Source Water Protection: Dairies, Irrigated Agriculture, and Groundwater

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Motivation

- Worldwide dependence on groundwater
  - 2.3 billion people
  - > 60% of gw use towards farming in arid/semi-arid regions
- Surge of groundwater use over past 50 years (turbine pump, cheap energy, food demands)
- Increasing intensity of landuse (crops, animals, industry, urban)

↑ dependency on gw  &  ↑ contamination

SUSTAINABILITY?

Pervasive GW Pollutant: NO₃

Note: 10 mg N/l = 10 kg N/km²/yr for each 1 mm/yr recharge

UN World Water Development Report II, 2006
Nitrogen Load: Risk Analysis

Based on logistic regression model:
- N loading
- % cropland or pasture
- Human population density
- Well drained soil
- Sand/gravel aquifer
- Depth to gw

Integrating GW Resources Mgmt

LOAD

Technical Measures
- Resource evaluation
- Hazard assessment
- Pollution control
- Pollution assessment
  - Geohydrology
  - Microbiology
  - Transport/Physics
  - Monitoring

Education

Institutional Measures
- Water rights
- Discharge regulations
- Landuse planning
- Economic incentives
- Local/regional planning and management
- Stakeholder interests

Ecosystems & Landuse Systems:
- Demand (Quantity)
- Usability (Quality)

USE

Aquifer Systems:
- Quantity
- Quality

Stakeholder Participation
Perspectives on NPS Pollution for Successful Source Protection

- Understanding NPS Sources
  - here: dairies/(C)AFOs
  - source control
  - management practices
- Understanding pollutants
  - physics/chemistry of environmental fate
    - Transport
    - Sorption
    - Degradation
  - analytical methods
  - assessment models
- Policy
  - regulatory programs
  - management programs
  - role of monitoring / feedback

Agricultural NPS Pollutants

- Salinity
- Nitrate
- Pesticides
- Emerging contaminants in animal farming:
  - Pathogens (E. coli H7 O157, Campylobacter, Salmonella, Cryptosporidium)
  - Antibiotics & other pharmaceuticals
  - Steroid hormones
The Federal Framework in California

**Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA, 1972)**
- registration of pesticides
- use of pesticides

**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**

**Safe Drinking Water Act, 1974**
- drinking water standards
- wellhead protection program
- source water assessment
- source water protection
- annual reporting to customers

**Dep. Health Services**

**Water Well Standards**

**Dep. Water Resources**

**Porter-Cologne Act**

**California Environmental Quality Act, CEQA**

**Dep. Of Toxic Substances Control**

- 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**

**Superfund (CERCLA, 1980)**
- cleanup and cost recovery program for contaminated groundwater sites


**Toxic Substances Control Act (TSCA, 1976)**
- registration program for toxic substances (other than pesticides)

**Dep. Of Toxic Substances Control**

**Porter-Cologne Water Quality Control Act**
Major Water Quality Regulations related to Farming

- **USDA**: Comprehensive Nutrient Management Plans (guideline only)  
field / subfield scale
- **NEPA/CEQA**: EIR process for new permits  
field / subfield scale
- **EPA**: Permit Nutrient Plans (under revised NPDES regulations)  
farm / field scale
- **CWA**: Effluent limitation guidelines (under revised NPDES regulations)  
farm scale
- **CWA**: TMDLs  
watershed scale
- **12/2002 sunset of 1982 CEQA a effluent waiver (Porter-Cologne)**  
* waste discharge requirements (e.g. dairy WDR)  
* waiver of waste discharge (e.g. Irrigated Lands Conditional Waiver)  
* salt / nutrient basin plans  
farm / field scale
- **FIFRA**: pesticide use  
farm / field scale

Understanding GW NPS Pollution: The Challenge

- **CWA**: TMDLs  
watershed scale
Farm Contaminant Sources: Basin Scale

- Geology
- Landuse
- Climate

Irrigated Agriculture as N Source

Irrigated Acreage (Year 2000): 9.5 million acres

Water Use:
27 - 35 MAF

N fertilizer Use (2007):
740,000 tons
On 6.7 million acres
+ 240,000 tons field applied from dairy animal manure

MAF = million acre feet
Dairies in the San Joaquin Valley

- ~1,500 dairies
- ~1.5 million milking cows
- trend to > 2 million milking cows
- additional support stock: 1.5 million
- 1 cow = 20 - 40 humans in waste production (solids, BOD, N)

Farm Contaminant Sources: Regional Scale

- Source of N (2007):
  - Fertilizer use (varies with farm / farming practices) 740,000 tons
  - Animal Manure 240,000 tons
  - Septic leach fields 27,000 tons
  - Irrigation water source & mgmt.
  - Treated municipal effluent 31,000 tons
Farm Contaminant Sources: Dairy Farm Scale

Sources of N:
- Feedlot
- Lagoon
- Storage areas
- Manured fields
- Fertilized fields
- Various crops
- Septic system

Overview of dairy farms

Figure 1. Overview of dairy farms
Dairy Nutrient Cycling

- http://www.youtube.com/watch?v=G6QliWbvBwI
- http://ucanr.org/spotlight/groundwater.shtml
Dairy Farm Contaminant Sources: Management Units

Statistical Analysis: By Management Unit

Harter et al., J. of Contam. Hydrology, April 2002
Dairy Farm Contaminant Sources: Management Units

Farm Nutrient Management

Nitrogen Management Case Study

NMPs: Balancing Nitrogen Application and Uptake

for publications: http://groundwater.ucdavis.edu/gw_201.htm
Central Valley Regional Water Quality Control Board
Dairy Waste Discharge Requirements

- Preliminary Dairy Facility Assessment
  - Existing nutrient management
  - Existing waste management conditions
  - Existing water quality conditions
- Nutrient management plan (crop land)
- Waste management plan (animal facilities, waste storage facilities)
- Groundwater monitoring

San Francisco, 15-17 June 2010 (tentative date)

For information and updates, check:
http://groundwater.ucdavis.edu/calendar.htm
http://www.ag-groundwater.org