Water Source Identification and Control

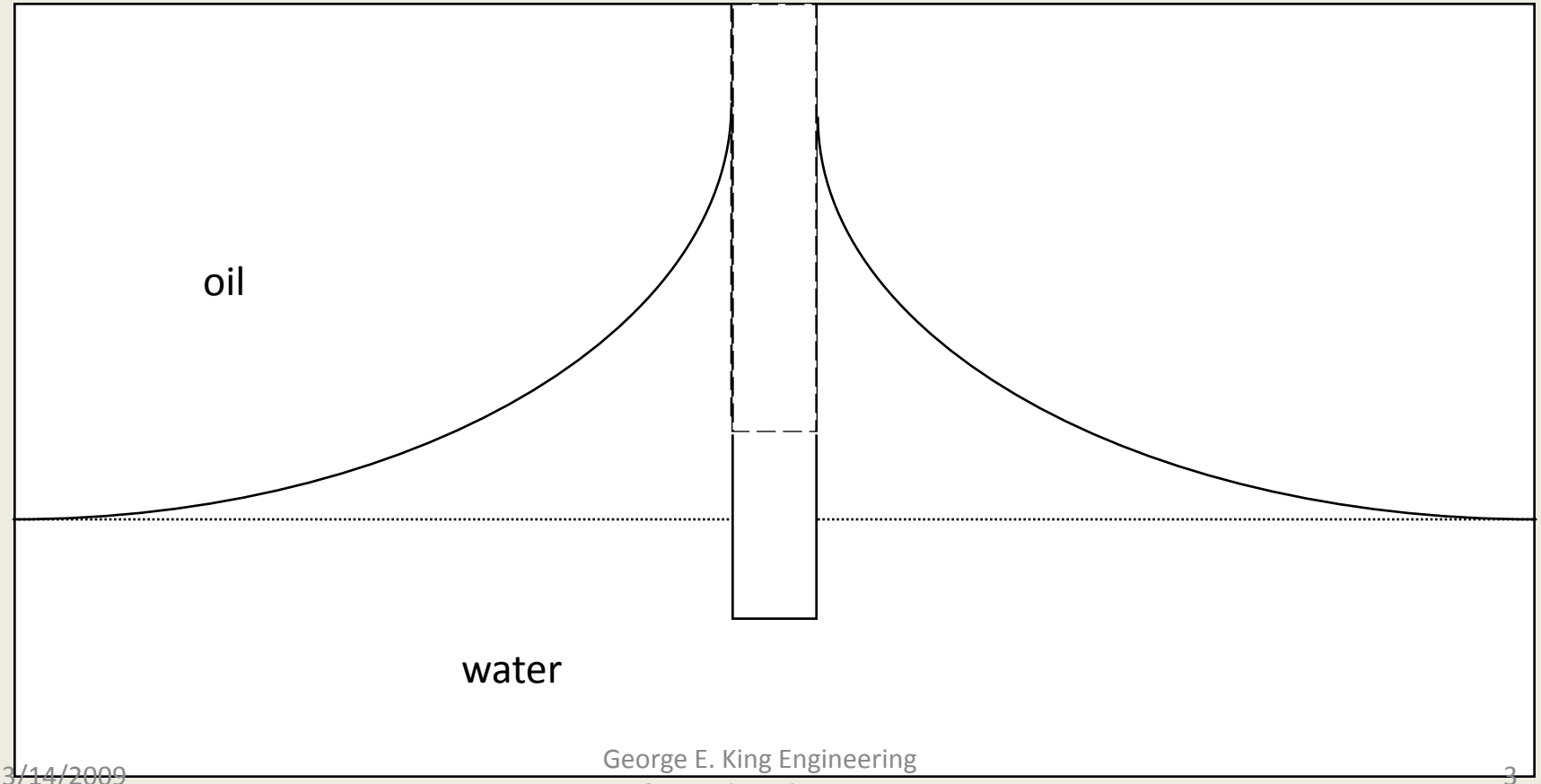
- **Potential sources**
- **Fluid paths**
- **Energy Level and Source**
- **Prediction**
- **Prevention and/or Treating**
- **Longevity of Treatments**
- **Technical Risks**

Water Sources

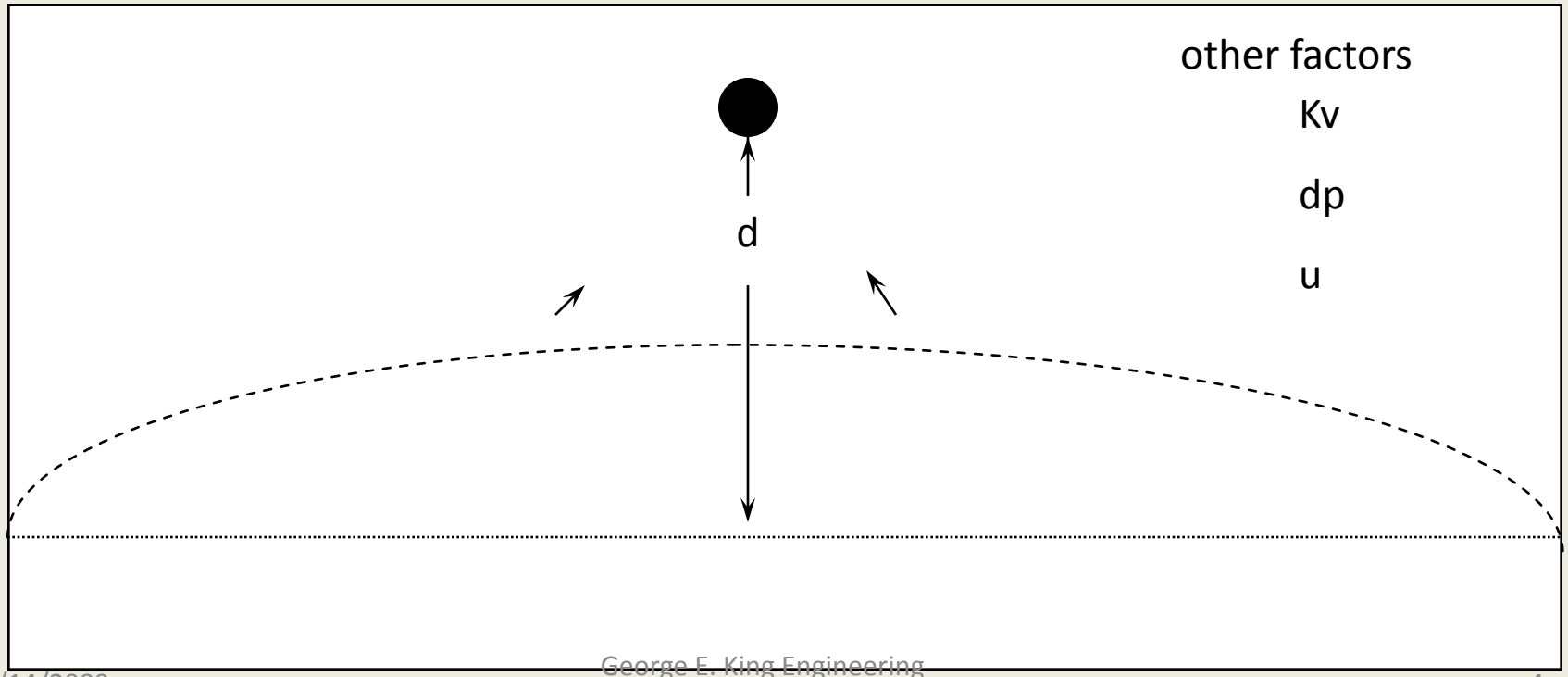
- **load fluid recovery**
- **connate**
- **water of condensation**
- **microporosity effects**
- **edge water**
- **bottom water**
- **flood fronts**
- **leaks**
- **load fluids**
- **crossflow**

Water Coning - no barriers, high vertical permeability

Solutions?? go with horizontal, stay below critical rate in vertical, recomplete into the water and cone the oil(?).



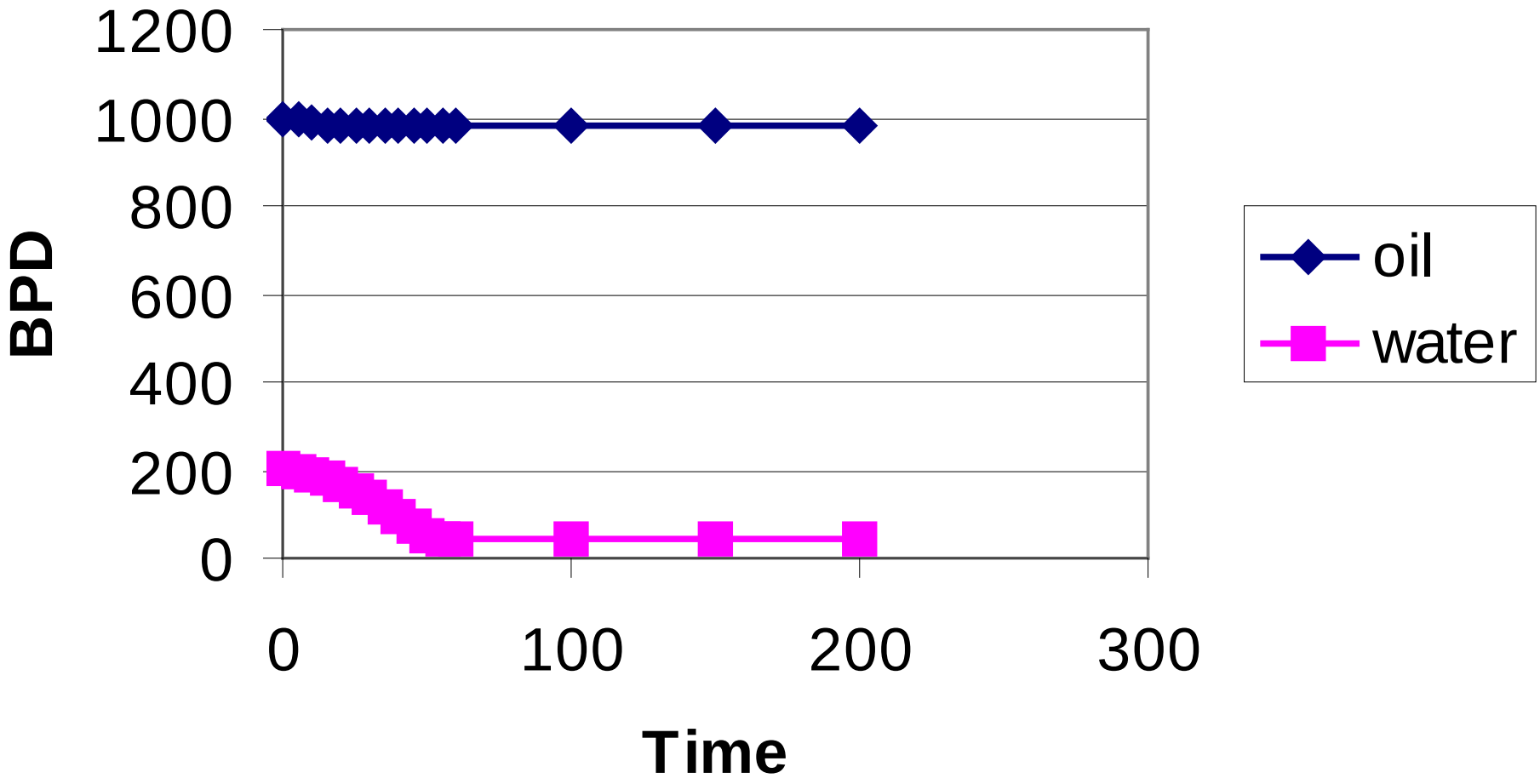
Water Cone in a Horizontal? Yes, but usually broader. The exception is high vertical permeability in channels or fractures.

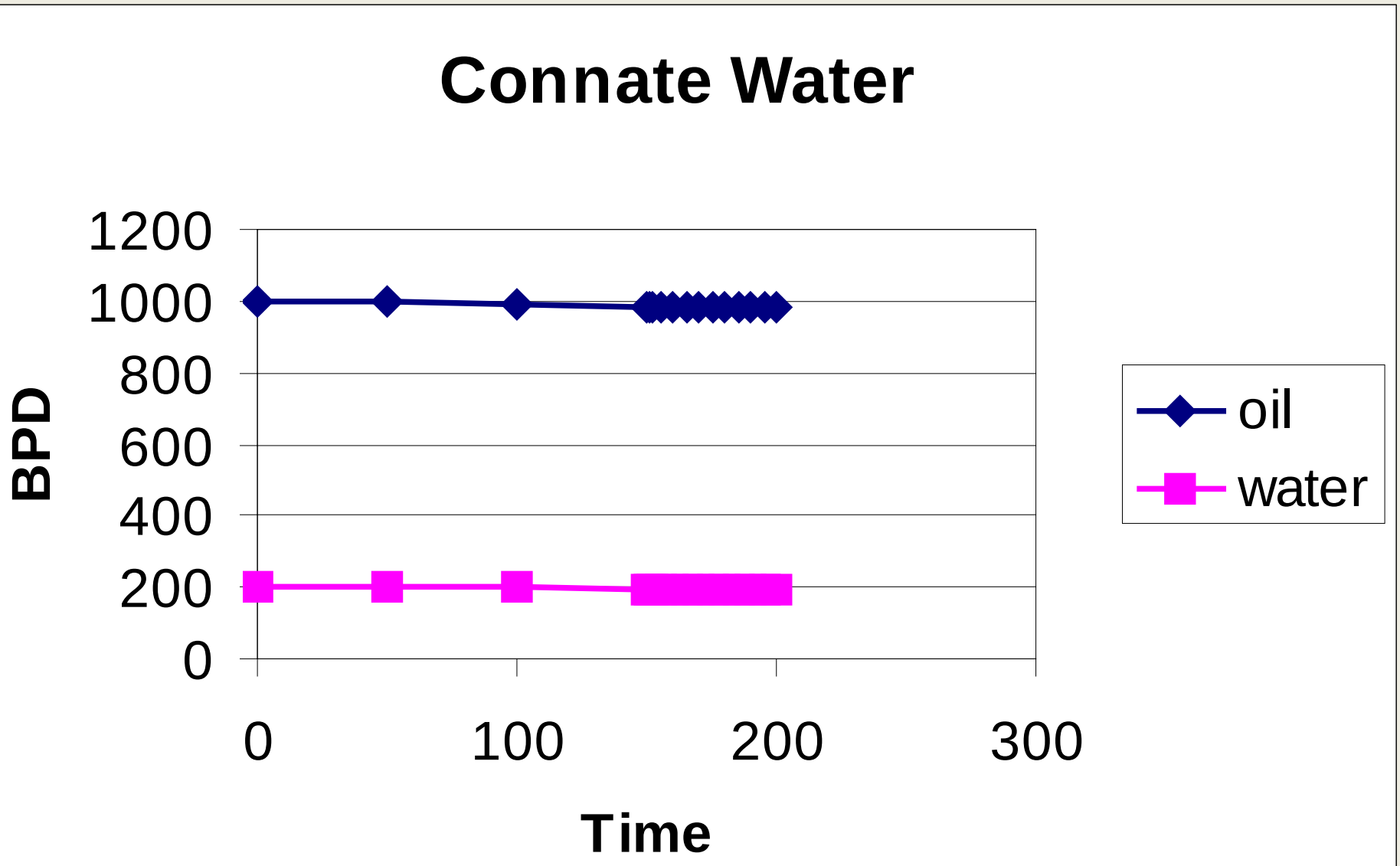


Identification of the water source

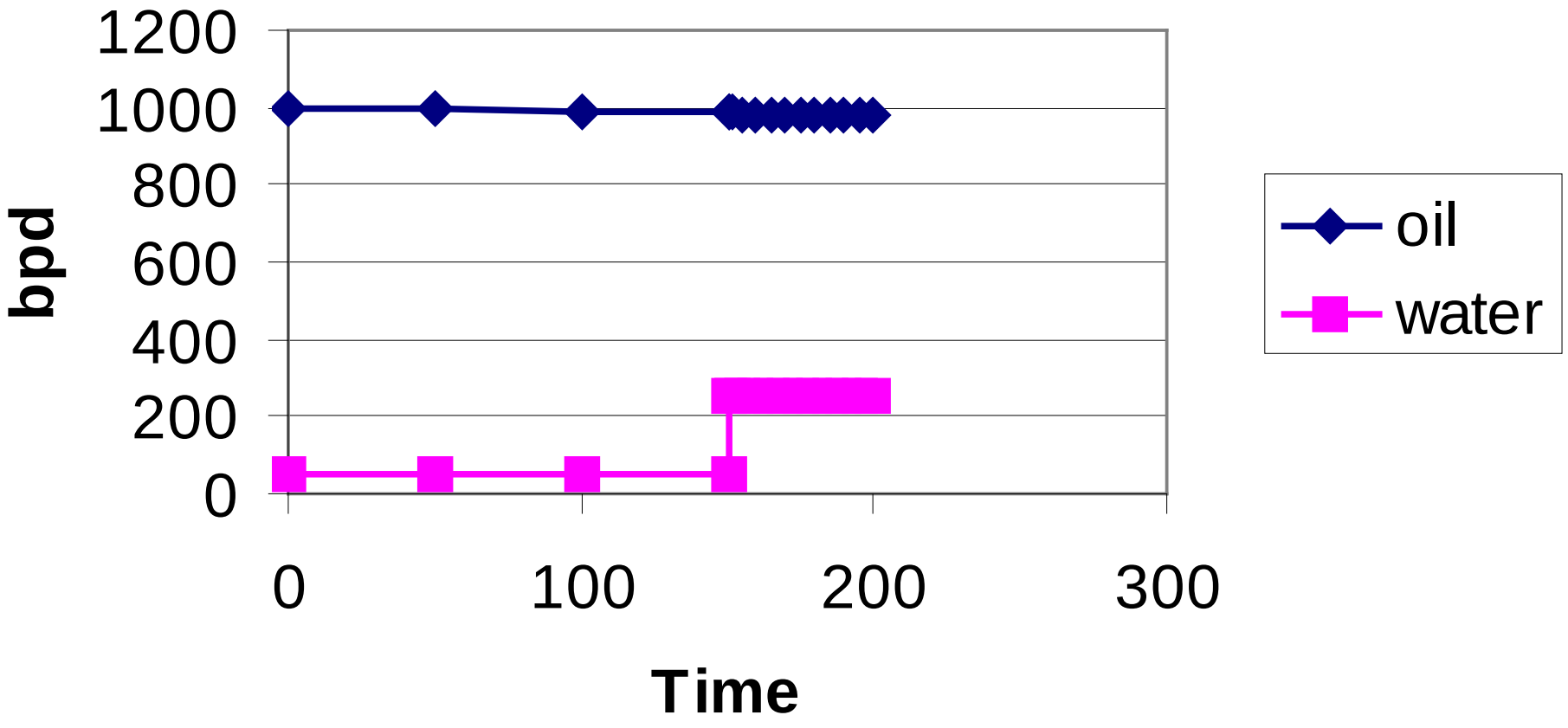
- characteristics of water appearance in the well (the following graphs are examples of single sources). Also:
  - experience
  - field models
  - deductive reasoning
  - type curves ????
  - salinity measurements

Load Fluid Recovery

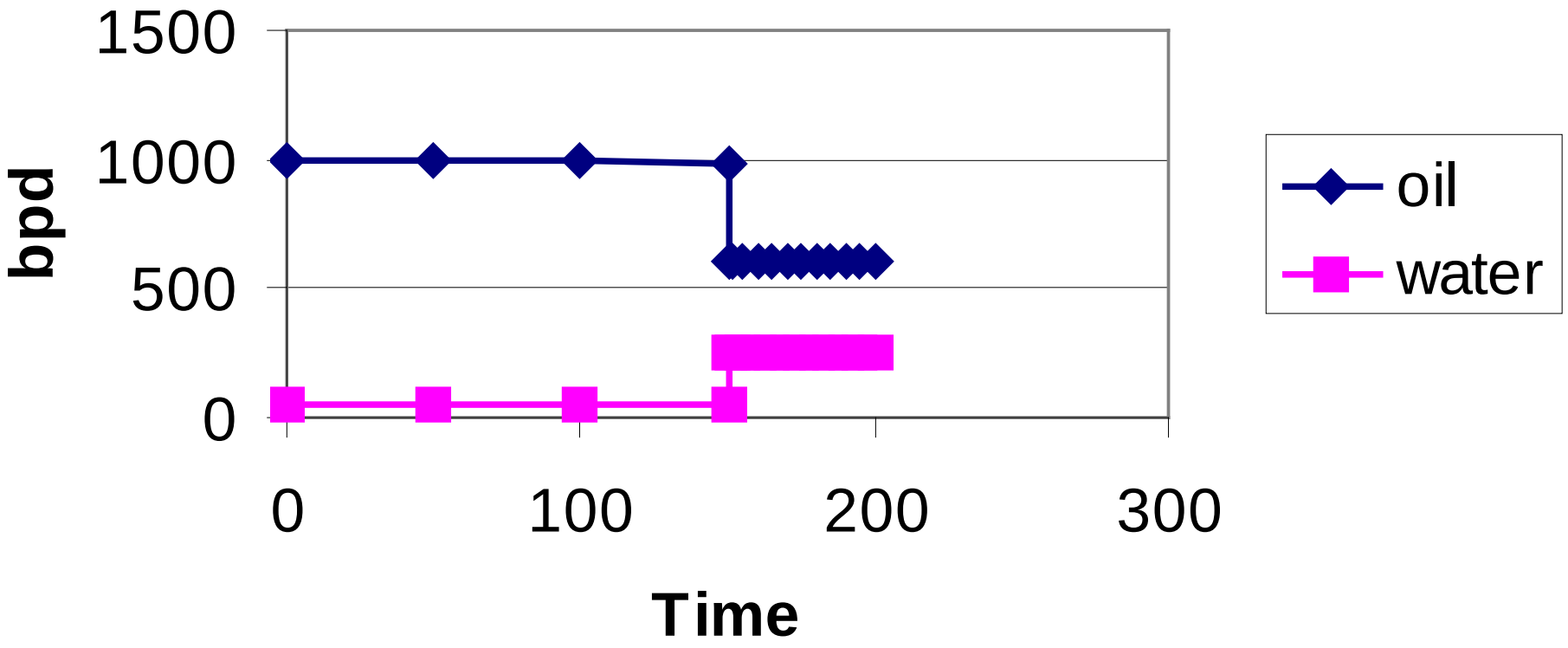



Connate Water
1200
1000
800
600
400
200
0
BPD
0
100
200
300
Time
oil
water

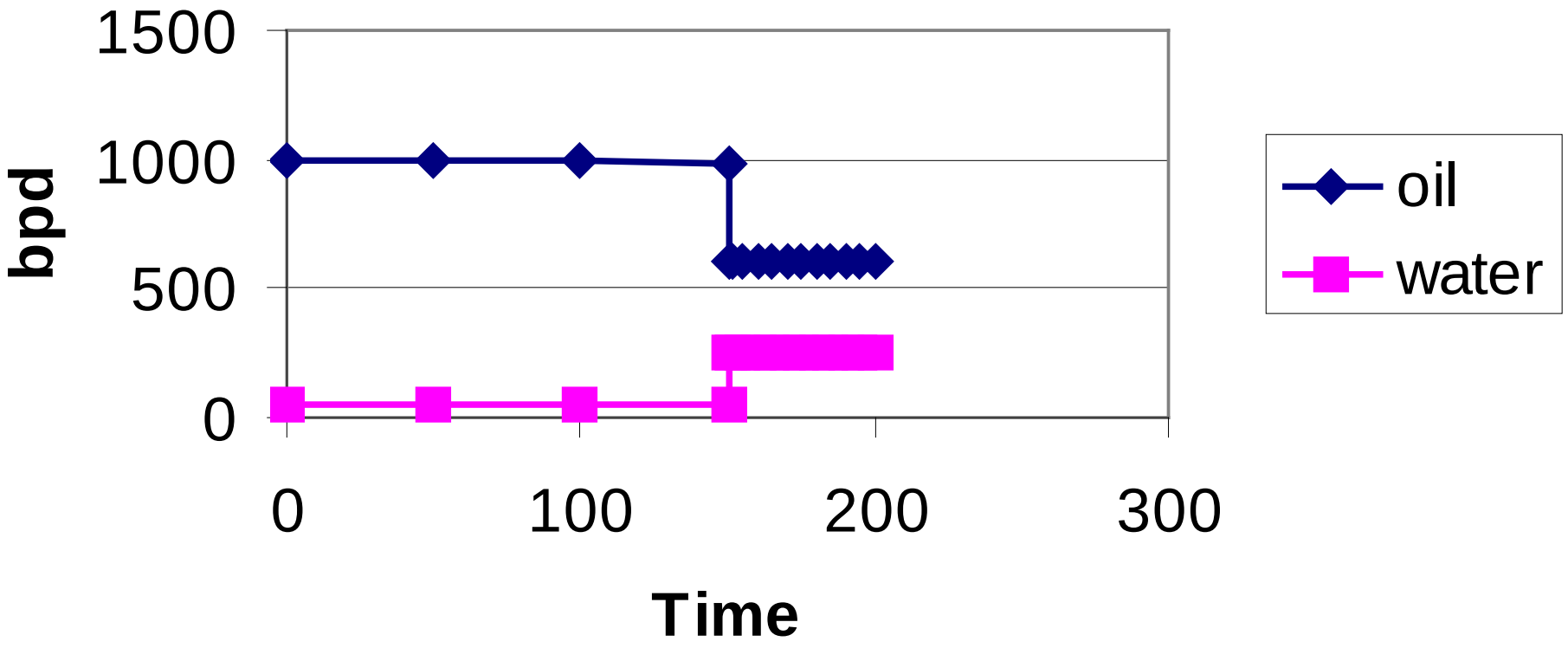
Water Leak - No Damage to Formation



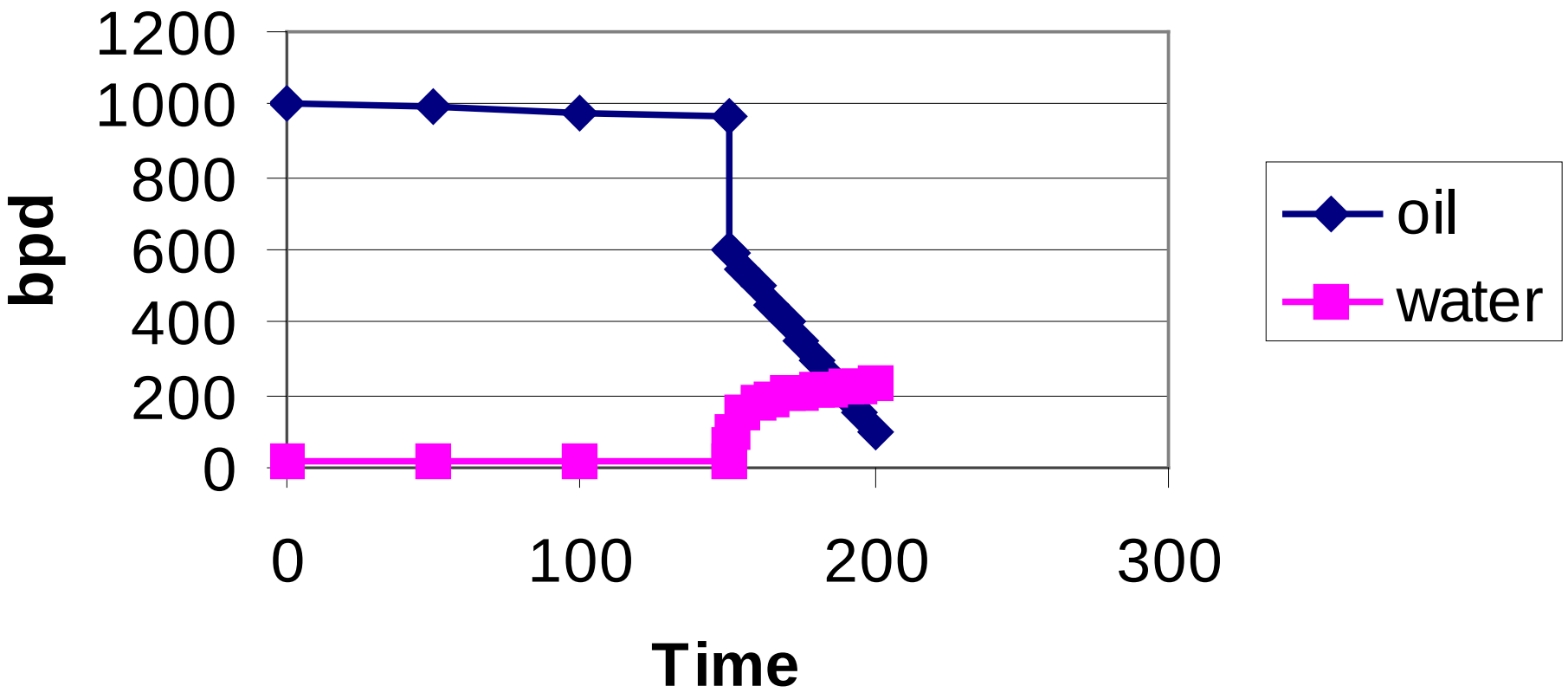
Water Leak - Resulting in Formation Damage



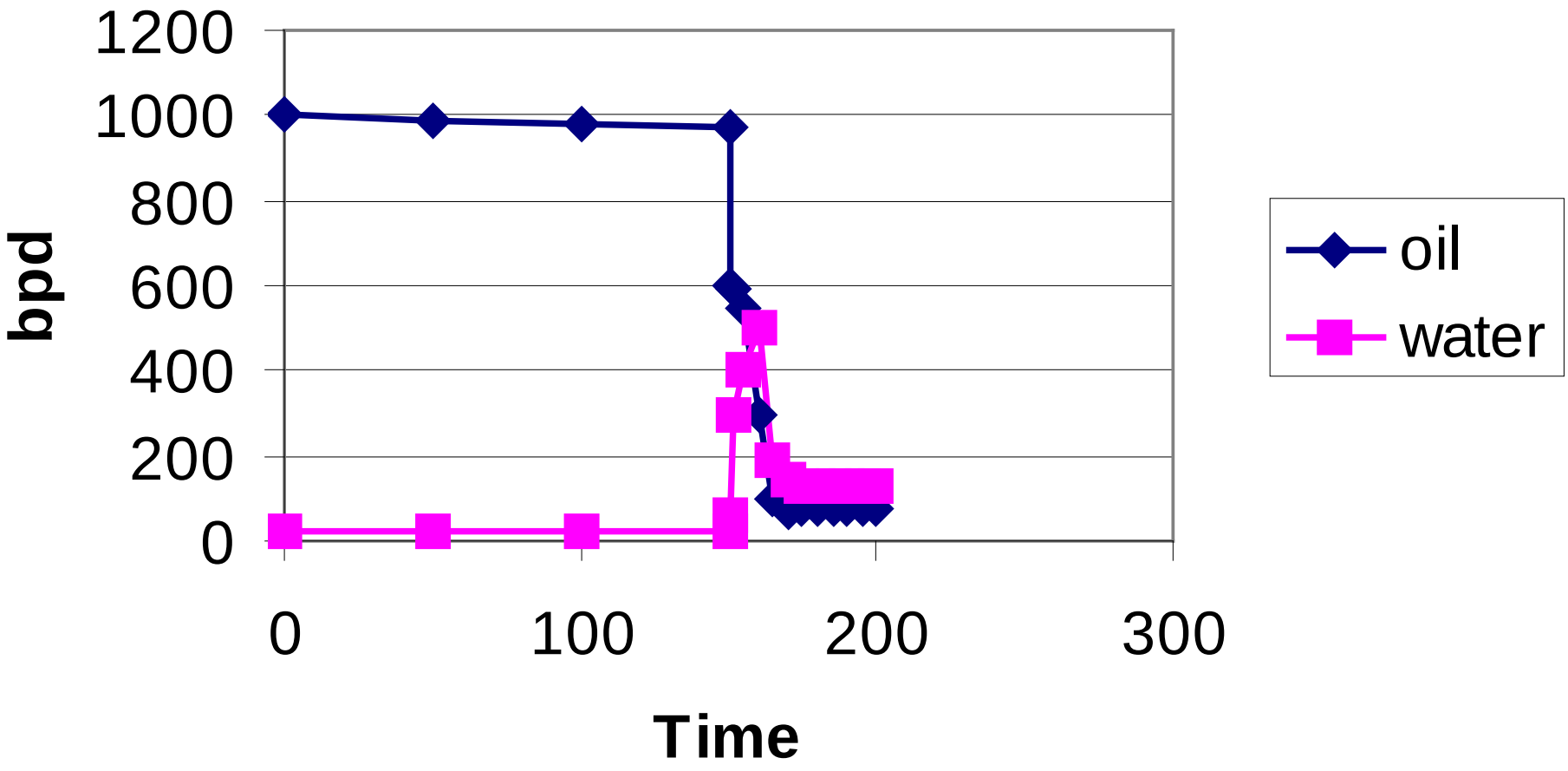
Water Leak - Resulting in Formation Damage



Water Block



Scale Formation



Water Control

- **load fluid recovery**
- **connate**
- **water of condensation**
- **microporosity effects**
- **edge water**
- **bottom water**
- **flood fronts**
- **leaks**
- **load fluids**
- **crossflow**

Load Fluid Recovery

- Function of:
  - volume of fluid lost
  - type of fluid lost
  - formation character

Connate

Really not much you can do about it without reducing hydrocarbon rate

Water of Condensation

- Very fresh
- 2 or 3 bbl/mmscf
- May condense at various points in the well with cooling of the gas stream. Conserving heat in the produced fluids helps keep water in the vapor phase.

Microporosity

- Can look wet on logs and produce little or no water – as much as 50% water saturation predicted on the log has produced dry gas. Look at the mineralogy.
- Culprits
  - smectite
  - illites
  - some chlorites
  - mineral structures with “interior room” to trap and hold water

Edge Water

- Thief zones typical culprit
- Can you selectively seal the zone?
- Can you seal zone from both ends

Bottom Water

- Coning response - model?
- Creating a problem?
- Barriers present?

Flood fronts

- Look for expected arrivals
- effect of thief zones
- salinity change
- scaling
- hydrocarbon “buzz”.

Leaks

- Often sharp increases in water
- may not interfere with production
- check salinity
- noise log, temperature log, oxygen activation log?

Crossflow

- kills the hydrocarbon
- particularly a problem in low pressure, multi-zone wells
- Production logging - watch deviation

Drive Energy

- Depends on:
  - source pressure
  - connection to pressure source
  - barriers and permeability of rock in the path
  - distance

Water Prediction

- Water cone and dome rise: coning models
  - how accurate? - how homogeneous is the formation?
  - Fractures and streaks create fast flow paths
- Offset experience
- Area experience

OK, what can you do about it?

- Control of water is *often* more expensive than producing the water.
- Are you ready to spend the money to *reduce* the water flow
- Preventing the water on initial completion is easier than remedial solutions

Solutions

- Prevention
  - isolation of section of wellbore
  - watch the fracture extension
  - avoid high perm/fracture completion?
- Intervention
  - mechanical isolation
  - deep plugging of a zone
  - plug from both ends

Before an Intervention, suggestions…….

- If the only cost is lift and disposal, only go for control where it can be done very cheaply and without potential to loose hydrocarbon rate.

- If the “cost” of producing water is a measureable loss of hydrocarbons, corrosion or other factor; and the job can be done a low risk, consider spending the money for control.

Things to consider...

- 1. The water source
- 2. The flow path
- 3. Barriers in the formation
- 4. The loss of hydrocarbon when water flow is reduced
- 5. The cost of the water control job
- 6. Longevity of the job

Loss of Hydrocarbon

- At about $50 per barrel of oil and typical water lift, corrosion and disposal costs ($0.50/bbl) , you must shut off about 100 barrels of water per day before you can afford to loose one barrel of oil.

- Economics change with high cost of water disposal, plant capacity limits that shut in wells and with increasing severity or complications of water production.

Methods of Control

- Surface blockers - cement slurry
- Shallow blockers - polymers
- Fracture fillers-monomer, silicate, cement dispersion?
- Deep matrix blockers - lignosulfonates, monomers, etc

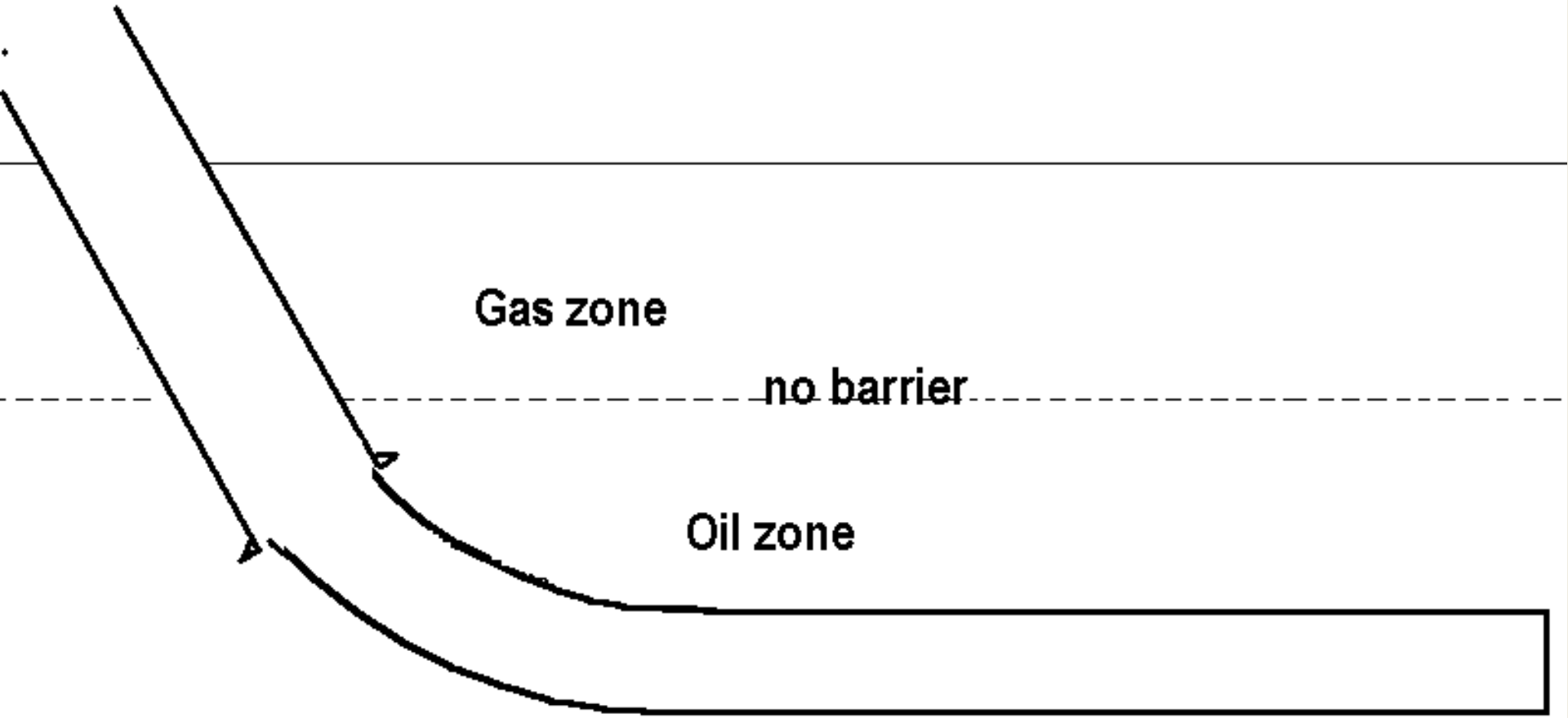
Reverse Coning

- Steps
  - perf into water zone
  - install DH pump
  - cone down
- Advantages??
  - Maximize producing interval
  - Minimize deposit and water interactions

Heel Gas Coning

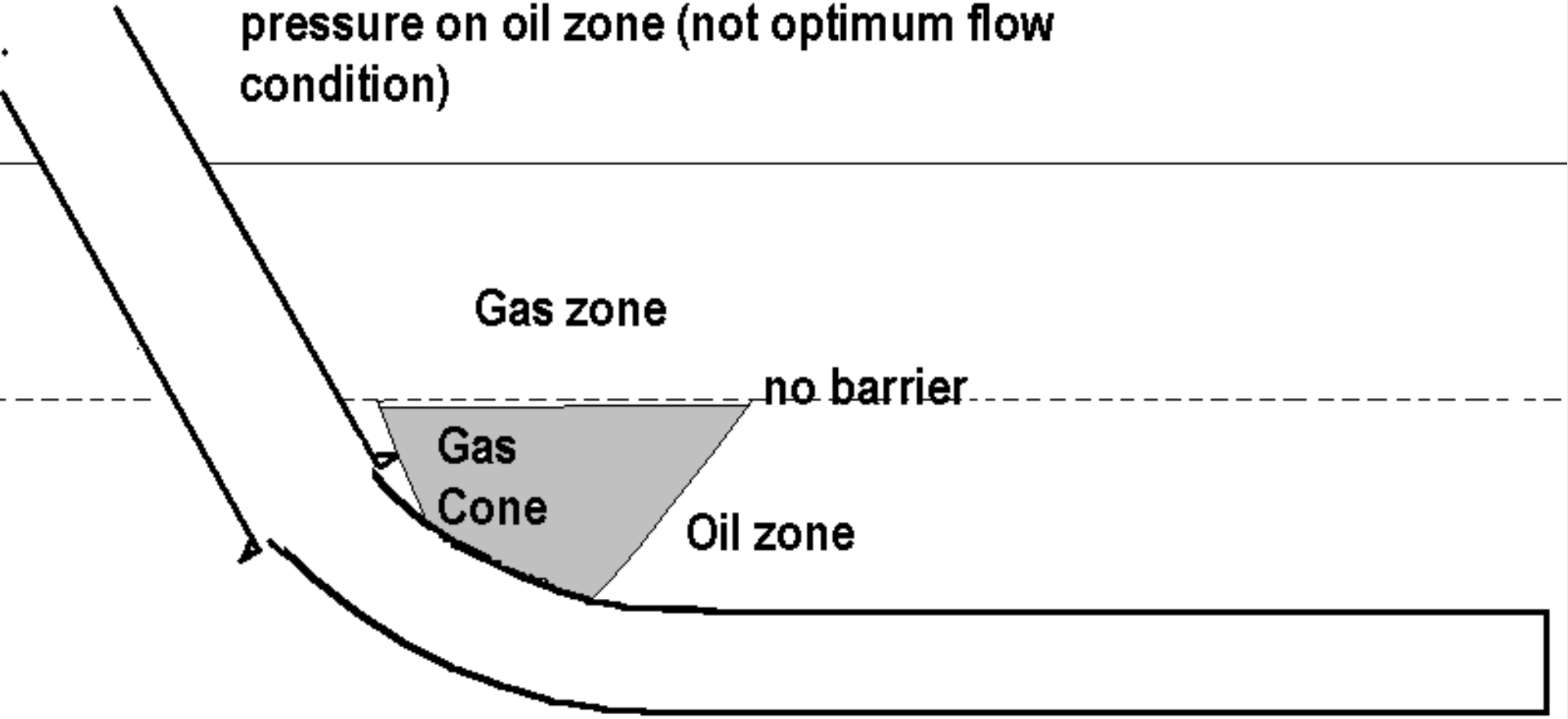
- Horizontal well in an oil zone with a gas cap above - gas is coning in.
- Completion type:
  - open hole
  - liner
  - cased and perforated
  - gravel packed
  - frac and pack
  - fractured

Example Case: Horizontal well in an oil zone with a gas cap - no barrier

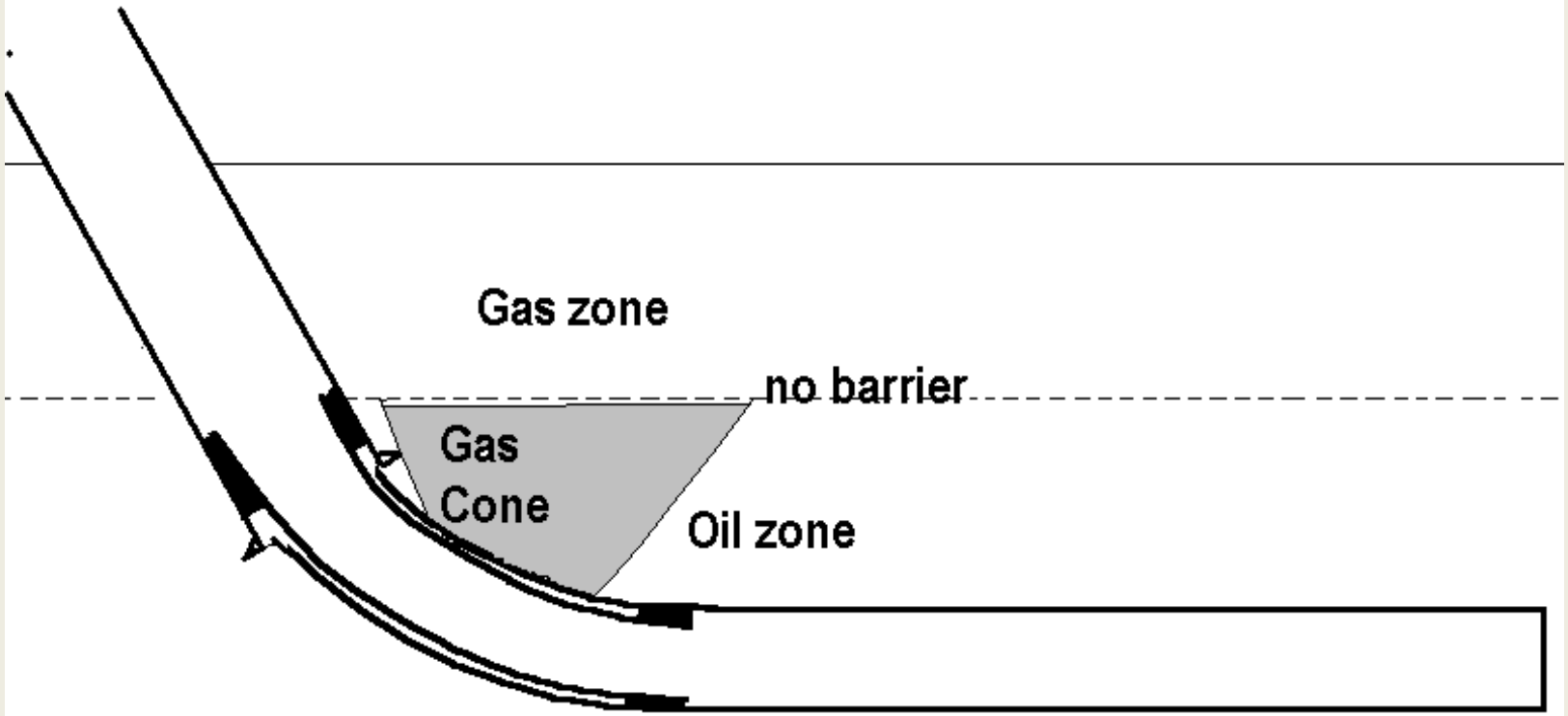


Example Case: Horizontal well in an oil zone with a gas cap - no barrier

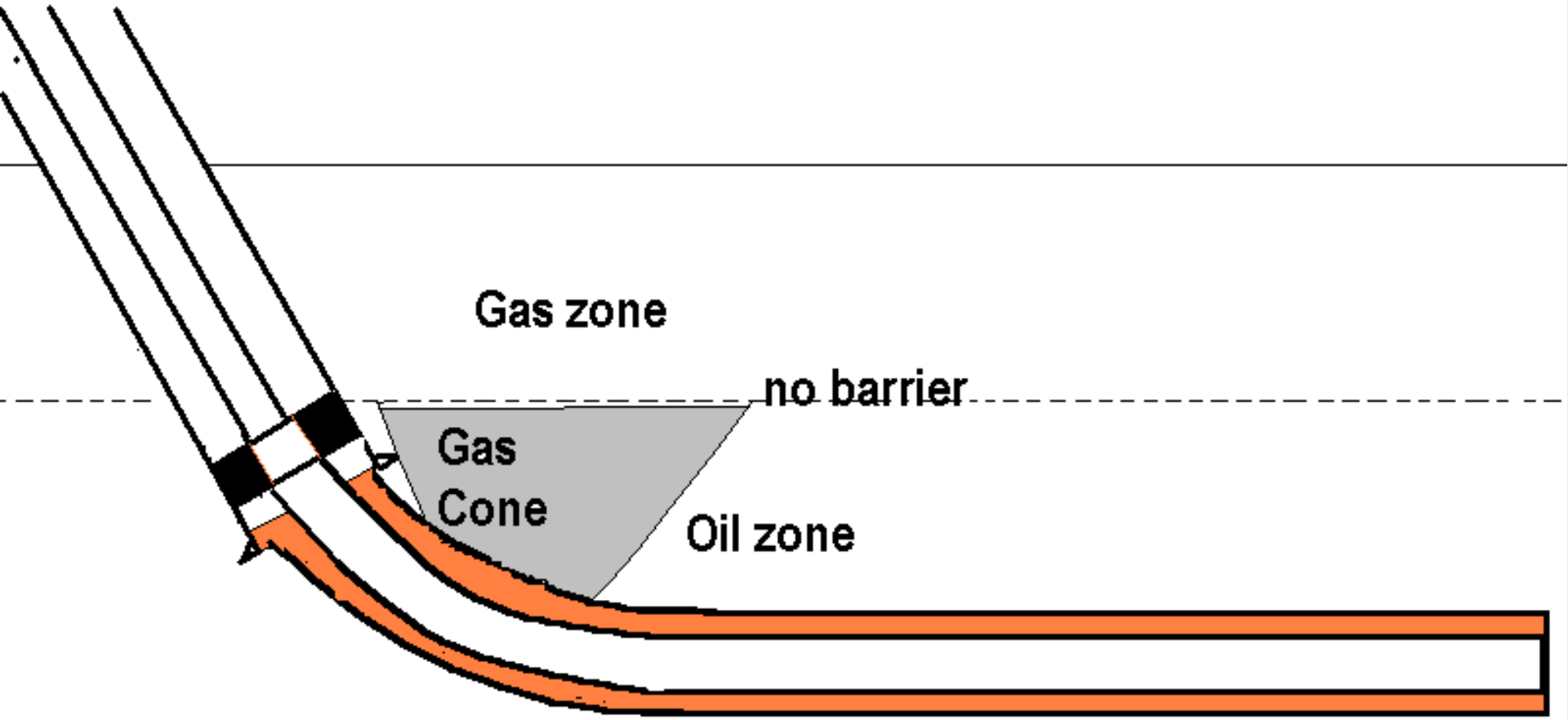
Gas cone: reduces total drive energy, holds back pressure on oil zone (not optimum flow condition)



Open Hole Repair Options: Run a liner with an ECP at each end (scab liner).
Alternatives: cement the liner in place

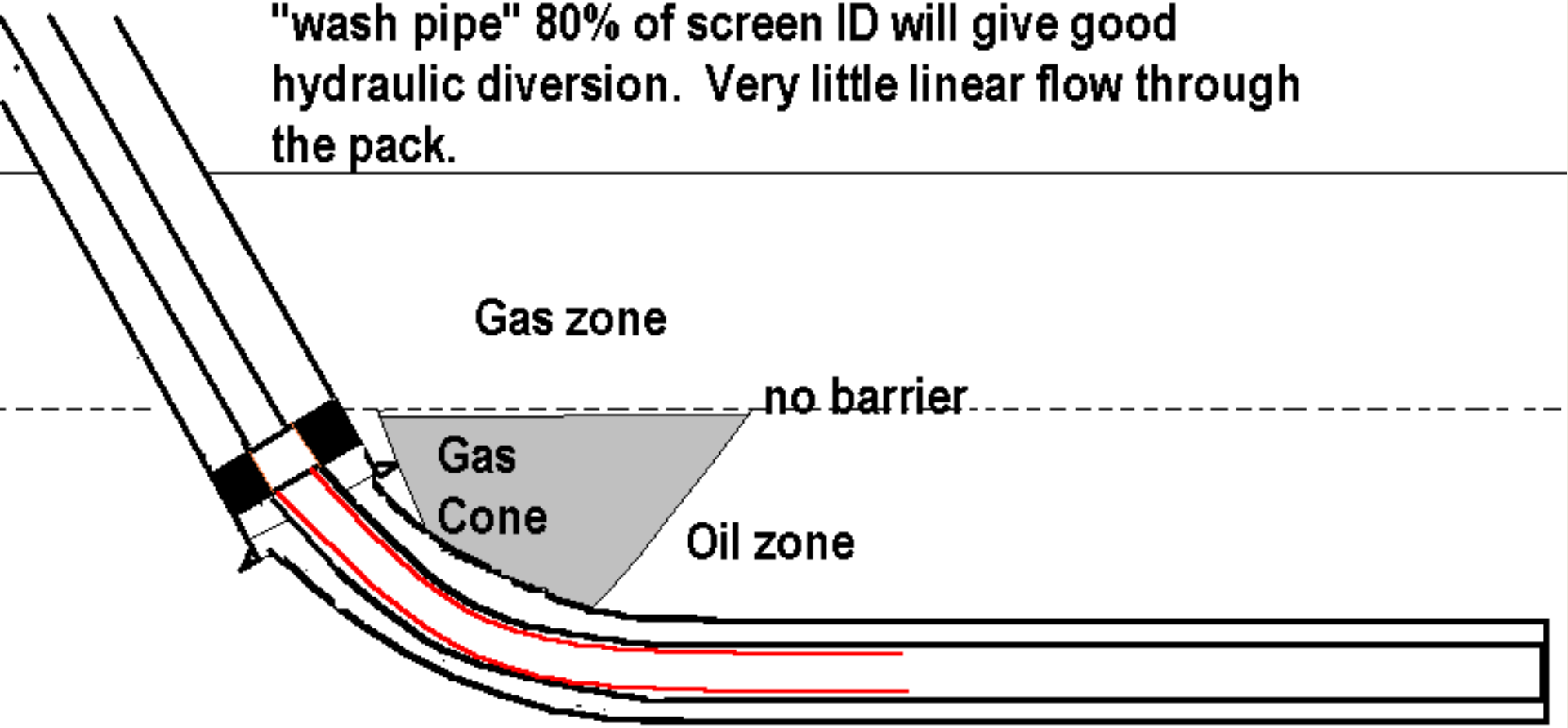


Gravel Packed Well, gas influx at the heel

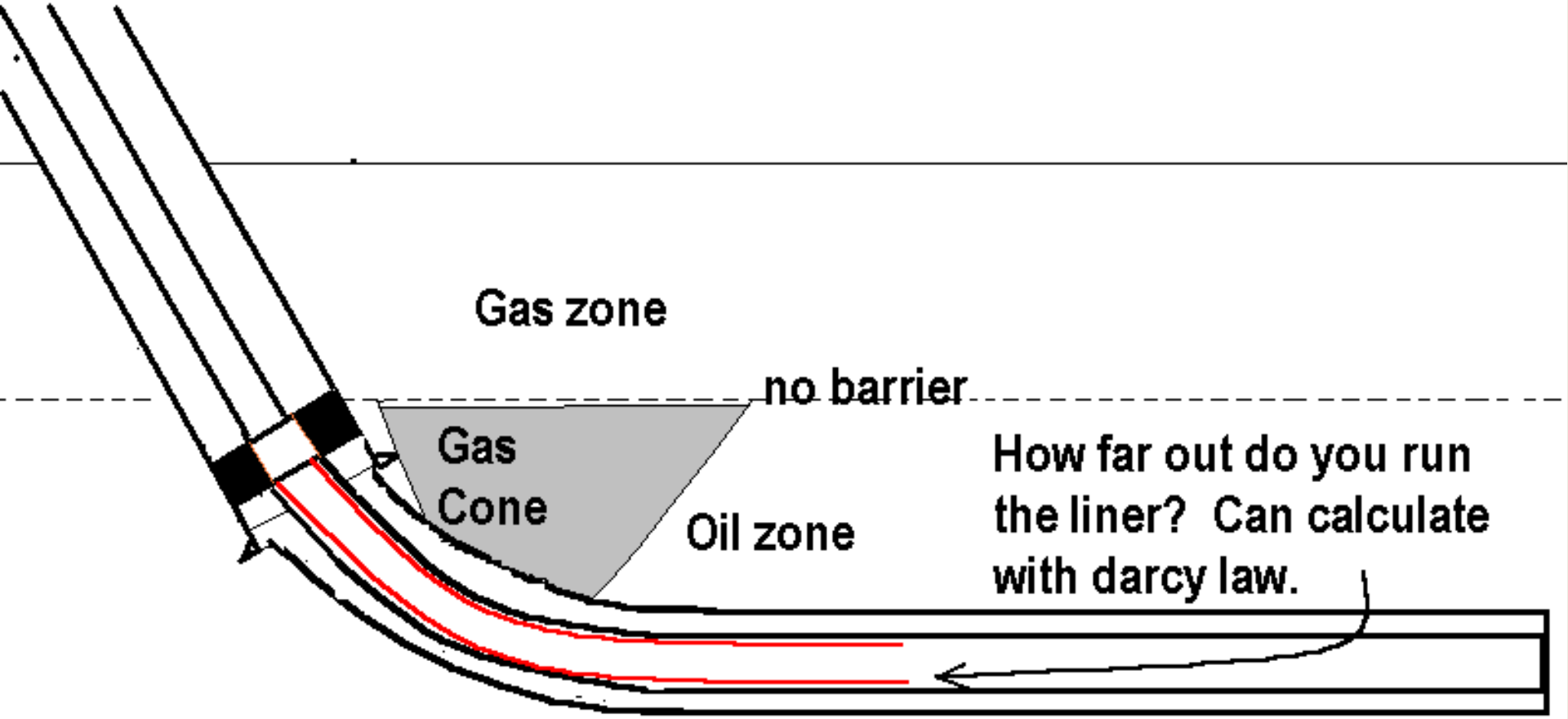


Gravel Packed Well, gas influx at the heel

Solutions: run a "wash pipe" inside screen - a "wash pipe" 80% of screen ID will give good hydraulic diversion. Very little linear flow through the pack.



Flow through the gravel (30 to 50 darcies), and flow through the microannulus (small open channel). If more gas flow is needed, could punch a hole (tubing puncher) through the liner.



Isolation Options

- Scab liners
- Hydraulic diversion
- Damage inducing materials (particles and resins)
- Inflatables
- Plugs

Success of Water Control Treatments?

- ***LOW***
- The problems?
  - Identifying the source of water and the pathways
  - Selecting the right method of control that will not shut off hydrocarbon
  - Placing the control chemical where you need it.