Environment Canada Environnement Canada

Canada

Agriculture and Groundwater

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Soils and Crops Workshop
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Three Questions

- How can agriculture negatively impact groundwater quality?
- What evidence is there of impacts?
- How can agricultural management strategies be applied to reduce or eliminate impacts?

Processes

How can Contaminants from Agricultural Lands reach Groundwater?

- Requires a combination of a contaminant source and a transport pathway
- Source is a potential contaminant either present as a result of agriculture or managed by agriculture
- Transport is usually by water movement

Sources

- Pesticides, veterinary pharmaceuticals
- Pathogens – livestock and wildlife
- Nutrients – soil, fertilizer and manure
  - Managed by agriculture
  - Become a source when in excess of crop requirements

Transport

- Water moving below the root zone
- Semi-arid to sub-humid climate
- Net downward water flow is not expected
- Seasonal variation in transport

Winter

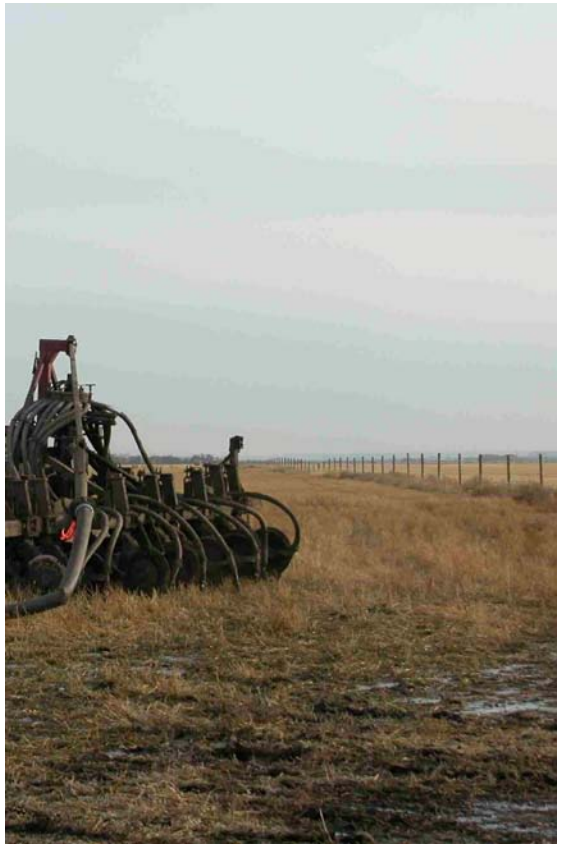
- 30-50% of precipitation
- Frozen soils – low infiltration
- 80% of annual runoff is generated during snowmelt
- Little downward movement of water

Summer

- Relatively low precipitation
- High evapotranspiration demand
- High intensity convective storms exceed infiltration capacity in surface soil
- Prolonged wet periods in “wet years” may lead to leaching through the profile

Fall

- Dry post-harvest soil profile
- Little active growth
- Variable precipitation
- Some potential for leaching through soil profile



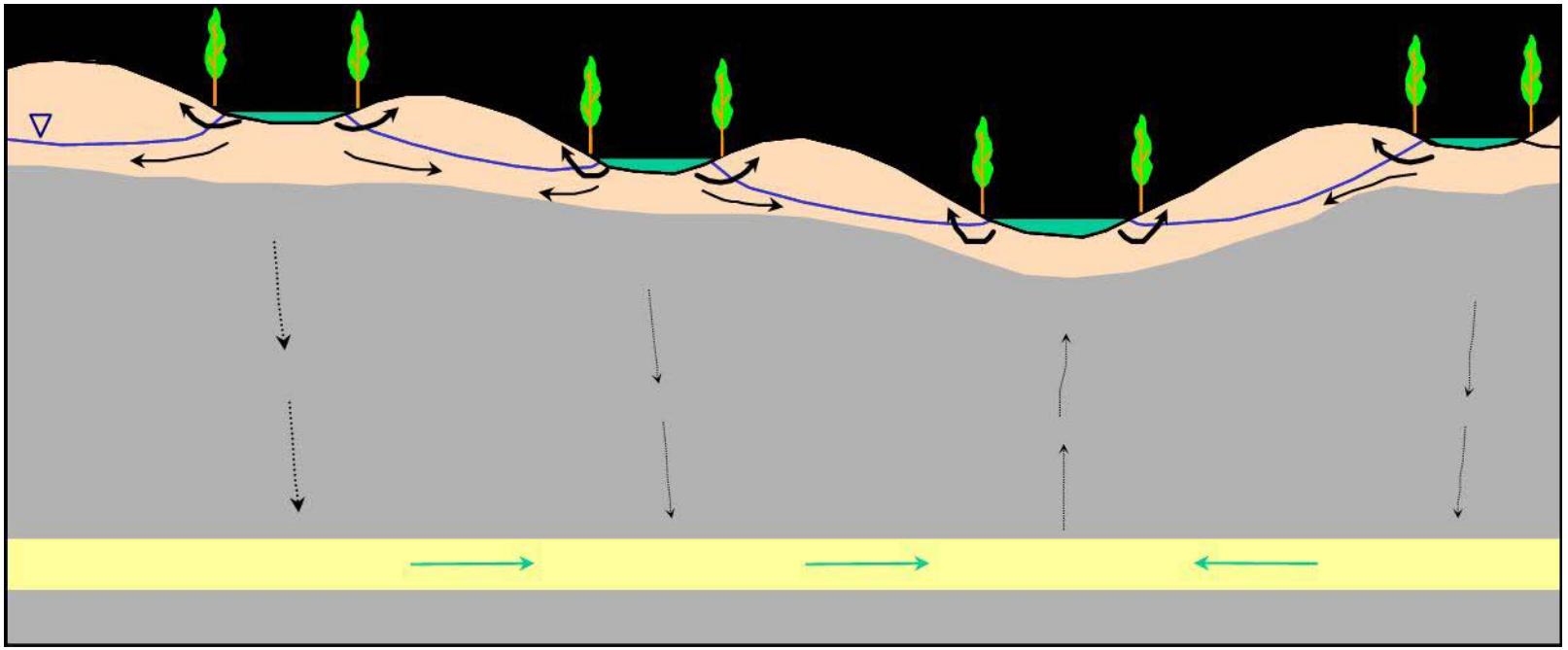
Spring

- Surface soil is moist after snowmelt
- Crop not yet established and using moisture
- Generally high precipitation
- Greatest potential for leaching through soil profile

Overall

- Little potential for leaching through the profiles of prairie soils
  - Most likely to occur in spring or fall
- Preferential transport pathways can lead to groundwater contamination
  - Infiltration of ponded water
  - Preferential flowpaths

Wetland Hydrology



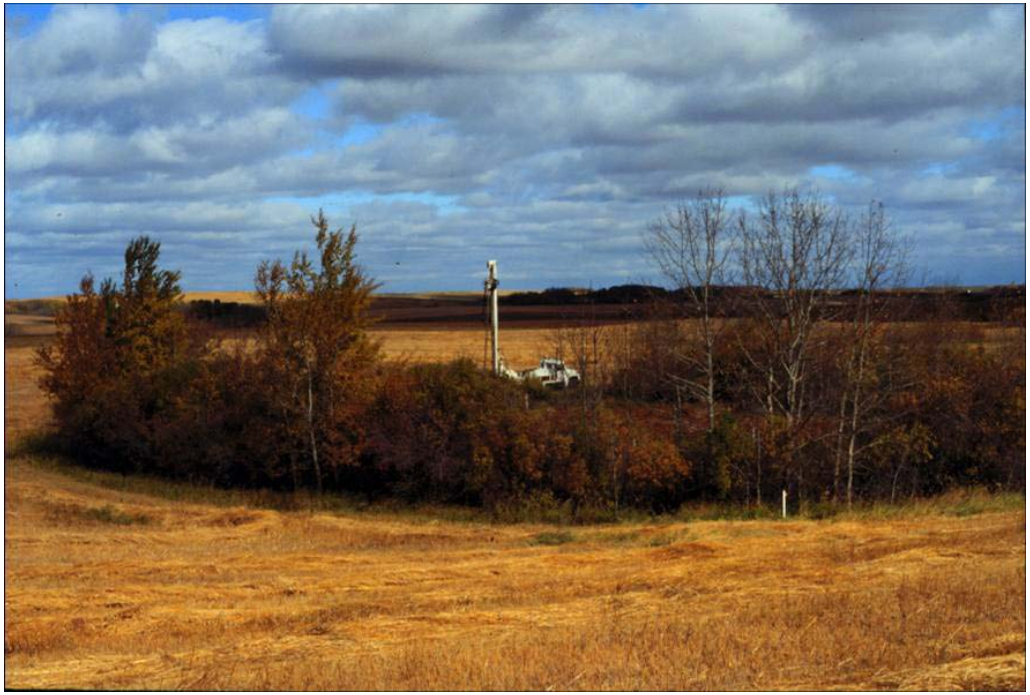
- The central ponds interact strongly with the riparian vegetation through shallow groundwater flow
- Groundwater exchange with regional aquifers is very slow

After Hyashi et al. 1998

Recharge through Wetlands

- Wetlands accumulate runoff which slowly infiltrates to recharge groundwater

- Healthy wetlands can filter contaminants
  - High organic matter
  - Active microbial populations



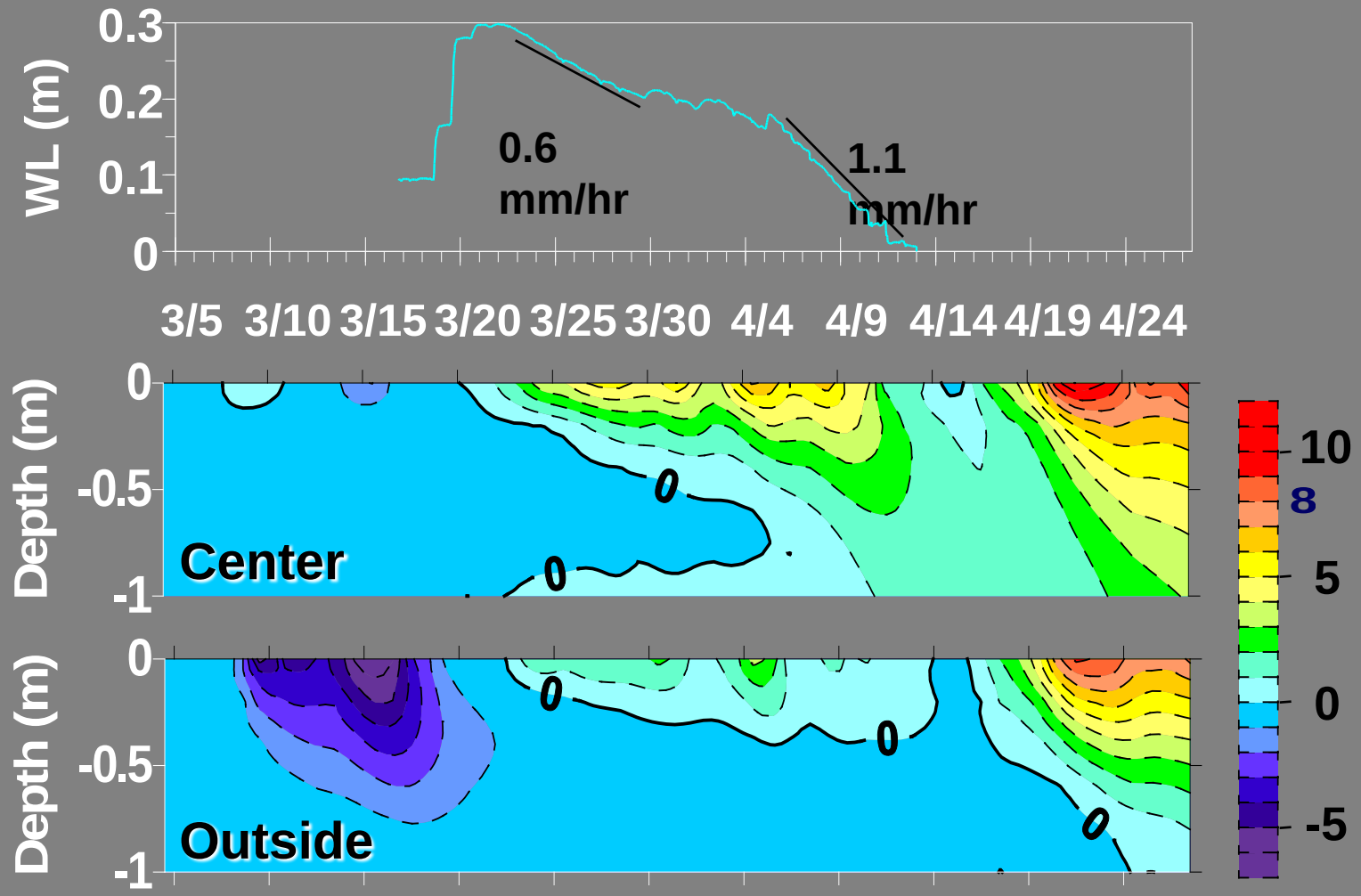
Puddles

- Temporary snowmelt water storage in weakly depressional areas
- Dry within a few weeks of snowmelt
- Don’t have ecological characteristics of wetlands
- Recharge groundwater

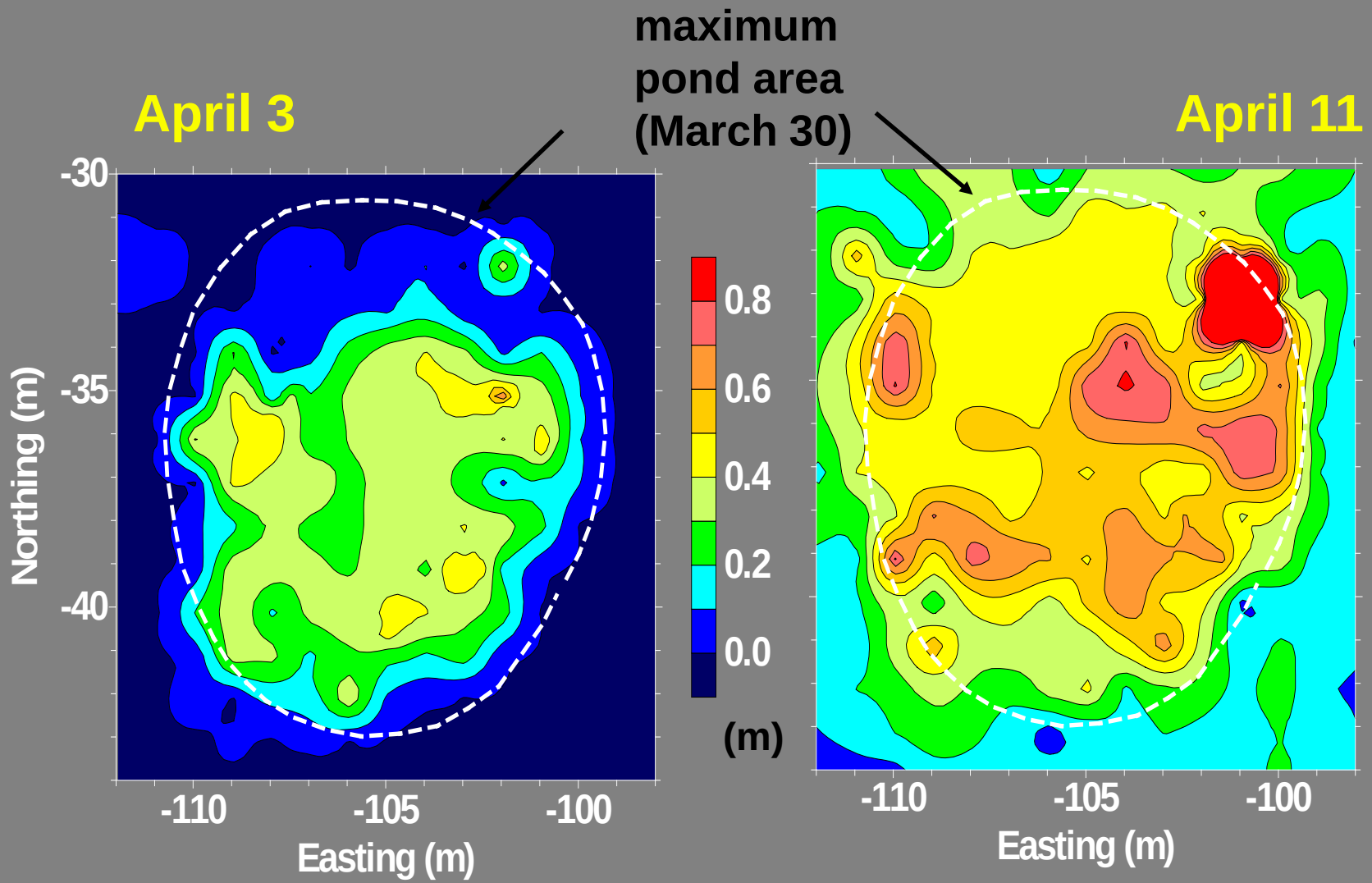
How do they Work?

- Water runs off frozen soil and accumulates in micro-depressions
- Stored until soil below depression thaws
- Rate of water disappearance exceeds evaporation indicating that the water is infiltrating

Water Level and Soil Temperature in Spring

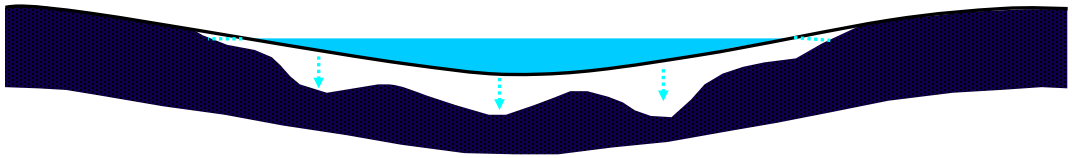


Depth to frost

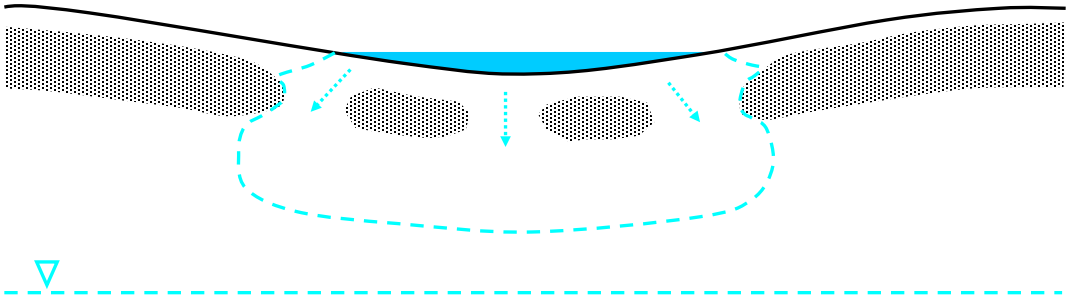


Conceptual Model

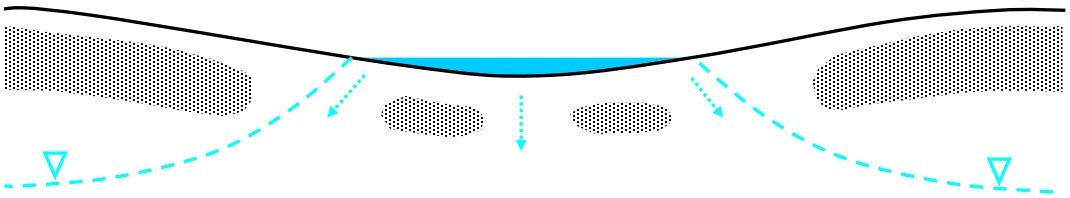
Slow stage



Short transition



Fast stage



Implications for Groundwater

- Water movement from puddles under strong hydraulic gradient results in relatively fast recharge of shallow groundwater
- Puddle areas do not have the same capacity as wetlands to “filter” the water passing through them
- Since puddles are generally farmed as part of the field they will be treated with herbicides and receive fertilizer and manure applications

Another Consideration

- Water stored in puddles is surface runoff
- Practices that impact surface water quality will also impact groundwater

Preferential Flow

- Can occur in any field
- Infiltrating water moves through the soil much more quickly than would be predicted by the hydraulic conductivity of the soil matrix
- Preferential flowpaths are thought to include cracks, animal burrows, root channels and variable hydraulic gradients
- Contaminant leaching studies and some tracer studies support the presence of preferential flowpaths

Implications of Preferential Flow

- Contaminants can be moved quickly through soil without interacting with the matrix
  - Sorption
  - Degradation
- Simple leaching models don’t account for preferential flow
- Post-harvest soils may have greater potential for preferential flow

Abandoned Wells

- Extreme case of a preferential flowpath
- Abandoned farmyards may contain unsealed wells
- Locations of others are unknown

Evidence

Well Surveys

- Deep wells are less likely to be contaminated than shallow wells

- Numerous surveys have been done on shallow prairie wells over the years
  - In general ~30 % exceed nitrate guidelines
  - A smaller proportion are contaminated by pesticides and pathogens
  - Some surveys indicate that contamination mainly occurs near livestock facilities

Pesticide Detections in Wells

- Pesticides are found in a relatively high proportion of wells
- Detections rarely exceed drinking water quality guidelines

- Higher pesticide concentrations have been associated with spills in the vicinity of the well

Assiniboine Delta Aquifer Study

- ADA provides high quality water to support many uses in southern Manitoba

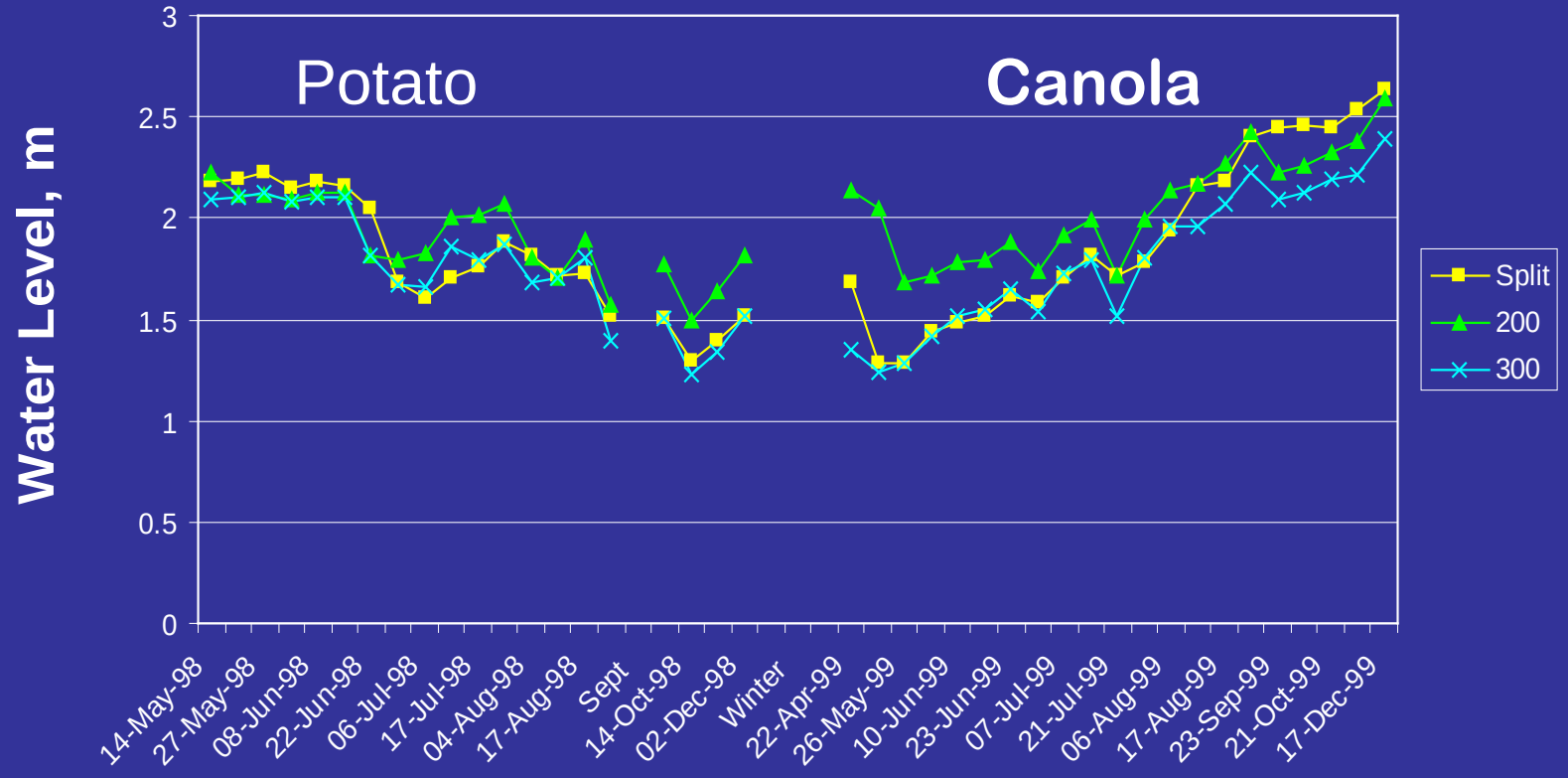
- Vulnerable to contamination
  - Shallow
  - Overlain by sandy soils
  - Irrigated potato production

- Preliminary results show pesticide detections in 40% of wells tested but concentrations are well below guidelines

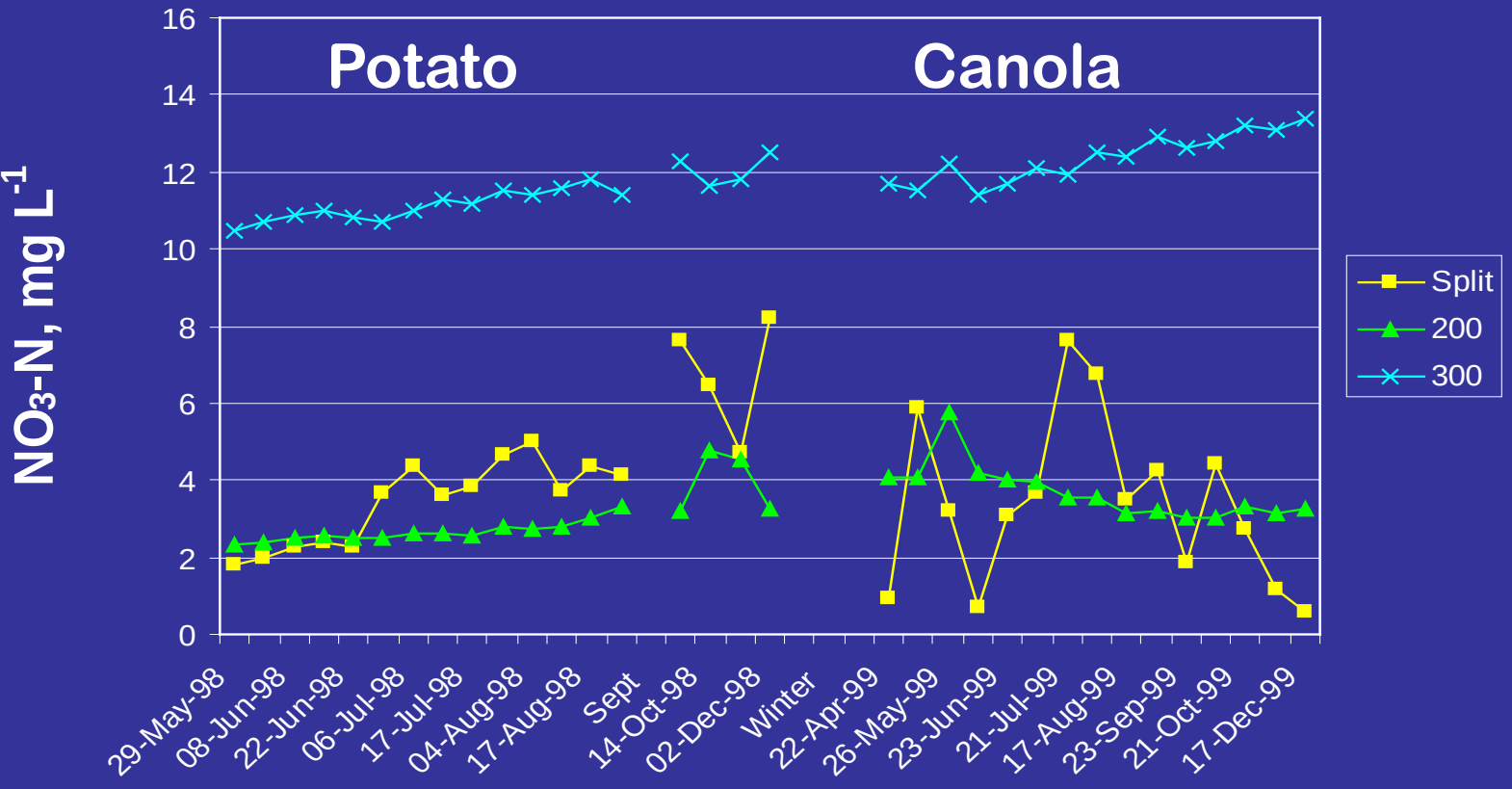
Irrigated Potato Management

- High value crop
- High requirement for:
  - Nutrients
  - Pesticides
  - Water
- Light-textured soils
- Row crop
- Shallow root system

Groundwater Level



NO_3 in Shallow Groundwater



Dryland Conditions

- Crop rotation research at SPARC
- Nitrate leached below root zone
- Crop-fallow rotation
  - Leaching greatest when a wet fallow year followed a dry crop year
  - Nutrients not used by crop during drought were leached in fallow year

Manure Management

- Study detected a veterinary antibiotic in shallow groundwater beneath a depression where manure had been injected
- Concentrations were low but detectable
- E-coli was not detected

Solutions

Wells

- Wellhead protection
  - No pesticides
  - Source area management
    - Limit use
    - Maintain healthy vegetation
  - Well construction
- Abandoned wells
  - Locate
  - Decommissioning

Nutrient Management Planning

- Matching nutrient applications to crop requirements is the best way to ensure that excess nutrients are not available for transport
- Soil testing to assess supply
- Rotate crops to better utilize nutrients
- P-based manure applications

Farmyards

- Management of drainage from livestock areas
- Secure storage of fertilizers and pesticides
- Location of well

Pesticides

- Avoid overspraying of wetlands or other sensitive areas
- Reduce drift as aerosols return in precipitation
- Choose to apply products that pose the least environmental risk
  - Decision support tools are available in some provinces

Conclusions

- Poor agricultural management can lead to groundwater contamination on the prairies
- Although leaching rates are generally thought to be slow there are some preferential pathways for transporting contaminants
- Good agricultural management can reduce or eliminate the risk to groundwater