

Conference on Safe Gas Extraction from Lake Kivu
Lyngby, Denmark, May 13-15, 2009

Analysis of unresolved matters - issues missing in the Management Prescriptions

Recommendations by COWI

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14 May 09

Safe gas extraction from Lake Kivu
Analysis of unresolved matters by CRJ

COWI

Content

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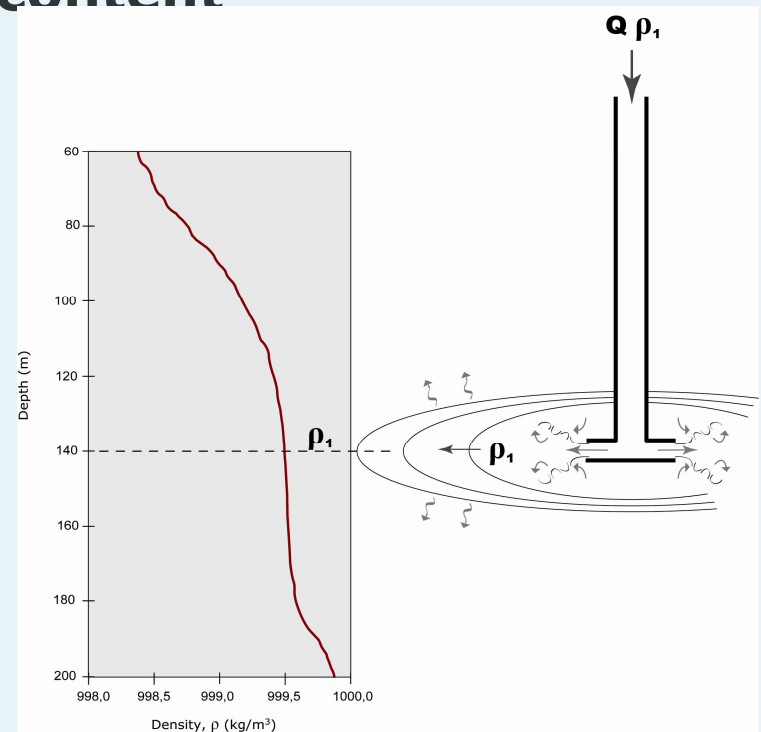
Time constraint

Risk increase + exploitation interests versus Establishment of decision basis

- **Risk increases as time goes by since the point of saturation moves closer**
 - **Concessionaires and the governments have commercial interest to start activities quickly**
 - **Decision base: What is necessary to know in order to make a responsible design? (Fate of re-injected water)**
- >If experiments are initiated now the decision base is expected to be sufficient within 1 year.**

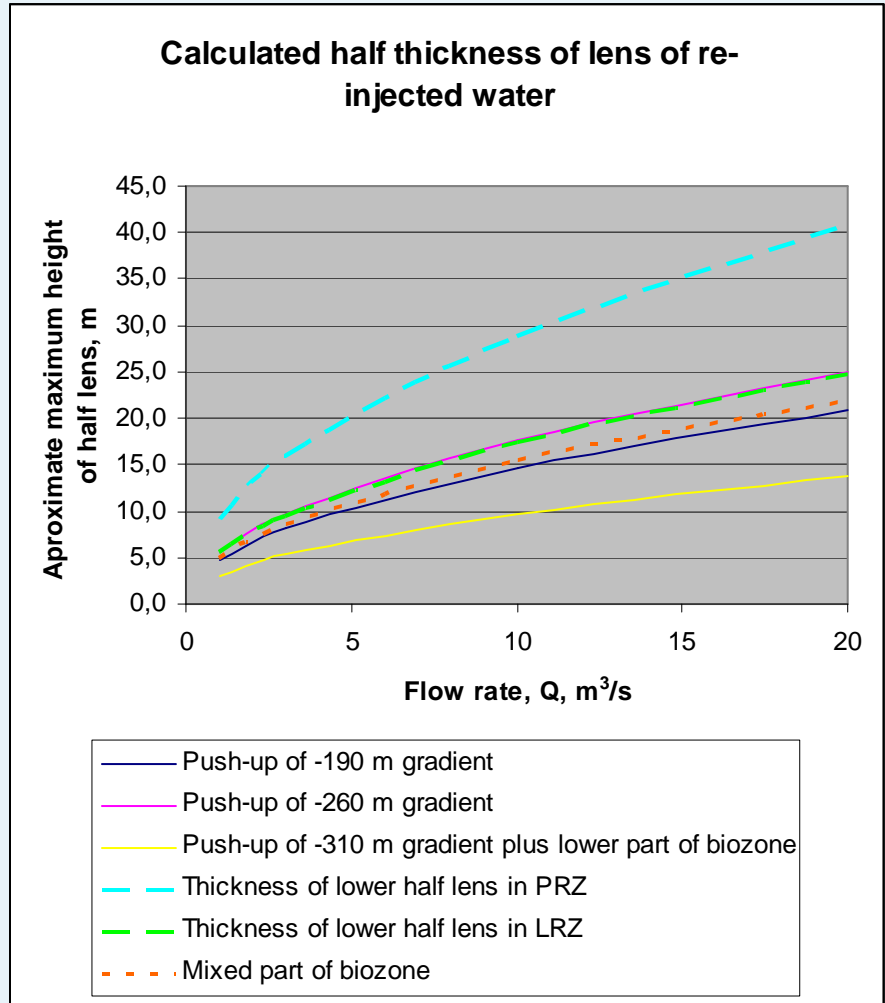
Uncertainties left behind (1)

- **Lens development for re-injection**
- The lens contains degassed water and shall be distributed over the entire Lake in order to avoid pockets of water with high gas content
- **Start: Density driven dominant**
- **End: Double diffusion dominant**
- -> **Lens thickness**
- -> **Extension time**



Uncertainties left behind (1)

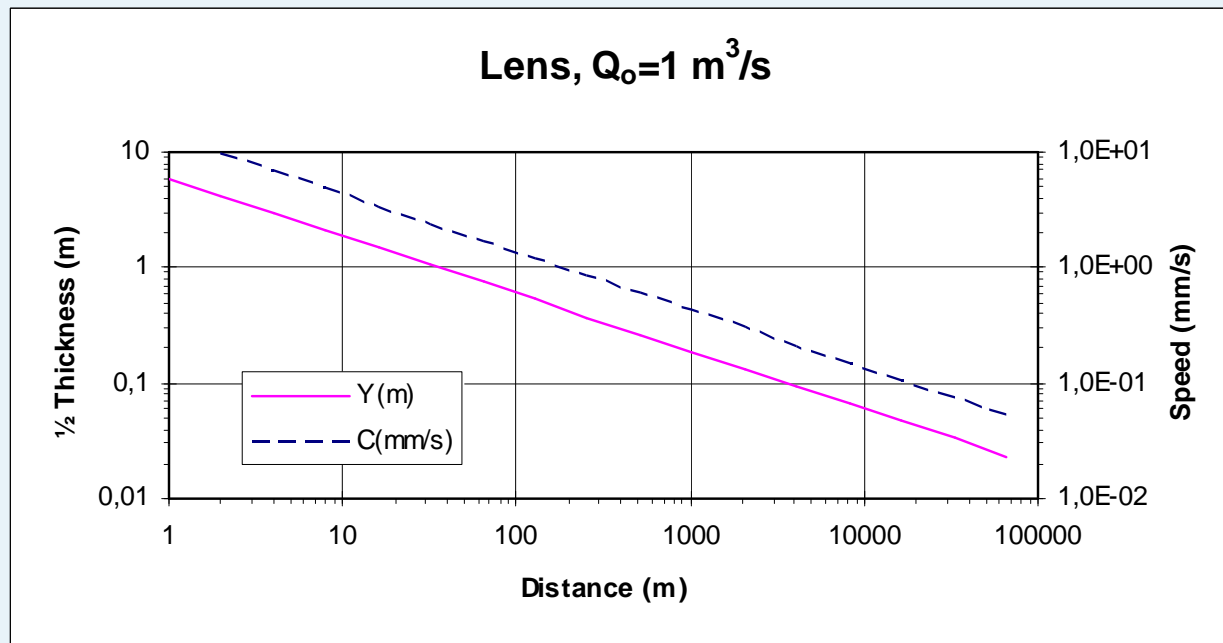
- **The lens thickness**
- **The thickness of the lens highest at injection point**
- **Will develop as a disk, thinner at outer part**



Uncertainties left behind (1)

- **Extension speed**

Expansion speed of lens gets very slow as the lens expands (larger perimeter, less thickness, less density difference)



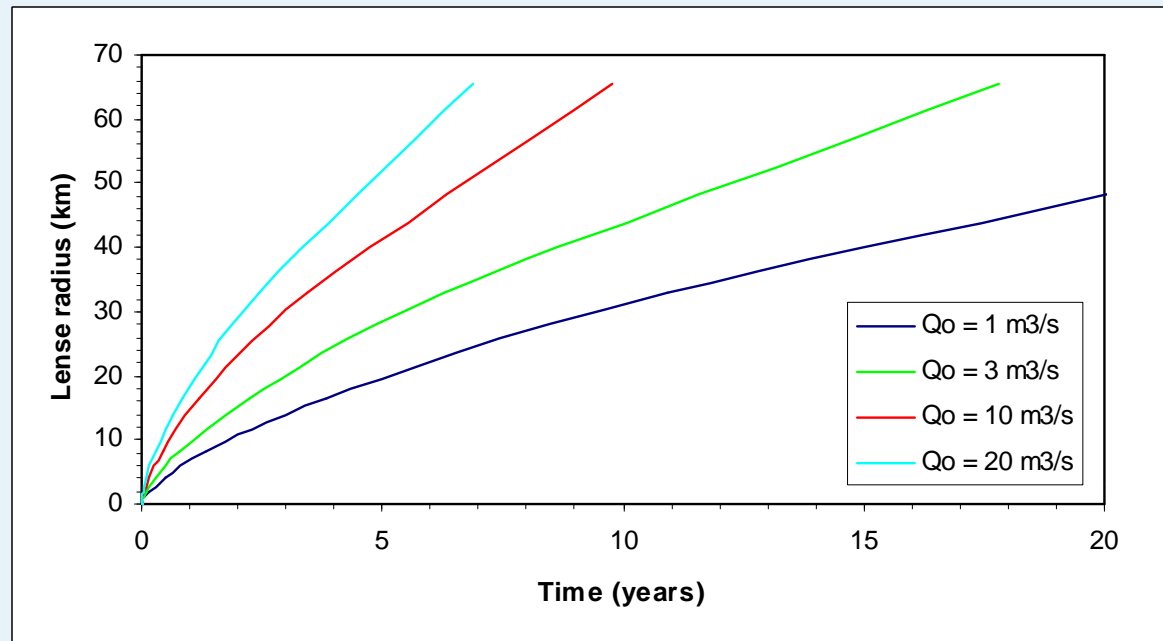
Uncertainties left behind (1)

- **Extension time (ESTIMATE)**

Criterion: Degassed water must be distributed within much shorter time than the period to the next expected outburst (100y) -> distribution within 10y

**THIS IS A
1. ORDER
ESTIMATE -**

**TO BE
VERIFIED
BY IN SITU
MEASUREMENTS!**

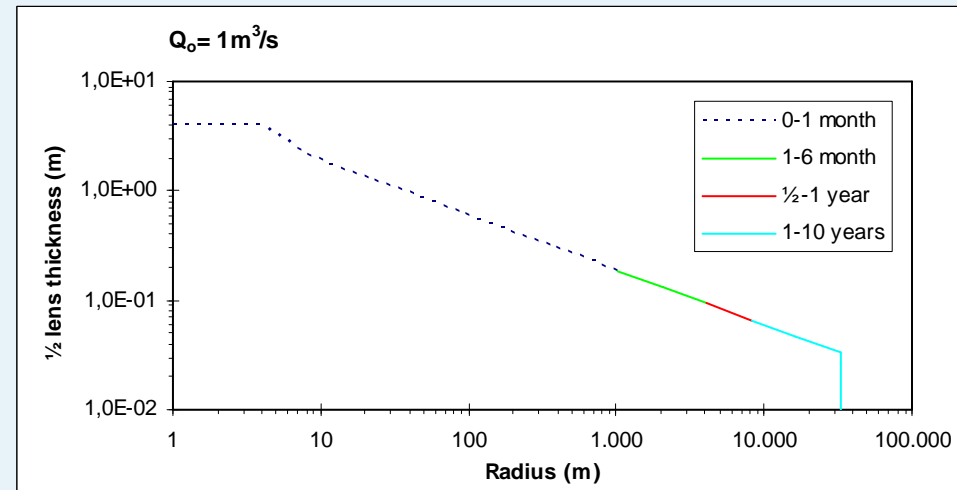
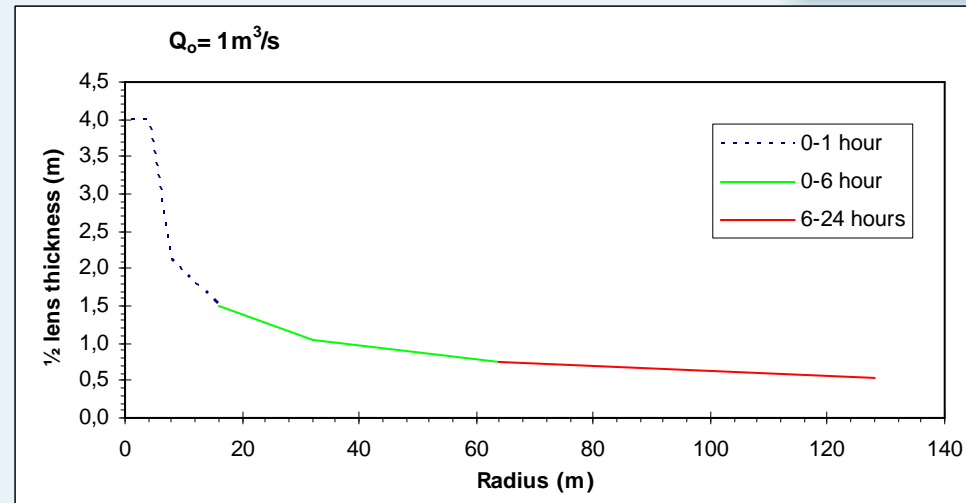


Uncertainties left behind (1)

- **Shape of the lens (ESTIMATE)**

**THIS IS A
1. ORDER
ESTIMATE -**

**TO BE
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BY IN SITU
MEASUREMENTS!**



Uncertainties left behind (1)

Lens development

- ***BP1.7, MT13 (short version)***
 - ***The split between Rwandese licences and Congolese licences should be according to area below -325m; approximately 50/50 %***
 - ***It shall be ensured that the extraction facilities are reasonably even spread of all over the lake, i.e. the bigger the facilities, the larger the distance***

Uncertainties left behind (1)

Lens development

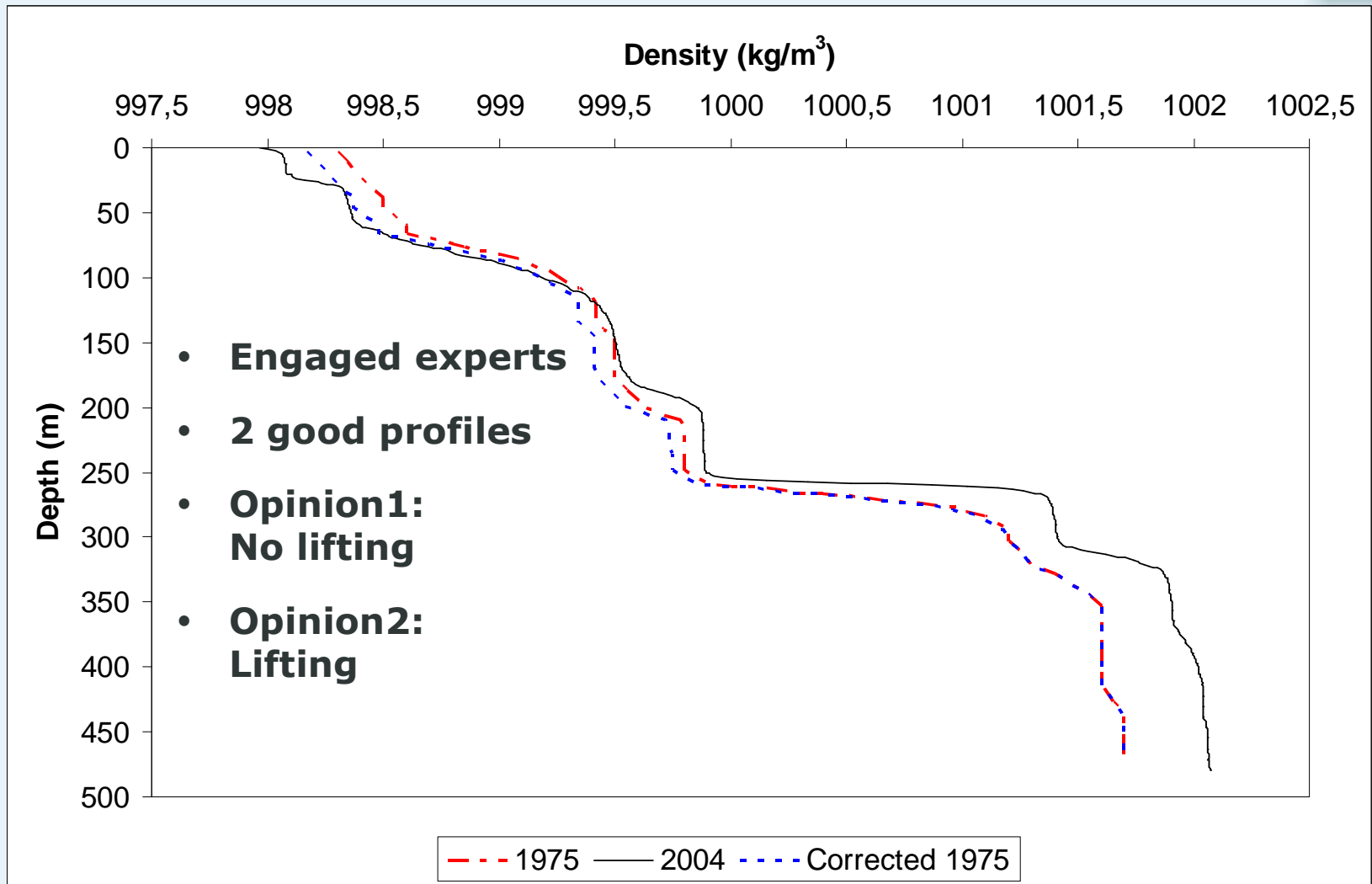
- ***BP1.8, MT13 (short version)***
 - ***The control of the gas pressure in the (Congo) zone to the east of the Idjwi Island should be the responsibility of the concessionaire on the Rwandese side (incl. full access right).***

Uncertainties left behind (1)

Lens development

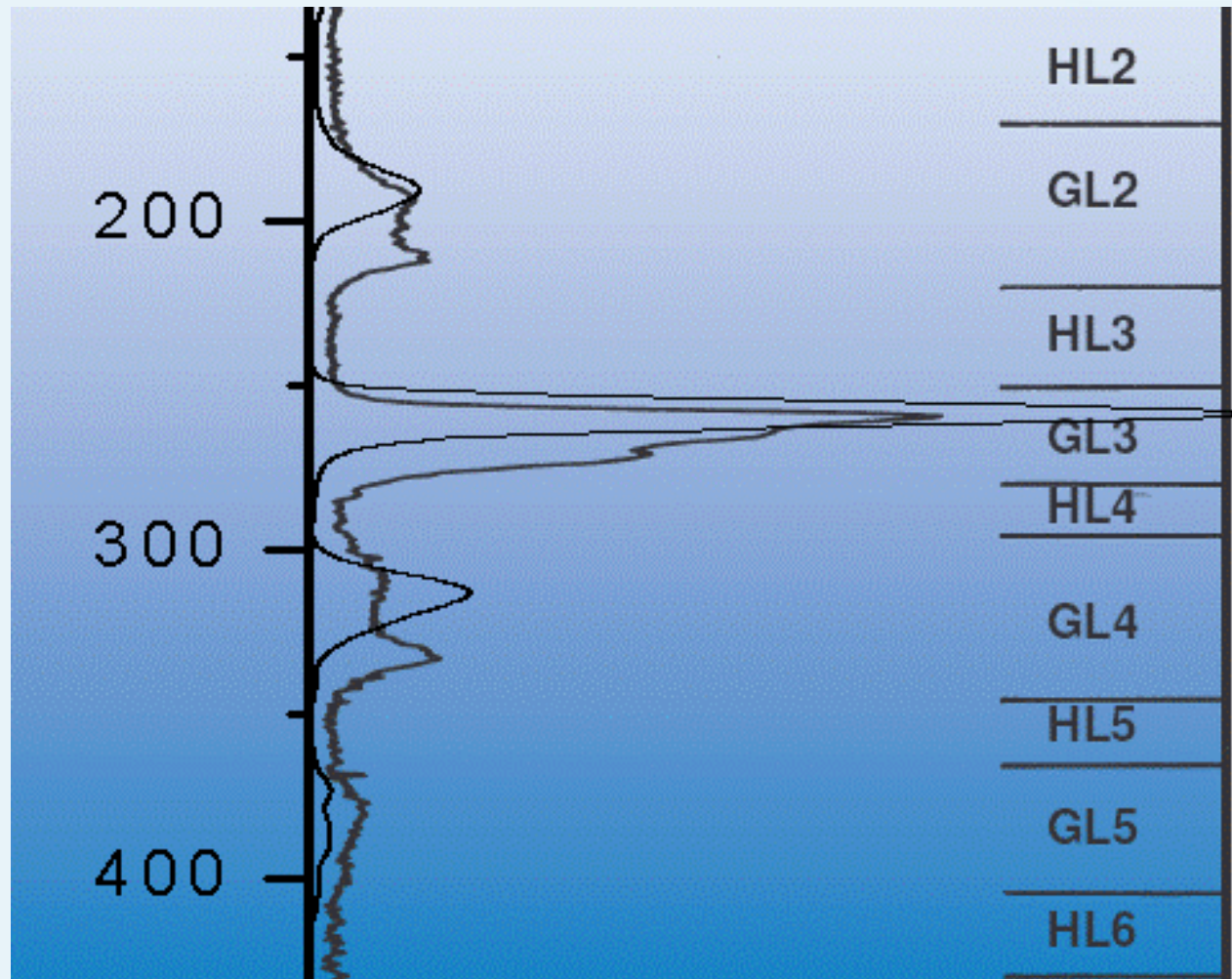
- **G13 (short version):**
 - ***Gas extraction plants shall be scattered evenly (with regard to their power) all over the deeper part of the lake.***
 - ***Installations shall be smaller than 20 MW (produced power).***
 - ***When more information on actual horizontal dispersion for Lake Kivu is available, it is possible that the above recommendation may be relinquished.***
 - ***If investors do not follow the above recommendation, the facility shall be downsized by order of Competent Authority***

Uncertainties left behind (2)



Uncertainties left behind (2)

- **Lifting of gradients**
- **The water body will be displaced upward by discharge of new bottom water (continuity of volume)**
- **Measured lift: ≈ 0.3 m/y**



Uncertainties left behind (2)

- **What may happen?**

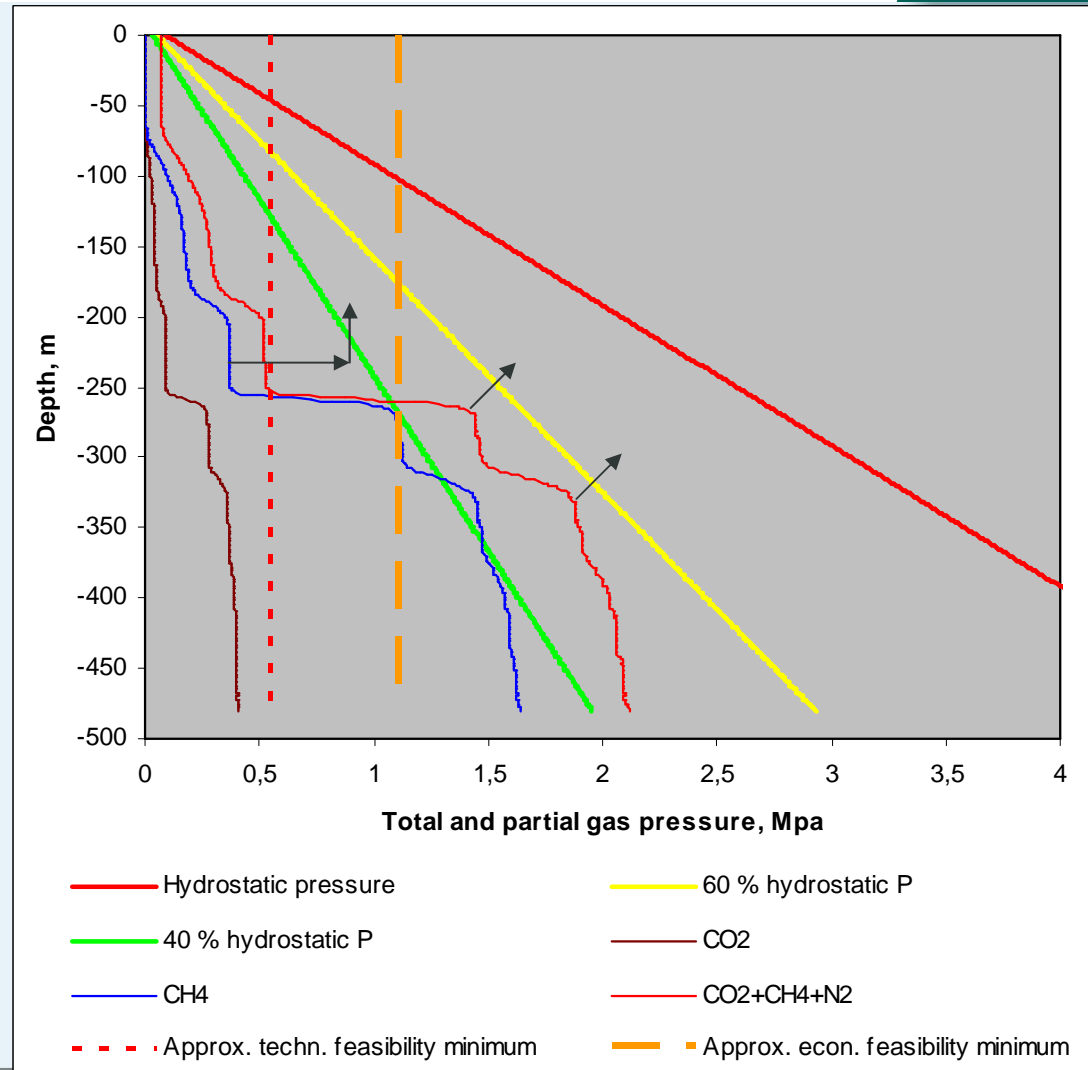
- **The measured lift will over time raise the risk for eruption.**

(Although the lift speed is not too precisely determined this uncertainty will only have effect on the WHEN, not the IF)

- **The measured lift will reduce the potential for commercial use of the gas in the potentially resource zone between 190m and 260m**

Uncertainties left behind (2)

- **What may happen?**
- **The measured lift will over time raise the risk for eruption.**
- **The measured lift will reduce the potential for commercial use of the gas in the potentially resource zone between 190m and 260m**



Uncertainties left behind (2)

- **What to do?**

- **Risk of eruption -> provide for possibility to keep interfaces "in place":**

- > **Res Zone: Mounting of a valve for partially outlet in the biozone.**

- > **Pot Res Zone: Facility to pump water to biozone**

Both will be activated after tests and assessments.

- **Consequence: Environmental impact on the nutrient content in the biozone**

- > **Environmental investigations/assessments**

Additional issues

Lifting

- ***BP1.4 (Short version)***
 - ***The -190 m and the -260 m density gradients in the lake must be prevented from lifting through discharge of the necessary fraction of degassed water into the biozone.***
 - ***Lifting and environmental impacts shall be studied in the first years and possible mitigating measures shall be determined.***

Additional issues

Lifting

- ***MTR15(short version):***
 - ***The first concessionaire shall within 2 years have established a test facility capable of discharging either 0.015 or 0.03 km³/year of degassed water into the **biozone** as much to the north as possible and inside the resource zone.***
 - ***The degassed water shall be re-injected at three different levels, and diluted 10, 30 or 100 times.***
 - ***Further details of the testing programme are to be agreed with Competent Authority.***
 - ***All test results shall be made public.***

Additional issues

Lifting

- ***MTR16(short version):***
 - ***After 6 years, all concessionaires shall establish facilities to prevent the lifting of the **-250 m** gradient.***
 - ***The totality of these facilities shall have a capacity between 0.15 and 3.0 km³/year of degassed water.***
 - ***The location shall be as much to the north as possible and inside the resource zone.***
 - ***Competent Authority will decide how much of the installed capacity shall be used.***

Additional issues

Lifting

- ***MTR17(short version):***
 - ***After 6 years all concessionaires will establish facilities to prevent the lifting of the -190 m gradient.***
 - ***The totality of these facilities shall have a capacity between 0.15 and 3.0 km³/year of degassed water.***
 - ***The location shall be as much to the north as possible and inside the resource zone.***
 - ***Competent Authority will decide, how much of the installed capacity shall be used.***

Additional issues (General)



BP: Best Practice

MTR: Mandatory Technical Requirements

MAR: Mandatory Administrative Requirements

G: General recommendations

Additional issues (General)

- ***BP1.5 (short version)***

Water extraction shall be sustainable:

- ***Method shall preserve for society the future ability to maintain safety while extracting gas***
- ***Revenue shall pay for continued necessary safety measures.***

- ***BP1.6 (short version)***

It is foreseeable that gas accumulation in the intermediate zone must be prevented in the longer run. The least problematic method should be identified before 2020.

Additional issues (General)

MTR1 (*short version*)

- ***In order to prevent disturbing of gradients the exit velocity from the pipe must not exceed 0.2 m/s***
- ***The design must prevent accidental deviations from this throughout the lifetime of the facility.***
- ***The design lifetime must be 50 years.***

Additional issues (General)

- **MTR14 (short version):**
 - ***Any concession includes the obligation to plan for and to actually transcend into a sustainable gas extraction mode after the Bonanza is over.***
 - ***In order to be able to do this, any concessionaire must have access to a piece of area in the deepest part of the lake.***
- **MTR18 (short version):**
 - ***Below the -190 m density gradient and below the -310 m density gradient the velocity of re-injection in the pipe openings must not exceed 0.1 m/s***

Additional issues (General)

- ***MAR8 (short version):***
 - ***A precondition for permission to start-up is that the Competent Authority has inspected all underwater piping and fittings when assembled onshore prior to installation.***

Additional issues (General)

- ***G14 (short version):***
 - ***At present (by 2008) it is not possible to foresee whether it is possible to go directly into a continuous mode for the facilities located over the deepest water or whether it is necessary to wait some years before as production is resumed, based on the yearly accumulation of methane in the resource zone.***

Additional issues (General)

- **G18:**
 - ***It is recommended to use a vertical pipe with a large number of holes drilled horizontally in the last part of the pipe to comply with the limitation on exit velocity.***
 - ***To avoid short-circuiting between the point of extraction and re-injection it is recommended not to locate these two points on the same vertical line.***
 - ***To avoid short-circuiting it is recommended to study lens spreading further.***