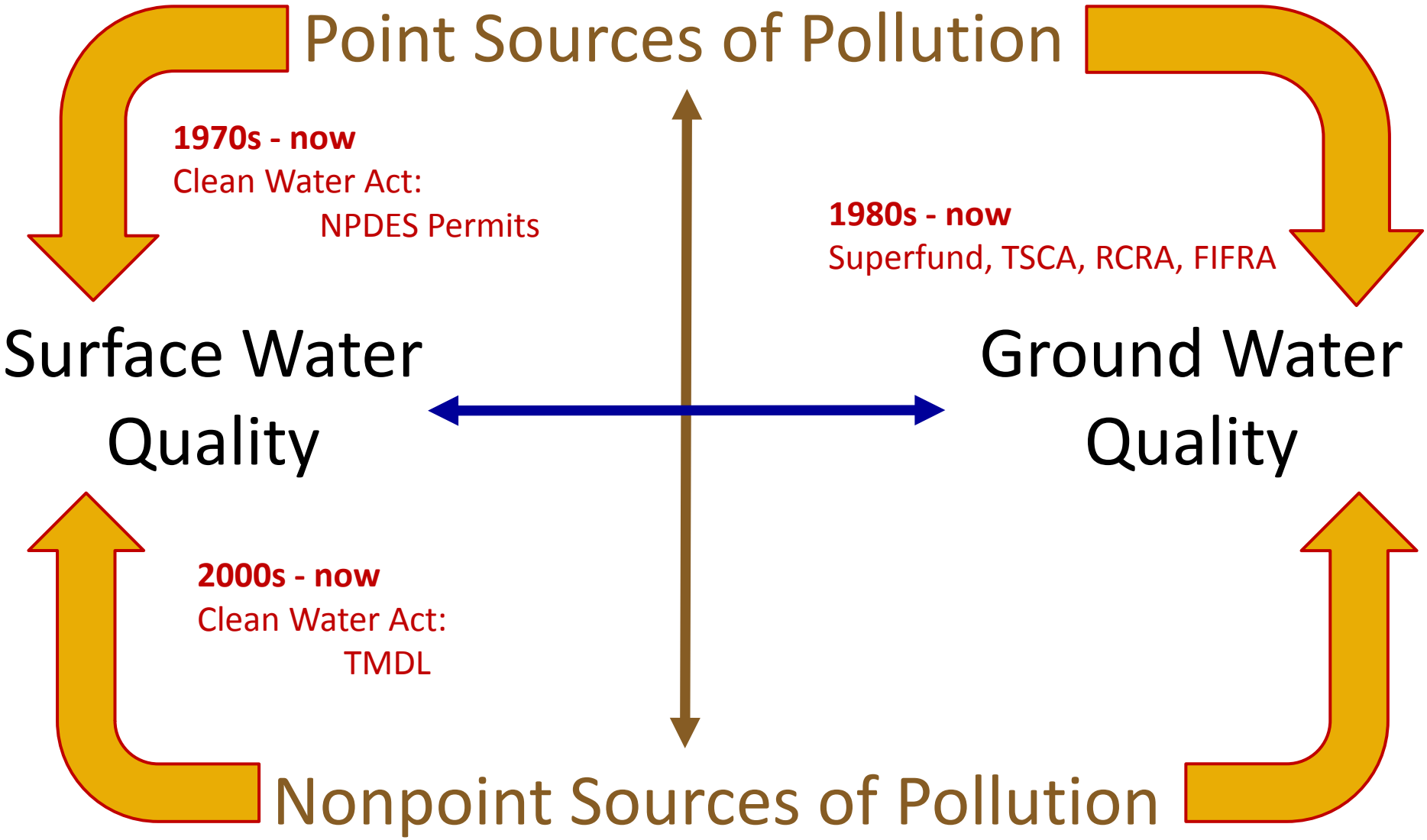
Regulating Water Pollution Sources



Regulating Water Pollution Sources



Regulating Water Pollution Sources



Focus: Enforcement Monitoring

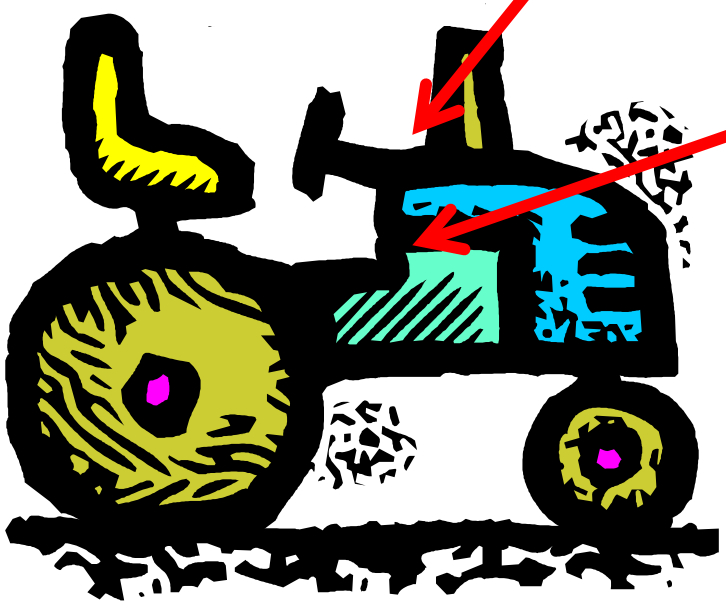
Example of Working with a Regulation: Speed Limit

Responsible Party:
Driver

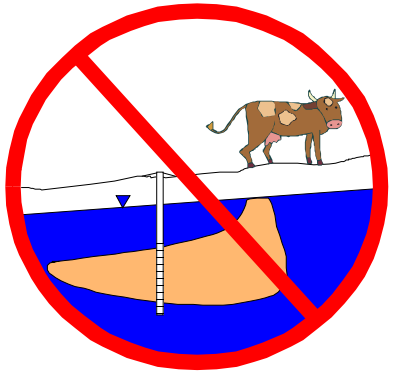
Feedback:
Speedometer

Management Tool:
Brakes

Enforcement:
Radar Controls



Why is Nonpoint Source Pollution Different from Point Source Pollution of Groundwater?



- Scale
  - Millions of acres vs. 1-10 acres
- Intensity
  - Within ~1 order magnitude above MCL vs. many orders of magnitude above MCL
- Hydrologic Function
  - Recharge vs. non-leaky
- Frequency
  - Ongoing/seasonally repeated vs. incidental
- Heterogeneity & Adjacency

Focus: Enforcement Monitoring

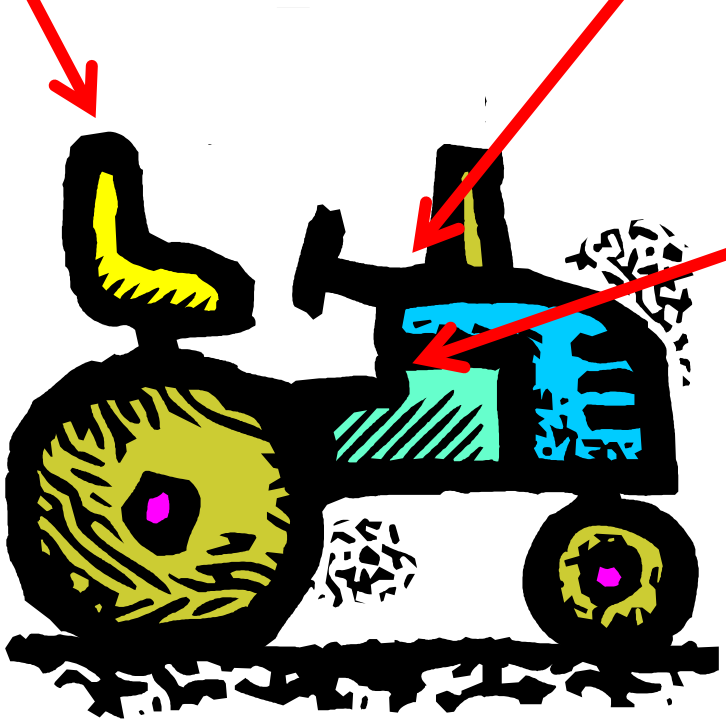
Applying Point Source Approach to Nonpoint Source:

Responsible Party:
Landowner

Feedback:
missing

Management Tool:
$$$ "agronomic"

Enforcement:
Monitoring Wells



Focus: Enforcement Monitoring

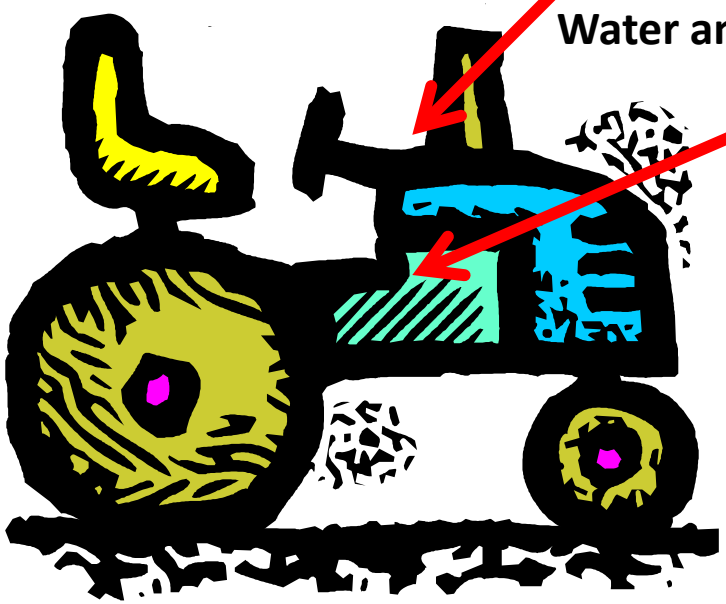
Alternative Monitoring Approach to Nonpoint Source:

Responsible Party:
Landowner

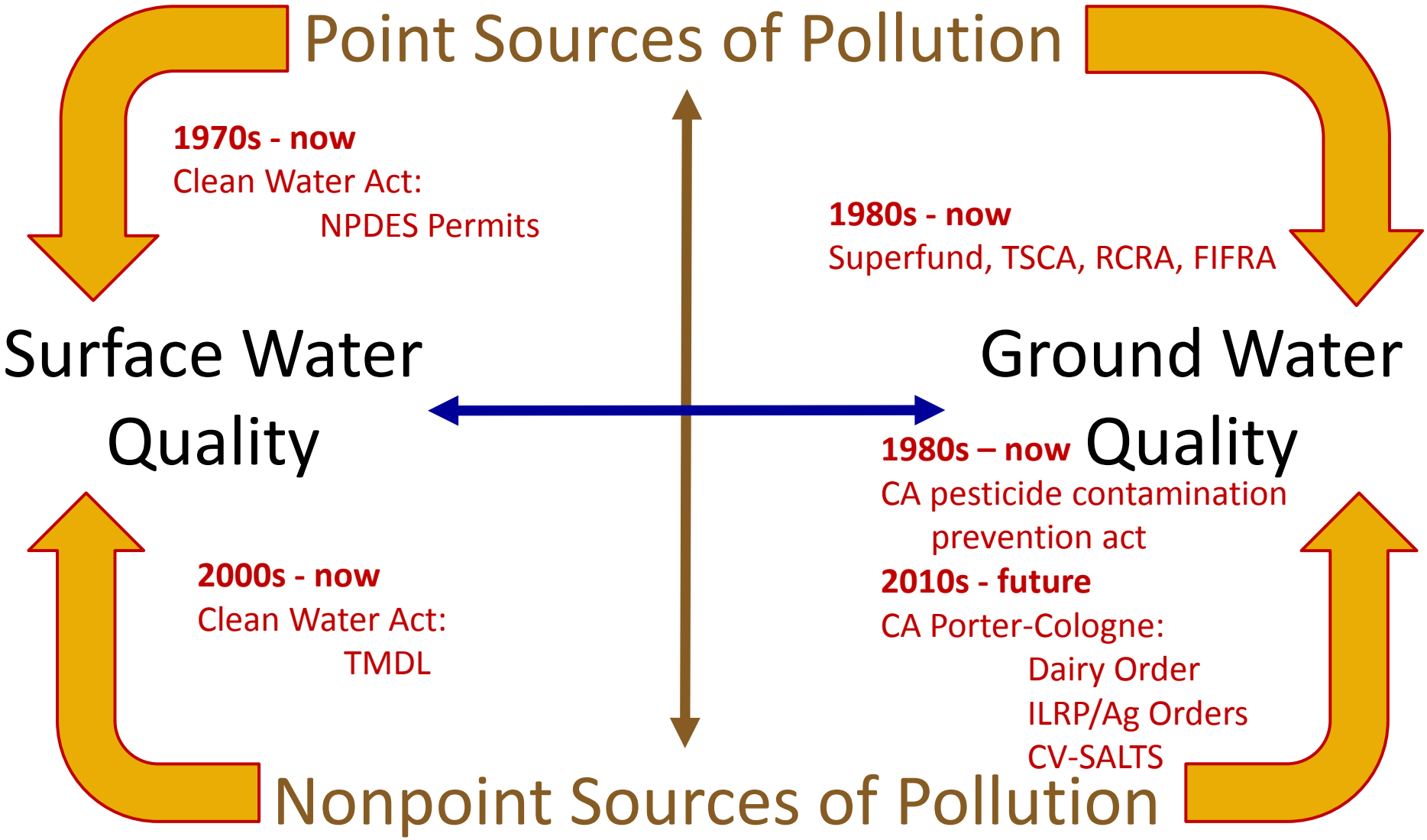
Feedback:
Nutrient/Water Monitoring & Assessment

Management Tool:
Water and Nutrient Management

Enforcement:
Annual Nitrogen Budget
+
Management Practice Assessment
+
Regional Trend Monitoring



Regulating Water Pollution Sources

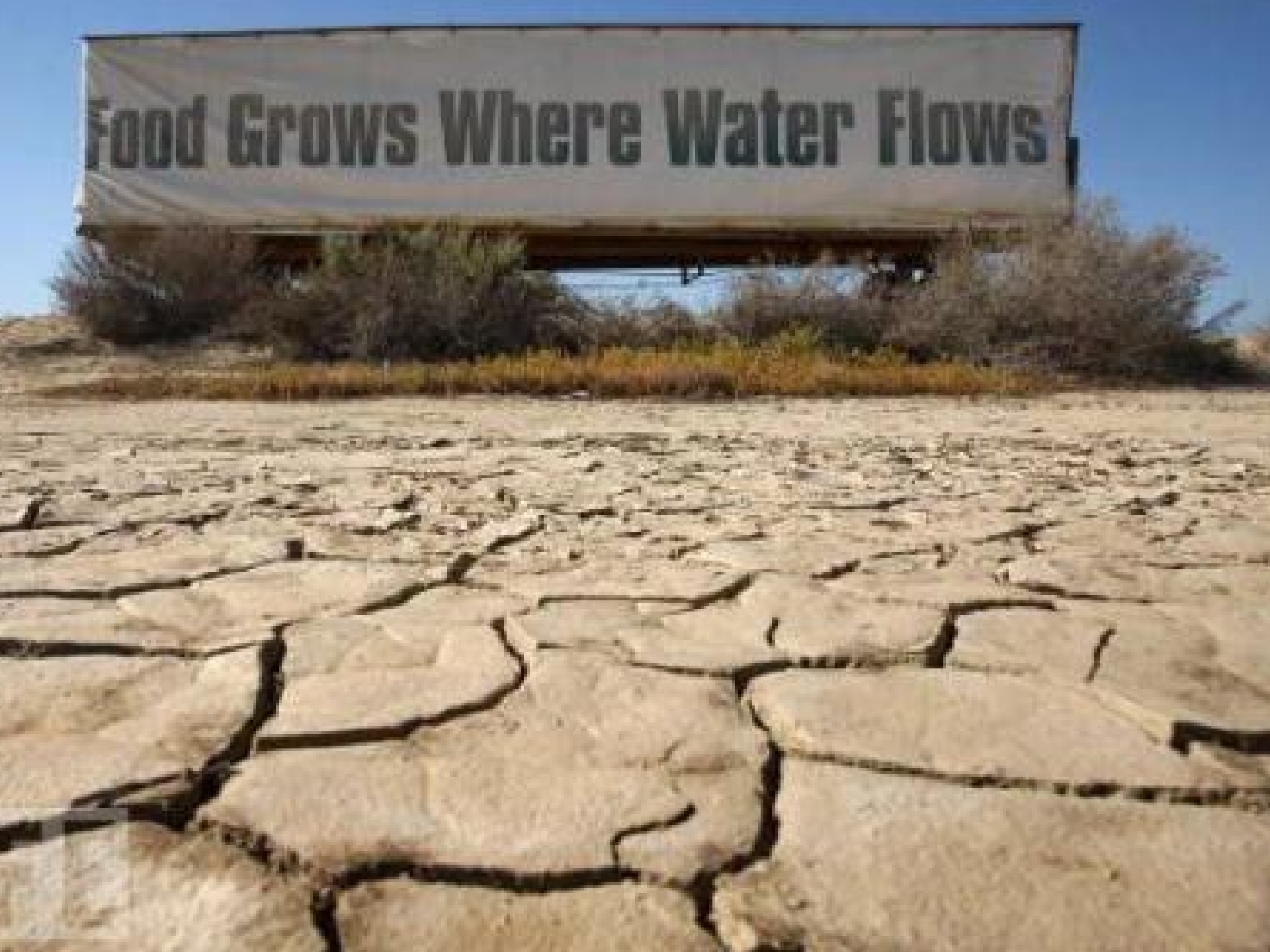


Future of Groundwater Management in Agricultural Regions:

Opportunity for creative solutions to **simultaneously** address

- groundwater supply enhancement
- groundwater quality improvement
- drinking water protection
- economic viability of agriculture

High irrigation efficiency + High nutrient use efficiency + CLEAN groundwater recharge


Food Grows Where Water Flows

13
15
20
18
18

Online Resources

- http://groundwater.ucdavis.edu/sgma
- http://groundwater.ucdavis.edu/calendar
- http://www.water.ca.gov/groundwater/casgem/ (California DWR groundwater level monitoring program
- http://www.water.ca.gov/waterconditions/drought/# (California DWR drought information)
- http://www.waterboards.ca.gov/gama/geotracker_gama.shtml (California groundwater quality information)
- http://groundwater.ucdavis.edu/links_California/ (miscellaneous groundwater information sources)
- Contact Dr. Thomas Harter at ThHarter@ucdavis.edu