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http://ag-groundwater.org

Unedited Personal Conference Notes
taken by
Thomas Harter

(represents roughly one-quarter of the conference talks)

No guarantee of accuracy!

Abstracts, presentations, and video-recordings of the plenary session and select special sessions will be posted on the conference website by August 2010.

Noel Gollehon, *Natural Resources Conservation Service, USDA*: A national view of the irrigation resources to grow biofuel and the groundwater role

- specifically discussed role of groundwater in biofuel production
- lots of nice graphs
- switch grass much bigger water user!!

Siwa Msangi, *International Food Policy Research Institute*: Feeding the world to 2030 and beyond: The role of groundwater

- Yield gaps related to irrigation
- Environmental challenges for future food:
  - growing population and income
  - need to grow more food while relying on les expansion in land
  - increasing competition from other sectors for water
  - expsanion of irrigated ag has been more rapid
  - key role of india in global balance:
    - ag revolution aided by green revolution
    - guarantee schemes
  - what if groundwater were to go away?
    - Deepening water scarcity in India
    - Increased competing demands
    - Megacities
  - Quantitative experiment:
    - Simulate dramatic decreases in groundwater availability in N. India (Ganges, Indus, a couple others)
    - Observe impacts on food production, irrigation, prices,….
    - Results:
      - Decreasse in cereal production in India
      - More grown in North Ameica, Europe
      - Major changes in global net trade (import/export)
      - Significant price increase (about 10-20% over business as usual)
      - Negative impact on child malnutrition globally
    - Would be similar of scenarios were done for N. China
  - Summary:
    - Liberalized trade needed
    - Better use of rainfed agriculture
    - Local level monitoring
    - Enforcement of best practices (innovative community schemes)
    - Not just India's food security, but global food security

John Bredehoeft, *The Hydrodynamics Group*: Conjunctive use: Streamflow depletion caused by pumping wells in a nearby stream

- what happens to a stream, when you pump a well?
- Theis found a solution in 1940s

- Then there was another author in the 1950s (Glover?)
- S_d = Q erfc (SDF/4t)^(1/2) (stream depletion)
- SDF = a^2 S/T (unit days)
- Every well with the same SDF, has the same impact shape of the stream depletion function (impact happens at the same time)
- In an infinite aquifer, asymptotically approaching the case where all the water to the well comes from the stream
- In alluvial, finite basin: eventually all well water is from the stream
- Seasonal pumping in agriculture: annual pumping impact on the stream
- Assumed square wave of pumping (4 cubic-ft/sec for Jun-Jul-Aug); SDF=3.2, a = ¼ mile (distance from the stream), S= 0.25, T = 35,000 ft^2/day
    - No real surprises
    - First year not quite like the second, but after that the same
- Let's move the well 2 miles from the stream:
    - SDF = 800; a = 2 mi; S=0.25, T = 35,000 ft^2/day
    - SURPISE:
    - Stream depletion increases over time: first year a little fluctuation, second a little more, third alittle more,…. Then stabilitzes after many years (about 20 years), never complete recovery
- When we move 4 miles back: no annual fluctuations, now it takes more than 30 years to go to equilibrion
- Let's turn this around and look at the **opportunities**:
    - Recharge 12 cfs in April only
    - At 2 miles back from the stream: annual flucturations, but it builds up over 10-20 years => outflow to stream about 1 cfs
    - => we could put all the water into the aquifer in one month and it would have a real long-term effect!!!!
- Response depends on valley width: the more narrow the valley, the more quickly and stronger the well pumping is from stream water
- Similar response when there are multiple wells;
- Recovery takes just as long as duration, Recovery is smooth, not with annual fluctuation.
- => in case of drought, shutting off the pump is not going to benefit the stream for a long time!!!
- Summary:
    - As we move back from the river (SDF>500) seasonal pumping causes more or less constant stream depletion (2 miles). The larger the SDF the more constant the depletion
    - Full impact only after one or two decades
    - Full recovery only after one or two decades!!
    - => effective management needs to take care of long-term effects

Jacob Burke, *Food and Agriculture Organization (FAO)*: Groundwater use for irrigation – a global inventory

- groundwater use for irrigation: a global use inventory
- Stefan Siebert is the key author
- Purpose:
  - Fill national and sub-national gaps in FAO AQUASTAT on the sources of freshwater that meet agricultural demand
  - Establish global extent of ag reliance upon groundwater sources for irrigation
  - Provide a standardized, digital product that can be used to assess current impacts of groundwater extraction
- Global intensity map (1997-2002) is on a 5 arc minute scale (10 sqkm at equator)
- At finer resolution, this is much better
- AQUASTAT definitions:
  - Areas equipped for irrigation
  - Areas actually irrigated
  - Area harvested and irrigated
- Method:
  - National and sub-national statistical census data (15,000 administrative units)
  - Rules applied to determine if area irrigated is by surface, or by groundwater
  - …
- Areas equipped for irrigation – worldwide 38% from groundwater (120 million ha out of 300 million ha)
- India and US: 60% of land area is equipped to irrigate from groundwater
- => generated a map of GROUNDWATER irrigated areas in the world
- Total crop water requirements are 1300 cubic kilometer (2700 cubic km total ag withdrawals)
- Groundwater crop requirements are 545 cubic km
- Issues discriminating surface water and groundwater irrigation => be careful in analysis
- Can groundwater irrigation be matched with hydrogeological mapping
- Conclusions:
  - No substitute for statistical data
  - Standardization has to start at the field level
  - Groundwater dependence is growing
  - Plea for high-resolution digital mapping
- Questions:
  - Do we need more teams to do the global inventory
    - Needs to be done by getting better national data / statistical reports

- Stephen Foster: surface water is pubic/govmt, so much on groundwater is private => no data collected, how do we set out on that
    - Good census structure that recognizes that there is groundwater
    - Good statistical data at the sub-national level, with high resolution is important to create baseline

Pep Mas Pla, *Universidad Girona, Spain*: Evidence for denitrification processes in nótate polluted groundwater using a multi-isotopic approach

- Catalonia, Spain case studies
- low nitrate are high in bicarbonate
- denitrification is taking place where pig manure is the source of nitrate (isotopes)
- sulfate isotope: pyrite oxidation? (S and O of sulfate) => no sulfate reduction
- what else causes denitrification? Organic matter. But 13C does not increase => but 13C is buffered by bicarbonate dissolution
- ok, lets look at Boron isotopes: ;pot 11B vs. 1/B to typify various waters
- Conclusions:
    - Specific hydrogeologic, hydrochemical and isotopic approaches provide sound description of nitrate behvor
    - Isotopic data define nitrate origin, and its origin and fate within the aquifer
    - Prevention of nitrate pollution should be based on appropriate data that describes the whole flow system, and HUMAN pressures
    - Request practitioners to gather isotopic data for administration studies related to nitrate pollution – in addition major elements, redox conditions: water isotopes, nitrate isotopes, 34Sulfate, 13C => will give you an idea about nitrate. 11B would even be better.
    - Weakness: failure to systematically monitor groundwater; regulate management practices

Stefanie Hedlund, *Best Best & Krieger*: Legal regimes for groundwater regulation: managing an increasingly crucial resource (only attorney under 35 that has worked on 2 adjudications already)

- of 400 some 23 groundwater basins in CA are adjudicated
- themes in CA water law:
    - connection between property ownership and right to use water
    - all water rights are usufructuary
    - complex water law – surface water and groundwater regulated differently
- supply and demand problems: spatial separation of water and people, land competition: urban, industrial, agriculture
- riparian rights are NOT quantified!!! Appurtenant to riparian lands
- all western states but CA eliminated riparian water rights
- riparian water rights overlying groundwater are a big deal!
    - Daniel Day Lewis: There will be blood

    - Clay Hamilton suggested: “Thirst” scene
- Overlying right to groundwater:
    - Use on the overlying property
    - Not quantified
    - Correlative
    - Not lost by non-use
    - NOT regulated or permitted
- Groundwater regulation – current challenges
    - Unquantified overlying rights
    - Conjunctive use in unregulated groundwater basins
        - Banking => an ATM account that is open to everyone
        - => lack of incentive to bank unless there is an agreement, which amounts to a quantified water right
        - Ownership of stored underground water
- Benefit of groundwater adjudication:

Eric Ofosu, *UNESCO-IHE, The Netherlands* & Regassa Namara, *International Water Management Institute*: Gendered access to shallow wells and riverine alluvial dugouts in the upper east region of Ghana

- you can’t talk about agriculture in Africa without talking about women
- upper east region of Ghan is one of the poorest areas in Ghana which is semi-arid with its inhabitants manly living on subsistence agriculture
- increase in groundwater-irrigation
- unfavourable land-tenure arrangements against women – denying ownership
- women are not passive victims of developing trend
- little know about persistence of women to ag development
- goal:
    - sustainable managmement of upscaling irrigation development
    - investigation of water rights
- Methods:
    - Interviews
- Landownership characterized by religious beliefs
- Land tenure extremely complex
- Authority overlooking land issues is the *tendana* , the traditional earth priest
- Women only have indirect land rights => access land through a male member
- Small reservoirs, two large reservoirs
- Several crops: rice: tomatoes, pepper, onions, cabbage, lettuce
- Recent developments: private installation of shallow wells, temporary shallow wells
- Permanent shallow wells:
    - one of the oldest irrigation technologies
    - permeantenly constructed, led by women
    - cost is $150
    - uses rope and bucket for lifting water

    - individually managed farms
    - farmer groups bring fatmers together
- temporal shallow wells
    - dug in the field
    - redrilled every season, during rainy season gets refilled
- riverine alluvial dugouts, use motorized pumps to lift over river bank
- research on gender role

Karen Villholth, *Geological Survey of Denmark and Greenland*: Constraints to small-holder livelihoods in irrigated agriculture in groundwater-dependent parts of Asia

- farmer and agronomic perspective
- Pakistan, Bangladesh, Eastern India: crop yields are 1/3 of what they are in NW India and China
- Subsidies only in NW India => overall much lower investment, but capitol cost is also much higher in NW India than elsewhere
- Coping strategies:
    - Deeper wells
    - More efficient wells
    - Jobs in urban areas
    - Crop diversification
- Groundwater Markets:
    - Mostly in India
    - Social regulation in some places
- Conclusions
    - Groundwater irrigation economy shaped by GW availability, energy access, poverty levels
    - Farmers are creative in developing creative coping mechanisms
    - Research and policy advice need to take into acoount heterogeneity in physical and scoio economit treatise
- BOOK: "Groundwater Governance in the Indo-Gangetic and Yellow River Basins, Aditi Mukherji, et al (eds.)

Reagan Waskom, *Colorado State University*: Trends and alternatives to ag-to-urban water transfers in Colorado

- various groundwater basins, various approaches to groundwater management, including fallowing, shutting down wells
- San Luis Valley:
    - Rotational and split cropping with dryland crops or fallow
    - Limited irrigation; partial seasn irrigation
    - Shift to sunflowers, sorghum, wheat, forage crops
    - Higher level of scheduling and water management
    - Reduced tillage; renozzle
    - Use EQIp money
- Solutions needed to overcome current policy/decision making challenges
    - Real-time pumping and aquifer level monitoring neede to inform decision support systems

- Better accounting methods for streamflow depeletions caused by pumping
- Basin-scale institutions for flecxible conjunctive management of surface and groundwater
- http://agwaterconservation.colostate.edu

Jacqueline Brook*, University of Waterloo, Canada*: Alternative N management in Ontario corn

- corn: less fertilizer with clover cover crop => same yield, same (little) nitrate leaching
- yield: 170 bu/ac or per ha?
- At more than 60 cm depth: typically less than 5 mg No3-N/kg soil (down to 2m)

Jim Beck, *Kern County Water Agency*: Groundwater banking

- Kern County has 800,000+ acres in irrigated acreage
- County is the size of New Jersey
- Top ten commodities: milk ($600 million), grapes - 560, citrus - 490, almonds - 390, carrots, hay, cattle, pistachios, potatoes, silage&forage – sum of theseis $ 3 billion
- Water sources: 3.7 MAF/yr of which 1.4 MAF is groundwater
- SWP contracts: 1 MAF signed up in 1960, 700,000af delivered in 2005, 500,000 aft delivered in 2009
- Groundwater banking: recharge basin, recharge canals, Kern River, => recovery wells
- Recharge basins are at the edge of greater Bakersfield => recharge areas compete with urban growth; mosquito abatement an issue!
- 1978-2007: total recharge: 5.6 MAF, total recover: 2.6 MAF
- Groundwater banking investments: 1977-2005: $80 million?
- Dry years and regulatory actions have driven groundwater levels doen
- Over 600 new wells drilled since 2007.
- Average depth to water: several 100 feet.
- What needs to be done:
  - Need a Delta solution
  - Need short-term measures to help us suvvie this until Delta survives
  - Needs to address concerns regarding local groundwater conditions
- 2005 and 2006 – record level groundwater input, water was at ground surface
- Groundwater reservoirs cannot be pumped out fast enough!!!!
- How much of the “banked water” has moved out of the bank?
  - The bank has 40,000 acres of land => cannot fit 5 MAF!
  - Bank is still sorting out the noise
- What are the main social and economic pressures
  - Third of county economy is tied to ag
  - Third of county economy is tied to oil

- Rest to industry
- High unemployment
- Folks next to bank complain loudly

Virgine Gillet, *University of South Australia*: Ag-Forestry and Groundwater

- conflict from social sustainability:
  - where is there agreement
  - where are potential solutions?
- First time in Australia that forests are looked at
- Lower limestone coast water allocation plan => sole source aquifer
- Review forestry to assess impact as part of water allocation plan (forestry plantations for harvest)
  - They are not irrigated, but impact from:
    - Interception of rain
    - Use of shallow groundwater
- Conclusion:
  - Social sustainability is not properly considered at the moment
  - Needs to be considered to address issues
  - Community needs to identify social objective of water
    - Community consultation step is compulsory for legislation
    - Discussion is mostly based on environmental and economic sustainability => community consultation:
      - Food security
      - Social redistribution
      - Social cohesion
      - Aboriginal cultural access to water

Bill Alley, *U.S. Geological Survey*: Challenges in groundwater supply and policy in the US.

- Maupin and Barber, 2005: graph of the 20 aquifers that withdraw 90% of US groundwater (largest: High Plains, second largest: Central Valley
- Total per person per day have declined since 1975 and total withdrawals have stabilized at 400 bgd.
- 31 eastern states withdraw about 12 bgd - increasing
- 17 western states withdraw about 40 bgd – stable
- Water use information needs:
  - Nationally consistent database
  - Annual and seasonal data – at a much finer scale than current
  - Consumptive use
  - Site-specific data on significant withdrawals – especially from the few dominant users
  - Improved application of remote sensing – will have a lot of power in conjunction with on-the-ground data
- Thomas, 1951: map of areas with perennial overdraft:
  - S. High Plains

    - Pecos Valley
    - Tucson-Phoenix corridor
    - S. California basins
    - Central Valley
- Reilly and others, 2008: map of water-level decline (at least 40' in confined aquifer or at least 20' of decline in unconfined aquifer):
    - Dakotas
    - Cental Valley
    - Phx/Tuc
    - SW of Great Lakes (historical context)
    - Along S. Mississippi Valley
    - Atlantic coastal plain
    - High Plain
    - Snake River Plain, ID
    - Columbia Plateau in WA, OR
- Oscar Meinzer, 1935: "The program should cover all water bearing formations all across the country" – referring to groundwater level monitoring
- How do we integrate monitoring and modeling?
    - We are not doing a good job at it
    - When the modeling is done, we put the model on the shelf
    - Rather: we should take the model and think about how to adjust the monitoring program!!!
    - http://acwi.gov/sogw/pubs national groundwater monitoring program
    - USGS has an active groundwater level network, but it does not include the state or local level measurements
- Groundwater-Surface Water Interaction
    - In some cases, it doesn't take much water to be withdrawn to induce surface water changes and induce subsidence:
        - Upper San Pedro Basin, AZ (Sierra Vista)
        - Edwards Aquifer (spring discharge, endangered species)
        - Republican River Basin: more than 50% of baseflow is lost
    - GW-SW Modeling
        - External representation
        - Fully integrated today
        - Biogeochemical reactions included
    - Heat as tracer (see http://pubs.water.usgs.gov/circ1260
    - Use of fiber-optic temperature monitoring
    - Geophysical monitoring
    - => we can pull in a ton of information, trick is how to interpret it
- Water quality constraints! => NAWQA Study Areas
    - In the 1980s, there was discussion about whether to include groundwater or not
        - Too large, to heterogeneous
        - We don't care, Love Canal was much more important
        - Few instances (like DBCP in CA) were minor

    - Do we do a statistical survey approach to GW or do we do a smaller scale research => decision to do both
    - Groundwater quality surveys:
        - Big picture overview
        - Where are the problems?
        - What are the problems?
        - Survey of private wells in US (Simone and others, 2009)
    - Surveys don't answer the basic questions: why? What's the future? How long will it take to go to the deeper groundwater?
    - => for those questions, the details matter
    - More focused site-specific research approach
- Saline groundwater resources
    - Focused on Westside SJV, entire south and southeast along coast
- Groundwater and energy:
    - the less water, the higher the prospects for solar energy
    - geologic carbon sequestration
- groundwater and climate: recharge….
- USGS groundwater information pages: water.usgs.gov/ogw

Stephen Foster (with Hector Garduno, Catherine Tovey), *World Bank GWMate Program*: The global boom in groundwater irrigation - experience of reconciling resource use and sustainability

- intrepidation of coming to SF:
    - last visit in October 1989 – earthquake
    - previous incarnation as director of British Geological Survey:
        - diffuse pollution (with British Survey)
        - resource management (with World Bank)
        - => can the two be combined?
- Global boom in groundwater irrigation – benefits and concerns
- Focused on GWMate experience in providing advice to public administrations
- Mainly focused on physical water scarcity
- Groundwater pollution not considered here – developing countries don't ask for this
- What is GWMate?
    - Part-time international advisory team
    - Small team with access to very large programs with the World Bank
    - Team support large projects that invite these teams in:
        - North China plain – lots of innovative work, satellite imaging, water productivity, communities having debit cards for pumping, concern on overdraft
        - Mendoza, Argentia – wine-growing area, groundwater very important, salinity threats,
- First reaction of most governments to overdraft:
    - Aquifer recharge enhancement
    - Efficient irrigation technology

    - => but without much thought about consequences on groundwater
    - GWMATE:
        - Refocus on causes for overdraft
        - Reduce consumptive water use
        - Raise water productivity to raise farmer incomes
        - Get governments to confront the harsh reality of weakly-recharged aquifers trying to support inappropriate agricultural economies
- Is it necessary for the public administration to intervene? Or let nature takes its course? Criteria:
    - Social inequity
    - Downstream users
    - Exit strategy
    - Non-reversible damage (subsidence, salinity)
- GWmate "Pragmatic framework" to selection of approach in excessively exploited aquifers – hydrogeologic AND socioeconomic approach
- Mexico: the COTAS experience
    - COTAS – aquifer management organizations
    - Too many consultants telling to many different stories to politicians
- Important: need harmony between "bottom up" and "top down" approach
- Generic lessons on groundwater management **POLICY** in developing nations:
    - Hard work
    - Needs a good understanding of use dynamics and resource status
    - Management by users alone is questionable, but without user participation it is impossible
    - Local government agency having legal mandatae and political backing as 'groundwater guardian' is critical
    - Requires the 'push' of groundwater champions
- Mobilizing user participation, community-based action
    - Self-regulation by community is ideal (dream), but to some degree has to happen, for fairly localized, robust groundwater systems that don't get easily damaged
        - Shift behavior from destructive competitive behavior
        - To some sort of constructive dialogue on safe yield
        - Andra Pradesh farm example
        - Hivre Bazaar experience
            - Deccan traps basalt with 450 mm/yr
            - Charismatic leader took action, enhanced recharge and stopped soil erosion
            - Allowed only dug wells in the shallow aquifer for irrigation, while having deep wells used for drinking water
- Use regulation and charging
    - Simple regulations effective if supported by stakeholders
    - Use (not ownership) rights desirable

        - Where moderate number of hig-value user an dcommunity small users aggregated
        - Must be realisticallyu based
        - Shold be subject to transferability
        - Mendoza, Argentina experience
- Agriculture and energy policy modifications
    - Modifications to ag policy can extert powerful influence on groundwater use for irrigation
    - Unraveling the groundwater-energy nexus is very complicated
- Higher irrigation efficiency will not always "safe" water
- Groundwater use rights at local/community level very useful to mobilize users
- Piecemeal regulatory action, economic intervention or technical innovation unlikely to be successful without some sort of integration

Bridget Scanlon, ***University of Texas Austin*** with Claudia Faunt, Guillaume Favreu, Laurent Longuevergne : **Satellite and ground-based apporaches for monitoring impacts of agriculture on groundwater resources**

- will talk about satellite and ground-based approaches to monitor impacts of agriculture on groundwater resources
- appreciates USGS' field studies and data
- I do "GRACE" – that's not a religion ☺
- Water balance components with various tools:
    - Precip – SSMI/I, TRMM
    - ET – MODIS, AVHRR, Landsat
    - Soil moisture – SSM/I, AMSR, SMOS
    - Groundwater – GRACE
    - Streamflow: Laser/Rada altimeter
- Background, applications (Ganges, Niger, High Plains, CV), global surface water basin product
- GRACE:
    - Two satellites, two satellites (Tom & Jerry), 200 km apart, 500km above earth
    - Launched on St. Patrick's Day, 2002
    - Measures total water storage changes (TWSC)
    - TWSC = changes in storage water + changes in soil moisture + changes in groundwater
        - Soil moisture: model estimates (GLDA) or field measurements
        - Surface water changes are very minor
    - Not for the faint-hearted, lots of processing
    - Several centers are using GRACE (CSR, GFZ, JPL, GRGS, DEOS
    - Time-scale: 7 d – monthly
    - Spatial scale: 400,000 sqkm
    - Centers do some processing and correcting (tidal effects, oceanic effects, destripe data, filter data (filtering removes some signal, so you need to put that back in – need error analysis: between satellite, soil moisture data, data processing)

    - Where discharge is small: will give the recharge rate
    - Where recharge is small: will give groundwater pumping
- Ganges Basin:
    - Trend in groundwater storage in irrigated area: 100 mm/yr (over 150,000 sqkm)
    - Use chloride mass balance approach to calculate recharge rate:
        - 60-90 mm/yr in rainfed agriculture
        - 50-120 mm/yr in irrigated areas
        - Conclusion: irrigate some percentage of the total area at 300 mm/yr
- Niger Basin
    - Groundwater level rises (Favreau et al, GW 2002)
    - Increasing cropping of millet, soils crusted, and there was more runoff, somehow ends up recharge more to groundwater
    - Guillaume focused on smaller 10,000 sqkm: trend +23 mm/yr
    - GRACE data over 150,000 sqkm: +18 mm/yr
- High Plains Aquifer
    - 450,000 sqkm
    - 40% of landuse is cultivated (12% is irrigated => 97% of groundwater use in the region, 28% is rainfed)
    - Water available: 4,000 cubic km
    - Water depleted: 330 cubic km
    - Recharge: 10 – 86 mm/yr
    - Recharge increase in south, 10-30 mm/yr due to cultivation
    - Irrigate 10% of the area at 300 mm/yr is sustainable
    - Comparison of GRACE data with soil moisture and groundwater level measurements: good correlation between ground-based and satellite data
- California Central Valley
    - 52,000 sqkm
    - Total water stored: 1,000 cubkm
    - Water depletion since 1963: 60 cubkm
    - Decline concentrated in the Tulare Basin
    - Large annual variations
    - Surface water storage changes based on 26 largest reservoirs
    - Snow cover changes
    - Soil cover changes
    - Some correlation between ground measurements, modeling (Faunt), and GRACE – Jay Famiglietti will publish shortly
- Google Earth Basin Explorer project
    - Available on the web soon
    - Amplitude of annual signals – global map
    - Trend in total water storage 2003-2009
    - Decreasing trends:
        - Irrigation in the Ganges basin
        - Drought in SE US

        - Drought in AUS
        - Drought in Southern South America
        - Loss of ice-cover in arctic regions
- Summary:
    - Useful tool for estimating seasonal changes in water storage in basins larger than 400,000 sqkm

Steve Carle, *Lawrence Livermore National Laboratory*: Denitrification at a dairy site supported by gas-liquid phase modeling of Tritium/Helium groundwater age

- Tritium/helium age set when recharge arrives at water table
- About 10 year delay at the Kings County dairy site between irrigation and recharge at water table (he has a graph)
- Modeling confirms tritium/helium age
- Inverse modeling yields 0.25m/yr recharge (!!)
- Mixing with older groundwater consistent with data
- Denitrification rates range from 4 – 50 g/cubic meter per year (consistent with Smith and Duff, AEM 1988, alluvial sand/gravel aquifer)
- K values in his model from 3m/d to 300 m/d to 3 m/d

Adriana Bruggeman, *The Cyprus Institute*: Groundwater or livelihood? The case of Al-Ajaz community in northern Syria

- recent legal decrees in Northern Syria farming areas:
    - licensing and metering of wells
    - provision of loans for modern irrigation systems
    - improved extension support
- effect of irrigation management much more important on yields than effect of varieties
- a single irrigation in rain-fed farming greatly improved yields => greatly improved water productivity
- policy implications:
    - limited economic opportunities
    - extension services needed to be expanded
    - depletion of groundwater resources may cut communities from their water supply
    - need better data
    - require support of farmer's union
    - increasing energy (fuel) cost may drive poorer farmers out of business

David Eaton, *University of Texas, Austin*: Groundwater Sustainability - Merely an Illusion

- (without any Powerpoint slides)
- even with modeling and data,
- even with all the data available to the public
- the data and the models are never sufficient **for people to believe that groundwater will be sustainable**

- Preference:
    - Did exhaustive efforts to find out people's preferences
    - Farmer, rancher, developer, etc – lots of consistent preferences
    - Even with sustainability as goal, reasonable water use is ALSO a goal
- As long as USE is a goal, SUSTAINABILITY is not possible
- Regulations make it difficult for sustainability to work
- Even when you have permits, they only apply to LARGE water users
- When small water users are not regulated / have to apply for permits, these will undermine sustainability
- When sustainability is not possible physical, then its to capricious to allow for regulation to try to achieve that per Texas court order
- In 2002, Texas legislature decided to have state do 16 groundwater management areas, corresponding roughly to aquifers, including many groundwater conservation districts, which are forced into a marriage of regional groundwater planning.
    - State incentives:
        - If you don't come up with desired future option, then the state can withdraw your water
            - In Texas, there are 16 other regions along river basins line, every five years they determine the uses and sources of water, what projects should be developed, this becomes the state water plan
            - If you want the state to include your water withdrawals into the state water plan, do the desired future plan by September 2010. All is open records, open meetings, by open public vote
        - This is then converted into the amount of water that can be withdrawn from the aquifer that can be withdrawn, according to models (data, models publicly available). Groundwater Conservation Districts convert these numbers into groundwater management plance
- In 2009, one of the districts came to University of Texas for help (David Eaton and Jack Sharp)
    - Began an effort to assist GCD 9
    - What do people care about? What are there desired future conditions
    - Five public meetings
    - 27 interviews with stakeholders (property developers, city folks, ranchers, farmer, environmental stakeholders
        - What problem do you see
        - What are the causes
        - What happens if nothing gets done
        - What can get done
        - What are barriers to get things done
    - Large number of elements that everyone agreed with
    - Large number that MOST agreed with
    - Few that many disagreed with

    - AGREEABLE POINTS:
        - Some dry wells, some dry springs
        - ….
    - POSSIBLE ACTIONS:
        - Agreed with sustainability
        - Agreed with reasonable water use
    - If farmers continue to use water for small uses (not permittable) that may overwhelm the groundwater resources
    - Put the state model into a wrapper and allowed the users to vary the pumping in the future => what-if analyses
- What they came up with:
    - In 3 of 9 counties: no drawdown of aquifer for spring protection
    - In 6 of 9 counties: some drawdown: 0.1 ft/yr drawdown, 30 feet over 50 years or something like that
        - Challenge by some people: if there is any use that increases then there is drawdown, and it becomes unsustainable. It would not work. Principle of reasonable use does not work – not sustainable.
        - David never heard of a case, where a groundwater management agency followed the process to the T, all the details
        - Here Texas Water Development rejected "groundwater sustainability" as a goal, because its physically not possible under doctrine of reasonable use. Currently challenged in the court.
    - "if you can't tell me what's going to happen to my spring, you can't do that"
- If you don't control everybody, you always have a conflict
- Police power to justify regulation of even small groundwater users can only be derived under massive damage, e.g., subsidence
- Managed depletion becomes a reasonable goal

Sharon Medgal, Chair of Session

- when economists do their work, there is not often a definition of sustainability offered (Keith Knapp)
- people make their investments
- challenges of water management in Syria and how deciscions are made there
- Texas GMAs want to adopt sustainability goal, but you cannot realized that unless you can assure users that sustainability can be achieved AND water can be used.
- Challenge to organizes: what is sustainability?

Elena Lopez-Gunn, *Marcelino Botin Foundation – Water Observatory, Spain*: Groundwater governance in Spain: Aligning science with policy

Key Policy Issues:

- diffuse pollution
- overabstraction

- economic water productivity
- illegal water use

Key innovative policy tools

- extended water footprint analysis
- water banking
- co-management by WUAs
- data transparency and information

Adaora Unoma Okonkwo, *South Africa Department of Water Affairs*: The use of reserve determination in assessing groundwater quantity

- South Africa is a water scarce country
- National Water Act, 1998
  - Covers both surface water and groundwater
  - Licenses for using water
  - Geohydrological report is required with the license application for water uses involving groundwater
  - To assess the license, the geihydrological report needs to be assessed or commented on
- What is the RESERVE?
  - Refers to both the quantity and the QUALITY of water in the resource, will depend on class of resources
  - The Reserve is required to provide for BHN
  - Protect aquatic ecosystem so as to secure ecologically sustainable development and utilization
  - Suraces water reserved
  - Groundwater reserve
- Groundwater Reserve:
  - Low confidence
  - ….
- Develop a tool to assess Water Use License application
  - Template, set of questions/questionnaire

Tom Glover, *Westlands Water District*: Managing the groundwater-agriculture nexus in the largest US irrigation district

- largest irrigation district in the United States
- delivers surface water to the growers
- district office is in Fresno, which is a world away from the Bay Areea
- 1034 mile s of underground pipe and metered outlet
- 54,000 irrigated acres
- History of the Westlands Area:
  - First deep groundwater well was drilled in 1909 by G. T. Willis just west of the present-day Lemoore Naval Air Station
  - By 1951 the number of wells had increased to about 1,000 and groundwater pumping increased to about 1 MAF annually
  - 1955-56 pumping depth had increased to a range of about 350-700 feet

- Long-term water service contract with the federal government on June 5, 1963
- Groundwater pumpage prior to canal happening:1950s to 1960s about 1 MAF
- 1968 the canal started and pumping dropped to 100,000 – 200,000 af.yr
- High peaks of around 500k – 600k in early nineties, 1977, and last three years.
- Water level rise from -150 ft to + 100 ft.
- Subsidence: largest human alteration of the earth surface (*by what standard?*)
- Subsidence is the story of three alluvial fans: Panoche Creek, Cantua Creek, and Los Gatos Creek
- Groundwater monitoring is essential, both shallow and deep aquifer, 589 production wells, 93% of the wells are metered
- Pass guidelines to grower to use surface water
- Groundwater pumping near safe yield of 200,000 acft/yr
- 80% drip
- Continue water conservation
- 200,000 acft safe yield is based on a graph of delta water level change vs. delta pumping
- Reliable supply is 40% of surface water contract

David Rudolph, *University of Waterloo, Canada*: Quantifying the performance of regional scale reductions in nutrient applications for source water protection through vadose zone monitoring

Evaluate BMPs for nitrate

1. Establish field facility
2. Develop monitoring strategy
3. Develop predictive modeling tool

- 5 production wells, 100 ft deep, overburden aquifer.
- Nitrate increase over time since 1990, like very frequently seen
- City approach: purchased a junk of ag land within two-year time of travel. Rented the land back into farm for reduced nitrate BMPs
- Would the BMPs help?
- BMP: Historically lots of cattle, application of 100 lbs/ac or 23 lbs more than needed and some manure
- New: go to 50 lbs and NO manure
- Monitoring strategy:
    - Quantify changes in n mass in vadose zone
    - Estimate nitrate loading mass to water table
    - Extrapolate point data to large scale
- Details on approach:
    - Coring across the site twce per year for nitrate, moisture, and bromide
    - Nice plots of cumulative mass of N with depth and over time
    - Recharge rate by bromide tracer data
    - Recharge = water content times pore velocity
    - Field site with monitoring wells etc

    - Extrapolated mass flux of N to water table mapped
- Nitrate concentration decreased from 17 to 7 mg/L. 60% reduction in n on Loading
- Prediction: regional scale groundwater and vadose zone model with Feflow (3100 ha) and highly detailed local transport model (700 ha). Pre-BMP with 17mg/L loading. Then run post-bmp. Only 10% improvement. 10-15 years to get Bette
- Implications:
    - Small chunk of land may improve all very much
    - Will rake time to improve
    - Vadose coring very useful

Dico Fraters*, National Institute for Public Health and the Environment, The Netherlands*: Relationship between nitrogen surpluses and nitrate leaching on sandy soils

- national sized field experiment
- groundwater is 1.5 – 2m below surface
- measure top 1 m of groundwater for nitrate
- how much N surplus can be allowed so that groundwater is not over 10 mg N/L
- deriving a nitrogen leaching fraction:
    - used farm accounting data to calculate farm input and output (national monitoring programme)
    - use model to compute N surplus
    - use environmental monitoring to compute leaching
    - N leaching fraction = leached N / surplus N
    - farms were monitored only in the sandy region:
        - 1992-2005
        - 360 farms
        - 210 dairy farms
        - 70 arable farms
        - 80 pig and crop-livestock farms
        - Monitoring water quality
- Sandy soils (podzol). Sampling:
    - Each farm 60 boreholes with a hand-auger, put filter screen in groundwater, take samples, and analyze in the lab
- 13 years of data for dairy farms (with 80% grassland)
- 11 years of data for arable farms (no grassland)
- Arable farms leaching > dairy farms leaching (grassland!)
- Fraction of nitrogen surplus that is leaching:
    - Sand deep, arable land: 89% grassland: 46%
    - Moderaly drained sand: 58% and 30%
    - Poor and shallow: 38% and 20%
    - Clay: 36% - 12%
- Trend in N surplus in dairy farms: 1990 – 2004: from 350 kg N/ha to 190 kg/ha
- Trend in N leaching in dairy farms: from 200 kg N/ha to 90 kg/ha/year

- Time lag effect:
  - Dairy: 50/30/20 (this year/last year/year before last)
  - Arable: 40/30/20/10
  - Yields about 5-7% lower N leaching fraction
- Consequences for policy makers:
  - Integration of monitoring farm practices an dthe quality of the environment has many advantages
  - Data acquired by trend monitoring networks mayb e used f orunderpinnin policy deciions
  - Small investment in additional monitoring pays off
- Manure: 250 kg N with manure 170 kg N on something else
- Total N application for all crops regulated with a small booklet based on a complicated model to compute application limits for specific crops

Reed Maxwell and Ian Ferguson, *Colorado School of Mines*: Impacts of groundwater pumping and irrigation on regional hydrology and climate

- Impact of pumping and recharge on regional hydrology and climate
- PARFLOW modeling; see Kollet and Maxwell, 2008.
- groundwater storage changes:
  - irrigation: rises
  - pumping: drops
  - pump and irrigated: rises and drops – spatial heterogeneity
- stream discharge:
  - irrigation: stream wins
  - pumping: stream looses
  - pumping & irrigation: pumping wins, but less streamflow loss than with pumping alone
- latent heat flux:
  - irrigation: increase in heat-flux
  - pumping: decrease in heat-flux, because of ET in the river valley, although the pumping cones of depression are scattered and larger than the river valley: where the water table is already disconnected from root zone, no impact
  - pump and irrig: mostly increase in ET, but scattered decrease, similar though to irrigation only
- Conclusions:
  - Pumping and irrigation significantly impact water and energy budgets at local and watershed scales
  - Impacts on local surface fluxes strongly depend o nlocal water table depth
  - When pumping and irrigation are combined, pumping is dominant in terms of hydrologic impacts (GW storage, streamflow) and irrigation is dominant in terms of land-enery impacts (laten and sensible heat flux)
- Implications:
  - We need to think about: can we affect local recharge and weather?

    - Need to consider GW in irrigation management
    - Managing agriculture: pumping affects streams, irrigation affects climate
- Next steps: integrated land surface and regional climate model
- Ian Ferguson: imfergus@mines.edu

Jennifer McKay, *University of South Australia*: Sustainable development law via regional plans for groundwater in Australia

- Five epochs of water policies and laws
- History matter in lawr, policies and instititutions including course
- AUSTRALIA
- Has licenses and NOT water rights (although may be called rights)
- Licenses are defeatable by the minister at any time
- Licenses given to farmers were taken away by minister in South Australia during recent drought => farmers learned that water can be taken away
- Substantial reduction of rainfall in SE Aus
- Federal-state control issues
- Movement to Legal Sustainability in State laws from 1992
- Judicial acceptance and strict adherence to ESD principle
- FOUR elements of environmental sustainable development law (ESD, 1992):
    - Sustainable use
    - Intergenerational equity
    - Intra-generational equity
    - Integration principle - integration of environmental concerns into decision making
- Example:
    - Famous case: principle of sustainable development is part of international law
- USA and AUS quite similar in size
    - Murray-Darling basin (most of agriculture, SE)
    - Great Artisian Basin (not much ag due to poor soils)
- Water laws, ESD, and policy problems:
    - ESD tells feds who tells state: you got to do this
    - Implementation issue: how to administer
    - Three pillars to achieve it:
        - Social capital
        - Economic prosperity
        - Environment
- Policy instruments:
    - Buy back of water and land
    - Water allocation plans reducing water on “consumptive pool”
    - Pay for infrastructure improvements to increase irrigation efficiency
    - Structural adjustments
    - Payments to growers for land retirement during drought
- Challenges

    - Recognition of the overuse of water already there in early 20th century
    - 1788-1901: state colonial law – introspective to each colony, water was a magic pudding
    - 1901 – 1983: Federation (built much like American constitution); water remained with the states, despite the federation
    - Next step: universal metering
    - Treatise power 1983-1994: enhanced federal power
    - 1994 – 2007: …..
    - Wheel meters were found faulty – overallocated by 30%
    - Water Resources Act 1997
- Today:
    - 56 NRM regions (each will have its water plan)
    - NRM plans done differently by each state
        - Stakeholder involvement
        - Major consumptive water use reductions
        - 800 water supply businesses now reduced to 300 WSBs
        - Used to be public monopolies, now mixture, some government owned, some corporations, some completely private
        - Water Act 2007 law that only applies to the Murray-Darling basin
        - To pass this law, state deferred their powers over water to the feds (done out of frustration)
- Epoch 5 drivers:
    - International agreements
    - Environmental disasters (algal blooms)
    - Loss of public support for dams
    - Feds will create basin plan for the Murray-Darling by this summer
- 30 years after introducing meters => farmers actually find it cool!
- Summary:
    - Laws can lead but mostly follow community attitude
    - Implementation of law should be considered
    - Process must be fair
- Comment on water markets:
    - Water markets only increased the water use
    - That was when there were very few plans
    - Water markets are fine, when there is an overarching science-based sustainability framework set
    - So the water market days in Australia are over

Mike Wireman, *U.S. Environmental Protection Agency,* A summary of laws and regulations related to agricultural chemicals and groundwater

- summary of laws and regulatory/non-regulatory programs related to agricultural chemicals in groundwater in the USA
- groundwater sustainability:
    - sufficient quantity for beneficial use
    - suitable quality for beneficial use

- focus: pesticides and nutrients
    - 20,000 pesticides registered, 5 billion lbs/yr worldwide, 1.2 billion lbs/yr active ingredient!
    - 12 million tons of N applied by US farmers in 2000
    - 200,000 animal feeding operations in USA – small and large
- Environmnental issues:
    - Pesticide toxicity – humans and animals
    - Nitrogen:
        - Drinking water (methemoglobinemia, bladder & ovarian cancer
        - Nutrient loading to surface waters – hypoxia, eutrophication
        - Mobilization of selenium by nitrate
- Primary laws and regulations:
    - FIFIRA
        - EPA responsible for registering / licensing
        - Requires strict adherence to label direction – IF you follow label directions, FARMER IS NOT LIABLE!! Else: civil & criminal penalties
    - FFDCA – food, drug & cosmetic act (pesticide tolerances for food/feed)
    - PRIA – increased type and amount of information
    - FQPA – tougher standards for food production
    - ESA – tougher standards
- Some other rules:
    - NPDES pesticide general permit (4 June 2010) for application of pesticides directly onto waters of the US
        - Mosquito control
        - Aquatic weed / algae control…..
- Nutrients – Ag Sources
    - We don't see big hot-spots of pesticides like we see with nitrate
    - Fertilizers
    - Animal feeding operations
    - At EPA trying to move towards a common understanding
- Why are nutrients important?
    - 10,000+ 303d listings = third larges cause of impairments
    - Over half of estuaries impacted low oxygen levele
    - ….
- What is the problem?
    - High percentage in every state of stream lengths that exceed N reference value (about one-third to more than one-half)
    - Enforcement issue
    - Cost issue in water treatment => costs a lot of money
    - Average N application: 140 lbs/ac – steady since 1980 and not going down, fertilizer cost has increased by about one-third in recent years, but no let down in use/acre
- Primary laws & regulations

- Fertilizer use NOT regulated
    - Most widespread groundwater contaminant in the US
    - Application of fertilizer is most common & widespread source
    - Nitrate concentrations in GW in major agricultural areas has increased in past 2 decades
- AFOs:
    - More regulation
    - Middle of promulgating new CAFO rule
    - 240,000 AFOs, 20,000 CAFOs (large & medium)
- CAFOs have moved west because there is a lot of land, and easier to do business in SOME of the western states
- Rule requirements:
    - All CAFOs must apply for permit even if there is no discharge
    - Nutrient management plan required
    - Manure transfer record keeping
    - All 20,000 CAFOs will be regulated
    - …..
- State regulation of ag chemicals
    - Focused on BMPs => reduce N loading to water; based on data, BMPs are not effective. Poor design or poor implementation – we don't know, NRCS through CEAP is finding out which.
    - GW classification
    - GW monitoring
    - CAFOR regulation
        - Monitoring
        - Lined containment ponds

- Examples from Colorado:
    - Monitoring in ag areas – lots of exceedance in South Plate
- Conclusions:
    - Some aquifers are highly vulnerable (sand and gravel, depth < 20 ft)
    - Some inefficiencies will remain in all BMPs
        - What do you do in those cases?
- Solutions
    - MUST limit non-point source loading to groundwater – increased regulation?
    - NUMERIC vs. narrative nutrient standards
    - MUST improve groundwater monitoring in agricultural areas
    - Incorporate differential management concepts – recognize hydrogeologic constraints (siting, landuse planning!!)
    - Need better science re: groundwater contribution of TMDLs through baseflow
    - Evaluate and improve BMPs
    - EPA Nutrient Initiative
    - EPA HQ and Regional offices are currently developing an effort to wrok with States and with agricultural community

- Farm bill provides conservation grants to NOT grow a crop in a sensitive area
- Must shift away from managing a small portion of the aquifer due to source area status to managing the entire aquifer
- Help with low-interest loans to help with transitions in farming practices

Stefano Burchi, *International Association for Water Law*: The Maturing Law of Groundwater – A Comparative Perspective

- maturing or rather "advancing" "expanding"….
- Substance for the talk comes from personal observations
- Outline: wants to map out evolution:
  - Gw-sw connection
  - Land-gw connection
  - Development and ecosystem-support function (baseflow)
  - Water rights situation
  - User participation
  - Highlight issues
  - Offer pointers for a legislative agenda
- GW-SW Connection
  - Conjunctive use as a matter of policy (China, India)
  - Conjunctive use as a mater of domestic legislation (USA, Jamaica – water act of 1995)
  - Interbasin water transfers as a means to relieve groundwater stress (Spain)
- GW-LAND Connection
  - E.g. Central Valley urban development affecting recharge and quality of groundwater
  - Regulation of land uses – very different from regulation of point sources polluting groundwater; mostly diffuse sources: management practices, siting,
  - EU legislation, 1991 Nitrate directive: instituted a number of controls on ag practices, mandated legislation of nitrate sensitive areas and development of codes of good ag practices that are becoming mandatory;
  - In other jurisdictions are examples, e.g., Austrian statute (amendment to water code) that incorporates concern of landfills on groundwater => landfills & dumpsite regulated under water authority
  - Protection of area around drinking water sources
  - Regulation of landuses affecting groundwater recharges – has not come across any examples of this being done anywhere in the world; in San Joaquin Valley this is brought in by bringing in landuse planning authorities into IWRMP => coordination and collaboration with general purpose government on voluntary basis
  - River basin plans: integation of diverse planning instruments (examples from Spain, France, Panama)

    - Some countries mandate coordination between different planning units
- GW-ECOSYSTEM FUNCTION Connection
    - Priority ranking of the environment-support function of groundwater in the allocation of the resource
    - EIA requirements of groundwater development projects
    - Water reserve of environmental conservation purposes (S. Africa)
    - Screening process of groundwater development applications / license administration
    - New Wales: provides for downward reductions in license to maintain sustainability of the aquifer
- Water Rights Trading
    - Contolled leasing of groundwater extaction rights
        - Within ag
        - Ag-urban
    - In Chile you can buy a water-right in the "supermarket" essentially without control
- Participation of Groundwater Users
    - Self-regulation of groundwater under stress by depletion/pollution by legally-constituted groundwater users' groups (co-management of common-pool resource)
- ISSUES
    - Legislation tends to be surface-water centric, PERHAPS INEVITABLY SO
    - Perception of groundwater as an intensively private source
    - Legal options disconnect surface water and groundwater
    - Coordination AND administration of variety of planning instruments to bridge SW-GW
    - Inability of government to deliver on a range of regulatory servivces – policing wells, monitoring groundwater especially
- CONCLUSIONS
    - Strategic important of gw and its vulnerability to oveuse/pollution => mix of regulatory and non-regulatory approaches
    - Legal status of gw as state-held resource
    - Allowances for intense, diffuse perception of groundwater as private
    - Facilitating conjunctive use (relax use it or loose it rules)
    - Opportunities fo managing water within existing land use regulations
    - Pursuing efficiency in allocation through trading, without loosing sight of third-party effects
    - Opportunities for gw user groups to relieve government of responsibilities
    - Non-regulatory responses and relevant agenda would include economic measures:
        - Gw abstraction and wastewater disposal charges
        - Gw users share cost of conservation/infiltration measures in some part of the watershed
- ANNOUNCEMENT

- Chairman of AIDA and Int Water Resour Association:
  - World Water Congress, Adaptive Water Management - Looking to the Future Sep 25-28, 2011, Recife, Brazil

Carolina Balazs, *University of California, Berkeley*: Just water? Environmental justice and drinking water quality in California's Central Valley

- what is the impact on drinking water and impacted lower income communities
- research question: At the water system level, are there higher nitrate levels in lower income communities/communities of color
- nitrate one of the most common contaminants in CA drinking water
  - health impact: blue baby and others
- treatment cost very high
- in SJV particular problem – lots of fertilizer use
- 95% of SJV population rely on groundwater
- 75% of CA violations in public water supplies are in the SJV
- Population: 41% white, 46% Hispanic, 13% non-hispanic people of color
- 10% of CA's population, 20% below poverty level
- Potential disparities in exposure may exist because…..
- MCL: 45 mg/L; at half the MCL: DPH considers it a system at risk – increased monitoring required
- METHOD:
  - Multi-level, longitudinal regression model
  - Sample selection:…..
- Data sources: CDPH, PICME database at CDPH, GIS and census data
- Variables of interest:
  - Average nitrate concentration in the system over time
  - Nitrate concentration at the point of entry to CWS
  - Potentially exposed population
- 87% ok, 10% elevated, 3% above MCLs (10 systems, 9 of which were <200 connections
- Increasing %Latino means more systems are elevated or in excess
  - Dependent variable: nitrate at point of entry
  - Independent: latino, white, color
  - Controlling for:
    - Valley floor
    - Unincorporated
    - Groundwater/sw
    - Ownership type
    - No of service connection
    - Implicitly controlling for # of samples
  - Stratified by number of connections
- Adjusted model:
  - For systems > 200: no relationship between dependent and independent variable
  - +1% in latino -> +.2 mg/L nitrate

    - +1% in homeownership => -.2 mg/L nitrate
- Potentially exposed population:
    - 2.8 million ok
    - 160,000 elevated
    - 3,000 excessive: 65% latino, 30% white, 5% color
- Summary:
    - Scale does not explain everything,
    - Small CWS + latinos + renters + nitrate levels
    - Power and proximity to ag
    - Invisible middle category
- Implications:
    - Economic burden for monitoring, treatment (2 water bills: water, bottled water)
    - Health risk to customers
    - Policy implications:
        - Need multi-level solutions:
        - System level
            - System consolidation
            - Targeted resources
            - Middle category to be considered (elevated nitrate)
        - Groundwater – drinking water connection
- Funding: NSF, CA Endowment, EPA STAR grant, Switzer Environmental Fellowship
- Questions came up regarding controlling for septic systems in small communities

Jack Rice, ***California Farm Bureau*: Ag perspectives on groundwater**

- largest farming organization in the state, 81,000 members, 54,000 families
- Norman Borlog (green revolution) look at agriculture: affording a healthy supply for the world
- New set of challenges: while less people are starving, need to maximize use of our environment while also taking care of an environment that we are much more aware of than in the 1950s and 1960s.
- Topics:
    - Groundwater rights
    - Groundwater management
    - Groundwater quality
    - Options and opportunities
- General thoughts:
    - Gw is essential to CA agriculture => necessity to usable groundwater
    - Important property right – impertinent to the land
    - Strained resources – quantity and quality
    - Surface water – groundwater connection is complex and varying; e.g., changing irrigation practices can have negative impact on stream temperatures

    - Technology (NASA report on measuring groundwater) => technology that exists may change how we can get information. NASA can also measure ET rates from space => may perhaps be important to agriculture in new ways
    - Water use efficiency: agriculture has a role in replenishing aquifers
- Groundwater rights
    - Overlying
    - Appropriative
    - Prescriptive
- Groundwater management
    - Adjudication
    - AB3030 plans
    - County ordinances
    - Special acts districts
    - Function:
        - Information: people don't really understand groundwater all that well
        - Allocation
        - Regulation
        - Improve supply/conjunctive use
- Groundwater quality issues
    - Priority of agriculture is to protect groundwater quality => affects agriculture, farmers, and their workers
        - 2 RBs are currently addressing these issues, FB is involved
        - Challenges: what causes it, how is it caused, and how can it be prevented
    - Causes and prevention of contamination
        - Natural and legacy contamination
        - Example: price of fertilizer has made people much more judicious about fertilizer use
- Opportunities and Obstacles:
    - Obstacles
        - Threats to property rights
            - Response from farmer: my lifeblood is at stake
        - Infrastructure of conflict
            - Fighting over environmental issues is big business
        - Uncertainty
            - Difficult to understand complex groundwater basins
    - Opportunities
        - Use existing information
        - Use new technologies

Tim Parker, *Layne Christensen*: National groundwater monitoring network in the U.S.

- Evaluate network, trying to differentiate non-stress and stress conditions
- Identify data gaps, well characteristics, spatial

- Data management through the same portal
- Data portal: to test soon, NWIS, STORET. - automate process
- Ballpark cost for pilot implementation
- Pilots are a one year deal, have been selected and initiated
- Transparent report
- More information: ACWI

Laurel Firestone, *Community Water Center, Tulare County, California*: Developing ground-up solutions to nonpoint source pollution of groundwater: An environmental justice perspective

- There is no quick fix on groundwater contamination from agriculture in rural areas
- Without the participation of those most-impacted, there will be no solution
- Organizing, advocacy, and education are the key elements of Laurel's organization
- Reality in agricultural areas: families lack access to drinking water on a daily basis, in homes and schools for a decade or more
- Maria Elena worries each day about, where she gets good drinking water; are developmental disabilities related to the water? Air? Pesticides?....
- There are people that drink contaminated waters every day, because they are not notified by landlord, language issues, unable to afford bottled water,
- Highest cancer rates, birth-defects anywhere in the state (not saying it's the water – many possible reasons)
- Sources of nitrate – documented in www.ewg.org "Pouring it on: nitrogen use and contamination": fertilizer 53%, animal manure 27%, atmospheric 14%, point sources 6%
- Most powerful oganizations are able to avoid regulations because:
    - Groundwater is complex
    - Groundwater is out of sight
    - Groundwater is not part of the federal framework
- Communities pay the cost:
    - Health, social, ….
- Above engineering and technology => this is about power and inequities/injustice
- Farmers use most of the water, while farm workers have no access to water
    - Inadequate infrastructure
    - Discrimination
    - Worst labor laws of any industry
- Call to Action: organization: residents have taken over their local water boards, written legislation, gotten seats on the RB => make it impossible to ignore these issues => develop partnerships with agencies, universities, local organizations
- SOLUTIONS:
    - Stop groundwater contamination from primary sources

        - Dairy permit that includes groundwater protection requirements
        - Developing groundwater regulatory program in irrigated agriculture for the first time
    - Fund clean-up, emergency water, rural infrastructure and treatment technology
    - Secure long-term sustainable water sources for communities through partnerships with IRWMP, universities
    - Establish a statewide "lifeline" rate for drinking water
- Comment on Jack Rice's comment on the "Culture of Conflict" in CA: yes, we are challenging the current power structure in rural communities in CA. BUT: we need to ultimately work together, because we live together, we have shared future together.
- Make the Invisible Visible – Give A Voice to those without a Drop to Drink
- DISCUSSION:
    - Kathleen Thomasberg: what is the obligation of the labor camp owner to contribute to this solution?
    - Laurel: housing issue, housing law requirements about habilability, responsibility of homeowners, labor camps, employee housing to ensure that there is potable water available. BUT there is not much enforcement, many labor camps are not even permitted; this area needs a lot of attention. 80% of the worst problems were in labor camps, farm camps, dairy employee housing according to Balazs analysis.
    - Laurel: in Tulare has worked with County Health Department to address this issue; some counties don't have jurisdiction over drinking water (Kern and Fresno) where CDPH does the oversight directly; some counties (anecdotally) to allow systems not to monitor at all for 9 years. It goes back to the fact that many of these communities are neglected and are invisible
    - Rita Schmid-Sudmann: governor vetoed lifeline bill (human right to water act, which passed legislature)
    - Laurel: governor vetoed over worries of too much state liability; act is about basic commitment to provide enough safe water to drink to all people in California
    - Stephen Foster: it is important that grass-root organizations get good technical advice and not take on the whole agenda; use publicity to suggest simple solutions to address the emergency. A small actor cannot tackle the big gw contamination problem, leverage.
    - Laurel: those with technical expertise here, please engage with your local groups, NGOs, this is very important
    - Laurel: we feel that only putting on band-aids will not stop the gushing; is very committed to try both.
- FINAL COMMENTS FROM JOHN SELKER:
    - Industry gone amok and no connection to people affected
    - Seen environmental injustice in US
    - Oil tragedy: corporate responsibility is to their stockholders

- Situation in Oregon and California about farmers disparate from their workers

Jens Christian Refsgaard, *Geological Survey of Denmark*: Nitrate Reduction in a Groundwater Dominated Catchment: How Good are Models?

- MIKESHE modeling – how good did the models do:
- simulations of annual water balance: with rivers a lot of errors, with rivers and drains – lots and lots of errors
- simulation of annual load: downstream river station: ok, upstream river station: mediocre; drain station: poor
  - nitrate load to surface water must be reduced by ~50%
  - 2/3 of the nitrate leaching from the root zone is reduced in the subsurface when flow lines cross below the redox interface
  - We are missing geological heterogeneity
    - We don't know where reduction occurs
- Nitrate Reduction in geologicall heterogeneous media (NICA, 2010-2014):
  - Research questions:
    - How can we improve assessment of local scale heterogeneity
    - How can we identify the smallest potential scale at which a hydrological model can have predictive capability?
    - What is the smallest possible scale at which nitrate reduction can be assessed
    - What is a good management scale?
  - Methods:
    - Field sites, 5 sqkm and 100 sqkm
    - New geophysical instruments: TEM, MRS
      - SkyTEM: transient electromagnetic system (TEM) => 20% of Denmark has been mapped for groundwater with TEM
      - Airborne
      - For NICA - MiniSkyTEM: smaller frame, larger flight speed => improved resolution of upper layers: 1-2m vertically and 20-50 m horizontally
    - Field work: ground truth, geology, depth to redox interface
    - Stochastic geology: TPROGS conditioned on available data
    - Scale analysis (representative elementary scale, RES – following Eric Wood, Princeton):
      - What is the smallest scale at which models can be predictive?: mean, variance, spatial correlation => generate a dozen or so realizations of the heterogeneity
- CONCLUSIONS
  - Policy problem: differentiated regulation of agricultural practice is more cost-effective than universal regulations
  - Differentiated regulation requires scientifically ased evidence to document that regulations are imposed on the right areas
- Questions: side-effects of denitrification: sulfur, GHG

Arnoud de Klijne, *National Institute for Public Health and the Environment, The Netherlands*: Nitrate Directive Compliance: Checking for Nitrate in Groundwater in the Netherlands

- hydrology: lots of water in Holland, wet and flat
- agricultural land with very high groundwater table, lots of surface water => closely linked => close relationship between sw, gw, and agriculture
- monitoring: drinking water wells, soil moisture, shallow and middle deep gw, water in ditches, water in tile drain water, regional and national surface waters
- politicians: focus monitoring on the sources (check your pulse right after you run your marathon)
- groundwater quality: showed decline of nitrate levels in four regions in NL (peat – lowest; then clay, above MCL around 70 mg/L – sandy region; highest – loess region: 80 mg/L => compliance in peat and clay, but not in sand and loess
- EU legislation: application standard N should lead to compliance with the target value of 50 mg L nitrate in groundwater: at field, farm, region, or national level; At what depth? How deep? From draft guideline: first five meters,
- NL politicians: change BMPs or just change depth of compliance in the soil? Is there an *environmentally sound* way to change the compliance checking level for nitrate in groundwater
- Research done as a consortium of various institutes: Deltares, TNO, Alterra Wageningen U for 10 years
- Extensive field testing, lab testing, modeling study
- Results of 8 years – a few bits and pieces:
    - Field test N profile in 10 dairy farms
    - Dry soils with > 1 m water table: sane nitrate throughout 5m of groundwater
    - Others much less (below 50) as depth indceases
    - Clear relationship between nitrate in upper groundwater and surface water
    - In "wet" soils the upper groundwater is really important for surface water, so going deep doesn' work, but maybe monitor surface water
- FINDINGS:
    - TRANSLATE: translate policy problem into clear scientific questions – and take your time for it!!! Do not answer a policy questions!!
    - COOPERATION with other institutions
    - INTERNATIONAL perspective and networking

Kelly Warner, *U.S. Geological Survey*: What is the background concentration of nitrate in groundwater?

- Works for USGS and NAWQA for last 20 years
- Is putting together/developing regression predicting models for what happens to domestic wells.

- One of the key questions: what is the background concentration?
- Definition of "background":
  - USGS: concentration indicative of minimal influence by human sources
  - Sometimes "natural concentration"
  - Shows a table on background concentrations numerically defined
- [I unfortunately missed the rest of the presentation]

Pamela Creedon*, Regional Water Quality Control Board, Central Valley*: CV Salts

- 45% or so of CA land area
- 80% of irrigated ag
- 80% of dairy ag
- 2nd largest contiguous aquifer in US
- 50% of all wastewater treatment plants discharging to rivers or land
- 50% of all septic systems
- Contains all of Delta
- Shows nice graphics of salt loading to/from Delta
- Inorganic salts mostly reach SJV & TUL through Delta
- 2006 study shows salt problems
  - 2 million tons of salt accumulate in SJV every year
  - Salt concentrations impact soils on Westside of the SJV => agricultural areas, future population growth
  - 400,000 acres of saline soil in Fresno County (120,000 more than 20 years ago)
  - 100,000+ acres removed from production on Westside
  - Mean EC at St. Vernalis has nearly doubled since 1940s
  - 400,000 tons of salt are added to confined aquifers each year
  - Ag, municipal, and industrial dischargers are facing discharge permits
    - =>cost of treatment are becoming astronomical
  - Nitrates are also increasing, domestic supply wells particularly hard hit
  - Bureau of Reclamation: Friant-Kern Canal and Madera Canal => completely diverted, now under restoration
    - Significance: instead of very low TDS from SJRiver, now comes the Delta-Mendota canal to Mendota pool, which is much higher than eastern Sierra water
- Problems:
  - Increasing salinity and nitrate in groundwater
  - Worsening conditions with drought
  - Needs attention now, not later
  - Economic study: 5-8 billion reduction by 2030; 34,000-64,000 jobs lost under DO NOTHING alternative
  - We don't have an economic method for salt removal
  - No uniform regulatory approach: right now facility by facility, site by site, staff by staff
  - Grossly outdated basin plan with respect to salt and nitrate
- Solutions:

    - Anticipated cost 20-40 million for development, more for implementation
    - Involve stakeholders in the solution process
    - Brand-new regulatory program that will involve all stakeholders and everyone that uses CV water
    - Revision of basin plan with stakeholder driven approach has regulatory backing (Hoover Commission)
- Leadership Group Goals
    - All users are engaged and actively participating
    - All users have to pay
    - ….
    - Program to be done by 2014; just now beginning to develop the technical and scientific needs to develop the policy
        - Non-for profit coalition and help in leadership of efforts to put this in place
            - Water and wastewater
            - Ag and irrigation
            - Industry and others
        - Not everyone can buy in, but there is a place for them:
            - Regional Board, SWRCB, US EPA, environmental justice, etc.
            - Technical committees, working groups
- PLAN:
    - Overarching work plan outline
    - Distributed implementation efficiency
    - …..
- Question: what is the crimp behind CD SALTS?
    - Pamela: we have this loading from the outside into the SJV. In the Sac Valley the EC levels are very low, yet total loading of salt is very significant
- Question: role of water board in the coalition?
    - Coalitions is separate 501c to get money, more efficient, but Board is not giving up its regulatory authority
    - Director of coalition meet with SJV environmental justice groups on regular basis; hopefully some video-conferencing
    - We can look at innovative solutions, market-driven, etc.
- Question: deadline about BMPs and technology
    - Iterative process to continue to evaluate BMPs, but start with evaluating todays practices

FINAL PANEL

Facilitato: Margaret Catley-Carlson, *Canadian Water Network* - C
Mark Giordano, *International Water Management Instit*ute - G
Michael Campana "Aquadoc", *Oregon State University* - A
Jacob Burke, *Food and Agriculture Organization* - B
Jean Fried, *UNESCO and University of California, Irvine* – F

(Questions were posed by Margaret)

- Were there any big themes missing?
  - G: overall coverage was good with exception of the final piece: how to drive policy issue. We got the view what's missing, the institutions involved. Was missing even at the local level
  - C: very impressed with new groundwater ideas
  - B: would have been nice to have USDA here on nutrient and pesticide control and economic impact, opportunity cost of foregone production; agriculture should have been more part of this.
  - C: agricultural people seemed to be quite a part of the participants
  - A: Heard a lot of interesting stuff, aphorism: opium for one elixir for others. Knapp: need to define sustainability before we address it quantitatively. Eaton: sustainability as no lowering of water table – too bad Bredehoeft was not in that session
  - A: missing was: place agriculture in the larger context of use of non-renewable resources, other users of groundwater
  - C: but if you bring in everything, doesn't ag get lost
  - A: someone could have placed ag use in the overall context, general use of nonrenewable resources
  - A: the theme of this conference was brilliant, we have not seen this kind of conference in the US for who knows how long
- Are we satisfied with the ability of measuring the impacts of agricultural practices?
  - A: I have no wisdom because it comes from Mike Wireman. He felt BMPs weren't doing the job of mitigating contamination of groundwater. Not sure whether BMPs were not effective or not implemented properly – that was a very prescient observation
  - B: groundwater practitioners are bad at getting the messages out, don't target the right people in the message about how much damage has been done
  - C: so, do we have anything, where improvements in ag practices create a measurable improvement in groundwater status that can be talked about
  - F: it's a problem of communication. Is there not also a problem of communication between the hydrogeologist and the farmers? Great example today with Sanjay Pahuja: how training and education to individual farmers makes a difference. This is what UNESCO presently tries to do, and the follow-up of the conference on Water

Scaractiy organized in 12/2008 at UC Irvine: we go into Kenya, Tanzania, Uganda, Burundi, perhaps Ethopia, Sudan – organize the training in the local points of the individual farmers, that' a problem of teaching and education.
    - Jennifer McKay: we certainly regulations of pesticides AND fertilizers
    - Laerke Thorling: this morning in session D from DK and NL on how BMPs have improved N without lowering crop yields due to adapting to this new regulation
    - G: a lot of water savings technieques mean we use more water to produce more crops.
- What does have illiteracy to do with how we can deal with groundwater in agriculture, teach better practices to protect groundwater?
    - G: not an issue of illiteracy question, more incentive
    - F: spent time in December with Massai, simple words help a lot, they know much more about their own water, better idea of water table than Jean's students, most of them walk 30 km/d to get water: have an excellent idea of what they are talking about. If you speak in a way your students better understand, you understand better
    - Tushaar Shah: No. In India, farmers have low level education. But very good understanding of groundwater and where the water comes from to their well. They have paid attention. Great deal of local understanding of hydrological processes. In some parts of India there is a popular hydrology, farmers will describe the entire watershed. Scientists look down on farmers, but indeed can learn from them.
    - C: so water literacy is more important than functional literacy
- Know-how between groundwater and agriculture: What would you do with a one million dollar price, or more: what would you do with it?
    - B: scaling innovation. Take a germaine idea and then take it to scale. The geology is something to which you are very sensitive. When you go to big solutions, you have to be able to take something an apply it to something at a large scale, but still adaptable to variations at local level and can be communicated.
    - A: I asked for advanced techniques to acquire information on very small spatial scales, something like the GRACE project (Bridget Scanlon), but that's of course on a large scale – we need that at a very fine scale.
    - F: – develop tools to monitor our groundwater that are not too expensive (drilling a well is expensive!). I would also have good MAPPING, so that individual farmers can use it.
    - G: A lot of farmers know exactly what the situation is. I would give my prize to something that measures when groundwater sustainability decreases
    - Bharat Sharma, New Delhi: local hydrogeology, local knowledge converted into a real piece of science
    - C: what about prizes for quality?

    - F: we speak a lot of developing countries, but not about so-called developed countries. Diffuse pollution is a big issue, nitrate is called the time-bomb in Europe, what do you do with it? We spent a lot of time to map and evaluate vulnerability of aquifers with respect to diffuse pollution, but something else still needs to be done.
    - C: I would work with the International Fertilizer Council to develop on granulating fertilizer so that it can be used in a very different way, not so much going into the groundwater (or surface water). This is being tried out in Bangladesh). Try this out possibly with seed drilling.
    - B: Science of sociology, which is also a science. Concerned about proliferation of ideas among users and the sociology of these ideas spreading among users – how can that be done effectively
    - A: development of nano-sensors for real-time based information across the landscape
- Another question on Know-how: at what level should the framework for farm regulation be set?
    - A: this may be the right answer to the wrong question: something that I get from here, people need to … the way we are doing things now is based on watershed boundaries, we need to have farmers have the means to manage their own water resources – in conjunction with their neighboring regions. There then also needs to be something overarching to hold/integrate it together. So something that emphasizes local level management with something that also integrates it across regions.
- Let's switch to policy and management of groundwater: How do we do it?
    - A: if I had done it successfully, I would not be here – I would be the water czar. We need to work very closely with the farmers and help them disseminate their information to their peers. I have given talks where I solicit feedback from them on "How would you deal with this problem?"
    - C: you would think that international organizations are particularly well setup to these kind of things – but then to get just one of each area of expertise needed into the room on gw-ag is already a large meeting
    - B: if you take a groundwater policy to scale, getting the right germ to set this in motion is the key thing, getting the players to be part of it. You cannot apply a generic approach or template. Find the people that prompt at the right time. We have to be atuned to that.
    - C: Has FAO done this?
    - B: with ministries of agriculture, but we take it outside the ministries, but to have ministers take on that responsibility is a struggle
    - F: this is part of the policy of UNESCO, to have multidisciplinary meetings. Difficulty is how to organize it, how to direct, make it interssting for everybody. But I want to come back to another institution that is less known here: the European Union (EU). EU is about politics between people of different cultures, north-mediterranean, south-mediterraean, northern Europe. Supernational

institutions like the EU, which also does it outside the EU. I don't' have any rules, just want to point out that there are other institutions that do this.

- M: related to research and universities: Charismatic leadership in various functions is the key and having the desire to step outside your own discipline and getting right incentive to step outside, pushing people to think outside the box.
- Mike Wireman: there is an issue of ag community not having any trust. The only way to overcome this and that is TIME. You have to go out there, again and again. The government is not set up to do this, with the right ideas. The only way to get trust is to spend the time and the hours to do this. Our government systems around the world are not set up to do this. At EPA we struggle with the same things, and often we cannot do that.
- C: The opposition ethos within government (attacking politically) doesn't help either.
- Tim Parker: CA has been a model in using the stakeholder process in developing regulations. Build a foundation of understanding first, reach out to people, which includes agriculture, water purveyors, local business, environmental people. There have been 20-25 partnerships for groundwater management plans. This has been fairly successful in many cases. When regulators come out and say that they are looking for long-term solutions and not regulation, that helps.
- C: I hear you also say that you are looking for neutral ground
- Jennifer McKay: farmer is pushing sustainability, was outcast, and now is back after building credibility. Another case is a forester – and other case studies like that: build trust to avoid litigation. In India we see this time and time again.
- Audience: I work for an RCD (Resource Conservation District). Farmers trust us, but our problem is the $$$.

- Question from the Hallway: how do you make good connections between existing age-old cultural structures and engineering solutions that were developed over a short period of time? Cultural Change?
  - B: if you look at the uptake of cheap pumps and the availability of propagation – whether in Central Valley, Andra Pradesh, or China. That quickly turns into agricultural use. Technology can work either way. Solutions can become habits very quickly. Even if culture has been there for thousands of years, this technology can be taken up very quickly, but it also can destroy structures.
  - G: needed cultural change? – I flip that around: speaker from USGS mentioned whether or not groundwater quality should be monitored or not? We should be careful about what's needed – depends on people.
  - C: "The Culture of Agriculture" a new book on my desk, not read it yet. Some cultures are resistant to change – here is a plug in for this book. The most dramatic culture change – with respect to food – was a woman in India – feeding her child. Feeding the child rice, was

carefully separating out all the protein. It would have done amazing things to that child. But the culture was to not give children protein until the age of 3. That's a culture and nutrition cameo example.

- Do international ideas at the national level. Do people inspired at the international level really make change at the national level? Aren't we just having a nice life at the international level.
    - F: partly yes. It really depends on the people who go in the field. I have had an excellent experience, not within UNESCO, but with different organizations, when I met in Central Asia with people with USAID, who really knew the culture, fully adapted to the country; and there, when we discussed with the Uzbek, the people there really wanted to learn. USAID were doing the utmost to transfer what they knew to their host country. It worked in other countries also. Of course, we know many people from international institutions like to travel and go to conferences. But not everybody. Many of these people are very efficient and effective. Also national institutions that deal with international problems like GTZ from Germany. We had series of engineers that really devoted to the colonies at the time, which contributed to the development and transfer of ideas.
    - B: there is no water convention, there is biodiversity, there is climate change. Perhaps they set an atmosphere of change. Coming back to groundwater: the conventional non-navigational use, is groundwater invisible enough, transboundary waters, …… not sure it would help.
    - G: Convention on Transboundary Waters: it was negotiated for several years, didn't think it would make a difference, but our research shows that it really does make a difference. National governments act upon it.
- Another audience question: how do you protect groundwater DESPITE politicians?
    - B: look at the multifunctionality of aquifers (urban-ag interface) – I think – certainly for urban and agriculture – the use of wastewater streams – the implications for recharge – aquifer storage and recovery – we shouldn't be too shy to go down that road. I am seeing ag being squeezed at the margin. But hang in there
    - A: I am not using the term tea-party, but if you band together and make an issue of it with the politicans, you'ld be surprised how effective it can be. You will find if you get enough people together, you can make a difference.
- How can groundwater advocates insert themselves into large political frameworks, EU water framework, US legislation
    - Rita Schmid-Sudmann: understanding of the resource is really missing. People care much more about the environment today than 50 years ago. But they just don't know about groundwater. How do we do that? Multiple levels. I thought school was just a play thing, but my daughter taught me otherwise. Public Television – people watch it. Cable shows too. It doesn't cost that much money to do it. We are not spending the money that we need to spend to get out there and get the

message out, a few small NGOs (groundwater foundation, etc.). But big industry doesn't want to spend that money.
    - C: What happened in the EU to a group of worried hydrologists and earth scientists when the EU Water Framework was developed?
    - F: It comes from the structure of the EU itself. It has been debated. From democracy. It comes from the fact, that the EU from the beginning has been directed by a system comprised of two things: the legislative body and the executive body are not separate. Council of Ministers adopt the law. The EU Commission (the executive) … therefore the experts working within the EU (small group of people) have the initiative – they can realize what is needed. And they can propose a law. That law will be discussed within the commission. For a long time the parliament had nothing to do with a law but give advice. Now it is a bit more participatory. But it comes from a small group of people. I was part of a group that wrote the first groundwater directive. We started to work on it in 1976, it was adopted in 1980. Then it gave us time to raise the awareness of everyone in the memberstates. At the same time we (a small group of people, 5 or 6) to have a survey of the aquifers of the EU (nine memberstates at the time), at the same time to support the groundwater directive (focused at that time on pollution). This evolved into that framework directive of 2000 and a second groundwater directive in 2006. This comes from the political structure and a SMALL amount of people that was convinced at the time that this was necessary. Today this would be much more difficult – more countries, more suspicion of EU Commission.
    - David Eaton: a comment on politician. Politicians can move things along very rapidly. For example LBJ in the US. How can ideas be entered. There is no reason why people here cannot get involbed in DC or in Sacramento. One can have influence. The question really falls back on us and on us to be engaged in the process. LBJ made some remarkable statements about how he came about to decide on the things he decided upon in the environmental arena.
- What are best ideas of sharing and moving ideas?
    - B: best practice never tells you what to do, worst practice always tells you what to not do. We all – World Bank, FAO, UNESCO – have ideas about good ideas. But we really learn most from the things that go bad. Look at the Gulf of Mexico oil leak – this will be a big lesson in many ways. Something to think about.
    - G: The Comprehensive Assessment on Ag and Water is an example of the ideas that people had about a particular issue, being advocates, picking up information from various sources and putting it together – a good example of a collaborative process to bring the funding and the people together for a creative process.
    - A: I liked what you said, Jake. I had a personal experience – every year at the conference it was SOS, same old stuff. And you'ld sit there,

and… I mentioned to the executive director, why don't you have one or two groups come and share with us how to not do it, give bad examples. Show what was done that didn't work, what should have been done. These screw-up talks pack the house. You have to see things that are in the book, but they didn't work.
    - C: I agree: if you have three projects that go wrong and go wrong for roughly the same reasons – we start to learn.
- John Selker: given that the price of extracting groundwater is very low, given the population, we have a groundwater problem. Don't we just rearrange the chairs on the deck of the Titanic. What about universal metering of groundwater extraction as the first step. Tell this all the governments.
    - Jennifer McKay: that's what we did in Australia, and now we charge. The meters have become really cheap and now are well-liked.
    - Tushaar Shah: I think that the developing countries have a very unique problem. Their problem is not a new problem. China, India, Bangladesh, Pakistan: what I see happening: lets' go to California, Kansas, or Australia, what are they doing. Without analysis of why it is working, what are the conditions, we cannot just adopt the solutions. In US the government makes a law and everyone follows it. In India, the government makes a new law, and noone cares. We need to be sensitive on how we adopt solutions in developing countries from developed countries.
    - Tim Parker: metering doesn't work in California either.
    - Jennifer McKay: folks used to put a stick into the water, remote meters were very expenive, there is also human factor, good will.
    - C: which goes back to Jacob's point, that this is about social organization, too
    - B: What's the resistance to putting in meters? Ah, too expensive and complicated, but the real reason was that the utilities didn't want to show the difference between what they use and what they bill.
    - A: the problem is finding the political will, a politician that will stand up to do this. It only happens, when the water is gone. I lived in Atlanta in the early 80s. One of the populare bumper stickers was "we don't give a dam how you done it up north"
- Adriana Bruggemann: should I pay the corrupt government for my water? And in the US: should the government pay for the farmer?
    - B: irrespective of the legal status of groundwater, if the use and practice is private, why is there even a need to pay somebody?
    - Bruggemann: yes in Syria you have to pay for extraction.
    - B: in most places you are not charged.
    - Shrikant Limaye: water meters are expensive, cheap ones don't work, and if they were there, farmers would just circumbuild them. Farmers don't like to limit the number of wells. A story for why regulations don't work: take a 1 ha farmland, its owned by farmer A. here is farmer B with 1 ha farmland, both of have one well and both want a

new one. Bank will tell farmer to build well as far away from the old well as possible – they both drill two wells side by side.

- How do we make the invisible more visible?
  - C: at the 5th World Water Forum, groundwater was actually part of it.
  - B: I am not quite sure that more case studies will quite do it. Certainly in creating an atmosphere, maybe the only way to get there, will the gulf story - great attention. Will groundwater crisis capture the attention? We need a bit of a wake-up story. We need to show we have a problem. It's a scale thing.
  - C: do we need more information to make the invisible visible?
  - B: it is quite difficult to differentiate by source, You can't distinguish the sources, like this amount of rice was produced with this much groundwater. Will the depletion of groundwater cause a shock in markets. Will everything collapse at some point? There are problem with depletion and degradation.
  - C: we spend too little time collecting the anecdotes into a big story. Instead we collect more data
  - A: the thing that helped put groundwater into the World Water Forum was having the Prince of the Netherlands show a graph of the transboundary aquifer maps, which hit home with a number of people that didn't know how extensive aquifers are, and how they underlie many countries in some cases. It took a while to put it together, but it was very effective.
  - F: sorry to disappoint you: In UNESCO, groundwater is not that important, in fact WATER is not that important. First, it's a problem of budget. If you have the right lobbies to get the budget to the divisions - water is not considered as important than other divisions within UNESCO, problems, issues. This is an institutional problem.
  - G: one thing my institute did is – there is a groundwater research group. Just by restructuring ourselves it made a difference. One is perception problem. We often don't know where our resources come from.
  - F: the water people should not multiply conferences and meetings without connecting these meetings. Coordinate these more and ALSO mobilize those that are not involved in those conferences. A lot of these international meeting are very inspirational.
  - C: too many global meetings, same reports, same conclusions over and over again
- Prologue: this has been an amazing meeting, so many sessions plugged into such a small space, time, people kept their time, a lot of basis were covered, very wise using the plenary sessions to ask people to talk about horizons on difficult issues, and use work sessions to have the practitioners present.
- Final question: where do we go from here? Let's not just come back in a few years and say the same things again? I want a bunch of ideas….
  - G: next step for the organizing committee is to ponder the key messages, outcomes, missing pieces. Then thing about what are the

key areas that need to be hit: goals of the participants in terms of their geographic focus. Wherever the conference will be, that's a geogrphic bias

- A: think globally, act locally. What I suggest: we don't all have the same vision about groundwater in agriculture. What we all should do, is go home to where we are engaged, and lobby there for your particular point of view. We don't want to come out of here and say we all agree. Do what you gotta do, go home!
- F: I give the example of what we did after the UNESCO conference in 2008. We want to the Intergovernmental Council to convince them what the conclusions of our meeting had to be implemented, and we had to immediately also go into the field. We established a category II center with UNESCO for training and other implementing UNESCO programs. We managed to convince the political people that it should be a GROUNDWATER center. It's the only (it's the third in Africa) it's the only one completely devoted to groundwater. Put your money where your mouth is.
- John, North Coast Regional Board member: there is a lot of information available, we got to get it to the people that need to use it, I like the idea of involving the social sciences into this.
- C: we need to study the alliances that make things groundwater happen
- Ramasamy: explore more in detail in smaller workshops and conference, how diverse models can get into the right place
- Shrikant Limaye: visit the website of best groundwater practices in groundwater management – write to Limaye. Build on what people have already learned.
- ???: transparency of agencies, make information more accessible to actual users
- ???, Educate, communicate, have a dialogue from the policy-makers, scientists to the folks on the ground. Workshops with 8-80 people scale with people in the community.
- Elena: listen to people from other communities/countries for new ideas, finding ways to exchange new information around the globe,
- Linda Bond: if someone could setup some kind of share point
- Rita: we will have the website for sharing this information. Links to webpages.
- Tim Parker: sustain groundwater legislative advocacy; have workshops on how to do this. This is a continued investment, at the state and at the federal level
- Laerke Thorling: something that has been very important, we invested a lot of effort on building mutual trust between farmers and hydrologist.
- Paul Martin: the comment about TIME from EPA is very critical. I remember a comment from a farmer state assembly woman: noone will tell me when to turn my pump on or off. But there is a fear of threat to economic well-being. Change can be threatening. You got to

balance the public good or the private good. There is an increasing awareness in ALL groups that this communication needs to happen. I agree with Laerke Thorling

[A video-recording of the plenary sessions and other materials will be posted on the conference website, http://ag-groundwater.org]