## Session 3A: Groundwater & surface impacts

Supported by the Australian Government through the Asia Pacific Partnership (AP6) Coal Mining Task Force

12th November 2006
Kolkata, India

## Potential environmental concerns

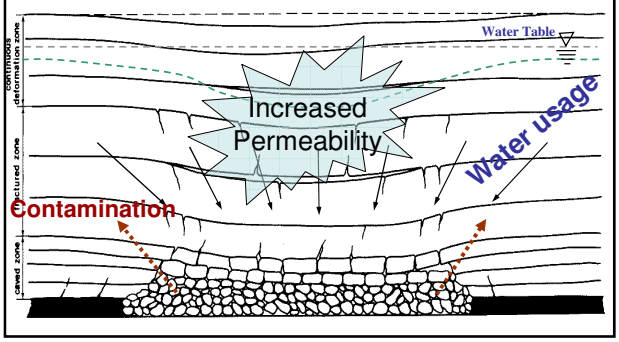
**Depending on the site and its geological characteristics, the major potential problems from UCG are:**

- Subsidence
- Groundwater depletion
- Groundwater contamination

**Other environmental issues, like waste water handling, can be handled using conventional equipment from existing industries**

## Physical Site Changes

**Surface subsidence**




## Subsidence

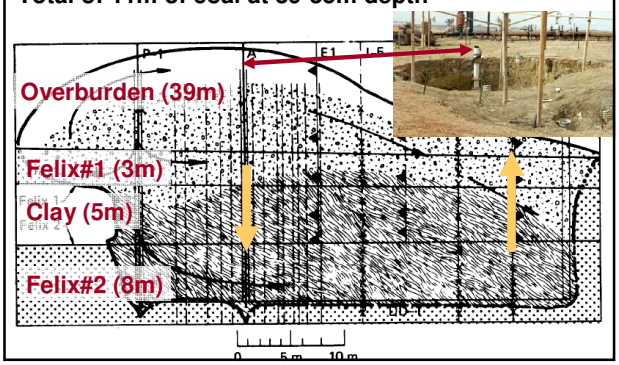
- **UCG, like any other coal extraction technique, will cause some subsidence**
- **The *magnitude* of this will be determined by the seam thickness, depth, site geotechnical properties and the UCG design**
- **The *impact* will depend on surface land use**

## Subsidence - Historical

- **Much of the Soviet and American experimentation took place in shallow, thick coal seams**
- **This minimises the cost of operation, but maximises the likely magnitude of subsidence**

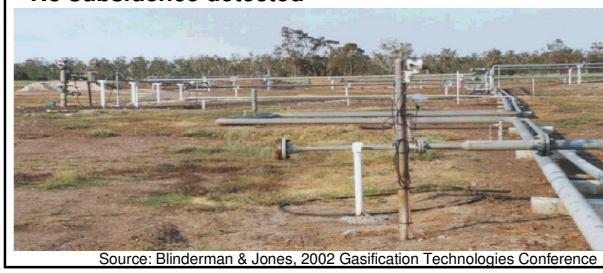
## Hoe Creek #3 Trial (USA, 1979)

- **Total of 11m of coal at 39-55m depth**



## Linc Energy – Chinchilla (1999+)

- **Approximately 10m of coal at 130-140m**
- **Low subsidence UCG technique applied**
- **Much more coal extracted than at Hoe Ck**
- **No subsidence detected**



Source: Blinderman & Jones, 2002 Gasification Technologies Conference

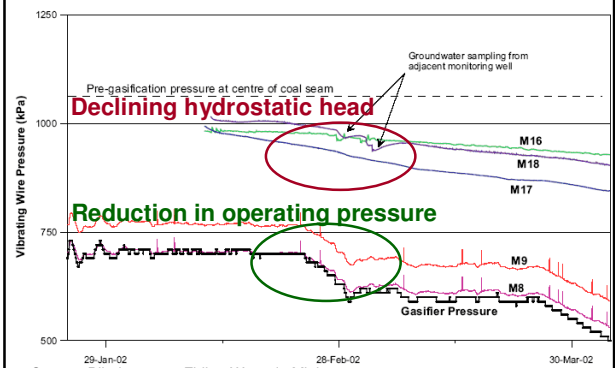
## Notes on Subsidence

- **Subsidence can be an issue, but can be minimised through careful site selection and UCG design**
- **Besides environmental impact, it will also have substantial process control ramifications if at excessive levels, so must be addressed during planning**

## Groundwater Depletion

- **Impacts:**
  - Shortages for other users of groundwater (eg. agricultural)
  - Can lead to high gas losses from the UCG operation (→Contamination)
  - Product gas composition changes and production pressure declines, with possible impact on the gas utilisation process

## Linc Energy – Chinchilla (1999+)




Source: Blinderman & Fidler, Water in Mining 2003

## Notes on Groundwater Depletion

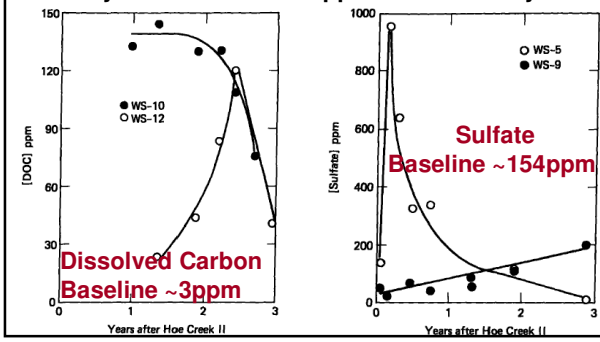
- **Depletion is site dependent but should be less than for other resource utilisation methods (eg. Coal Bed Methane or Underground Mining) when performed on a similar scale**
- **Plant size will have a large impact and this may be a limiting factor in specifying the plant design**

## Groundwater Contamination

- **Benzene and other organics have been found in groundwater near two UCG sites in the USA**
- **Organic contamination is linked to high operating pressures and was avoided in subsequent US trials**
- **Soviet testing identified elevated salt concentrations around a large UCG site after closure, but these rapidly decreased to background levels**

## Hoe Creek II (USA, 1977)

- Hoe Creek II ran at a 300kPa operating pressure
- The hydrostatic head dropped to essentially zero




## Hoe Creek site (USA, 1973-2003)

- Contamination was noted in 1977, but did not exceed the limits for livestock watering
- The US government committed to cleaning up old DOE sites in 1991
- Clean-up started in 1995 and continued intermittently to 2003
- Contaminant limits were set by Wyoming State as "Not Detectable" due to the lack of a site environmental licence and full background testing prior to the trials

## Hoe Creek site (USA, 1973-2003)

- Initially, the groundwater was extracted and filtered through activated carbon
- Then combined air-sparging and bio-remediation was performed
- Later, only air-sparging was used

Hoe Creek II, October 2002

## Summary

- Environmental issues are largely determined by the combination of site characteristics, gasifier design and the operating conditions.
- Analysis of these for a prospective UCG process will be the major focus of the case study analysis

## Session 3B: Site selection & characterisation

Supported by the Australian Government through the Asia Pacific Partnership (AP6) Coal Mining Task Force

12th December 2006
Kolkata, India

## Site selection criteria

- It is possible to set a series of guidelines that simplify decision making when selecting UCG sites
- Several proposed sets of criteria from the UK, USA and Australia are given on the following slides, however, all are based heavily on Soviet experience with bias towards local conditions

## UK site criteria 1 (National Coal Board, 1976)

- 5 Mt of coal in resource to provide 20 years of operation
- Not marked for conventional mining
- Not adjacent to working mines
- Removal won't cause unacceptable subsidence
- Seam thickness at least one metre, or banded seam totals over one metre
- Depth greater than 20 metres to minimise gas leakage

## UK site criteria 2 (National Coal Board, 1976)

- Ash content less than 60%, including any dirt bands, as combustion may be impeded
- Area free of excessive faulting

Other notes:

- Leakage may be excessive if adjacent to old mine workings or in faulted area
- Impact of faulting and roof material on operation largely unknown
- Progress and control of multi-seam operations poorly defined
- Expect initial operations at 3 times the manpower efficiency of conventional mining (rising to 10 times)

## US site criteria 1 (Williams, 1982)

- Seam thickness greater than 1 m or 0.6 m for steeply dipping seams
- Avoid variable thickness seams
- Avoid seams with multiple partings
- Avoid seams with overlying coal within 15 m that is thicker than 0.6 m
- Minimum of 3.5 Mt
- Minimum overburden of 100 m
- Minimum of 1.6 km from populated (>100 people) areas
- Minimum distance of 0.8 km from major faults
- Minimum distance to oil/gas recovery development of 1.6 km

## US site criteria 2 (Williams, 1982)

- Minimum distance of 0.4 km from major highways and rail
- Minimum distance of 1.6 km from rivers and lakes
- Minimum distance of 3.2 km from active mines
- Minimum distance of 1.6 km from abandoned mines

Other notes:

- Steeply dipping (>30°) seams favoured due to lack of mining interest
- Floor and roof conditions "examined"

## CSIRO site criteria 1

- Seam thickness >5 m
- Coal ash <40% (air dried basis)
- Seam dip <20°
- Seam depth 200-400 m
- Minimal faulting and no dips/sills
- Roof thermally stable with minimal permeability, preferably structured to encourage even caving

## CSIRO site criteria 2

- Hydraulic head >200 m
- Adjacent aquifers contain poor quality water and are of minimal permeability

Other notes:

- Limited human activities in vicinity
- No waterways overlying the site
- Subsidence must be acceptable at location
- Coal resource size suitable for long term operation

## Site selection summary

**All sets of criteria are based around:**

- **Establishing that it is an economic resource of suitable size**
- **Geological conditions are suitable for consistent coal removal**
- **Environmental impacts are acceptable**

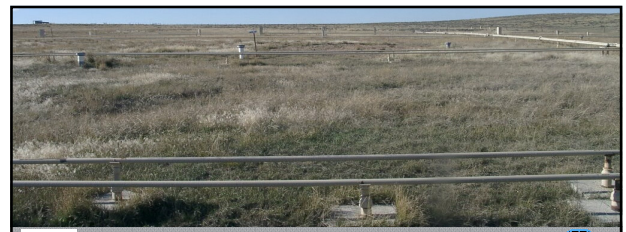
**A comprehensive analysis will still have to be performed to ensure that the site is suitable, but use of simple criteria can eliminate unsuitable sites quickly**

## Site characterisation

- **Accurate characterisation of a site will take a similar amount of exploration work to development of an underground coal mine**
- **Failure to do this has resulted in serious errors in a number of past trials**

## Important characteristics

- **Coal seam definition**
  **(continuity, partings, interburden, etc)**
- **Coal properties**
  **(ash, permeability, etc)**
- **Overburden properties**
  **(permeability, strength, thermal behaviour, etc)**
- **Aquifer properties**
  **(locations, permeability, water quality, etc)**



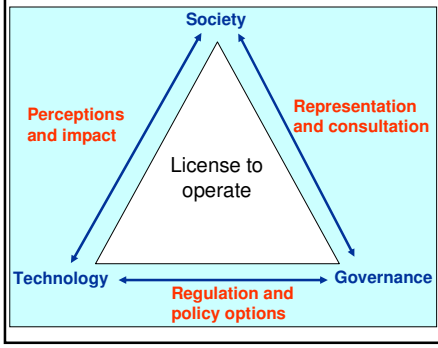
## Session 1C: Social perceptions

Supported by the Australian Government through the Asia Pacific Partnership (AP6) Coal Mining Task Force

12th November 2006
Kolkata, India

## Social considerations

Public perception framework




Impacts:

- Economic
- Environmental
- Social
- Cultural

## Public perception survey

| Benefits of UCG | Prospective concerns with UCG |
|---|---|
| **Better way of exploiting coal reserves** | **How safe is it?** |
| **Economic benefits** | **Who's monitoring / controlling things overall?** |
| **Economic benefits to regional economy** | **What impact will it have on people's property?** |
| **Environmentally beneficial** | **What about the impact on the environment?** |
| **Benefits to regional community** | **Is it economically beneficial to the region?** |
| | **Will we be kept properly informed?** |
| | **Aren't there better ways of investing in emerging energy sources?** |
| | **Who's really going to benefit from this, and when?** |
| | **Don't believe that politicians, scientists or business will be truthful with us** |

## Then there is the media…


**New Scientist (1 June 2002) article on underground coal gasification. This is one of four pictures in the article showing coal fires caused by conventional coal mining activities in India (we think). There are no known outbreaks of this type relating to UCG activities, which are typically deeper and operate under the water table.**

## The End

Supported by the Australian Government through the Asia Pacific Partnership (AP6) Coal Mining Task Force

12th November 2006
Kolkata, India