

Geological constraints and modifying factors - Cement

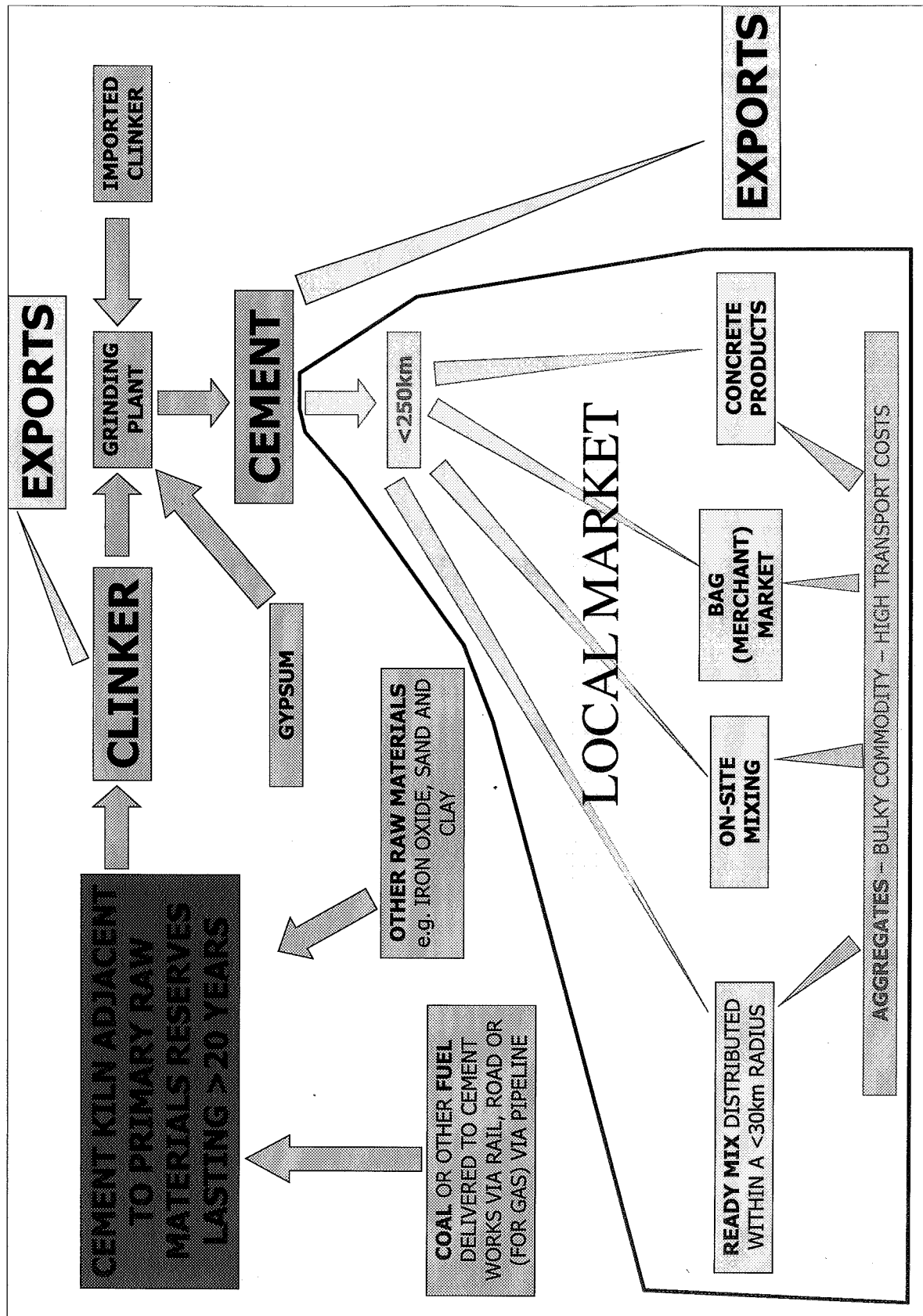
Ruth Allington (Council member
EFG and Joint Senior Partner, GWP
Consultants LLP)

Key features of cement raw material reserves

- For a modern cement plant, sufficient reserves of suitable quality for >25 years are needed close to the plant (many international companies look for >50 years and some for 100). **Overriding driver for location is quality and quantity of raw materials**
- Mine production rates are considerable, typically 6,400 tonnes of dry raw material per day to produce 4,000 tonnes of clinker (>2M tonnes of dry raw material per year).
- Transport of this raw material over long distances is not economic so plant close to reserves.

Cement manufacture

- Cement clinker is predominantly calcium silicate. Limestone is burnt, releasing CO_2 , and combined with silica to produce calcium silicate (with iron and alumina combined with calcium as minor constituents).
- Clay and limestone materials with a combined CaCO_3 content at between 78% and 80% (and constraints on Fe_2O_3 , Al_2O_3 and SiO_2), heated in a kiln to temperatures greater than $1,200^\circ\text{C}$ to produce CLINKER.
- Clinker ground finely in mills and with the addition of gypsum and/or other materials to produce CEMENT.



Pre-feasibility/site
selection stage.

Increasing the level of confidence

What investigations and analyses will be necessary to reduce geological uncertainty and define and manage the modifying factors?

Is there anything about this site we can identify now that is an obvious 'show stopper'?

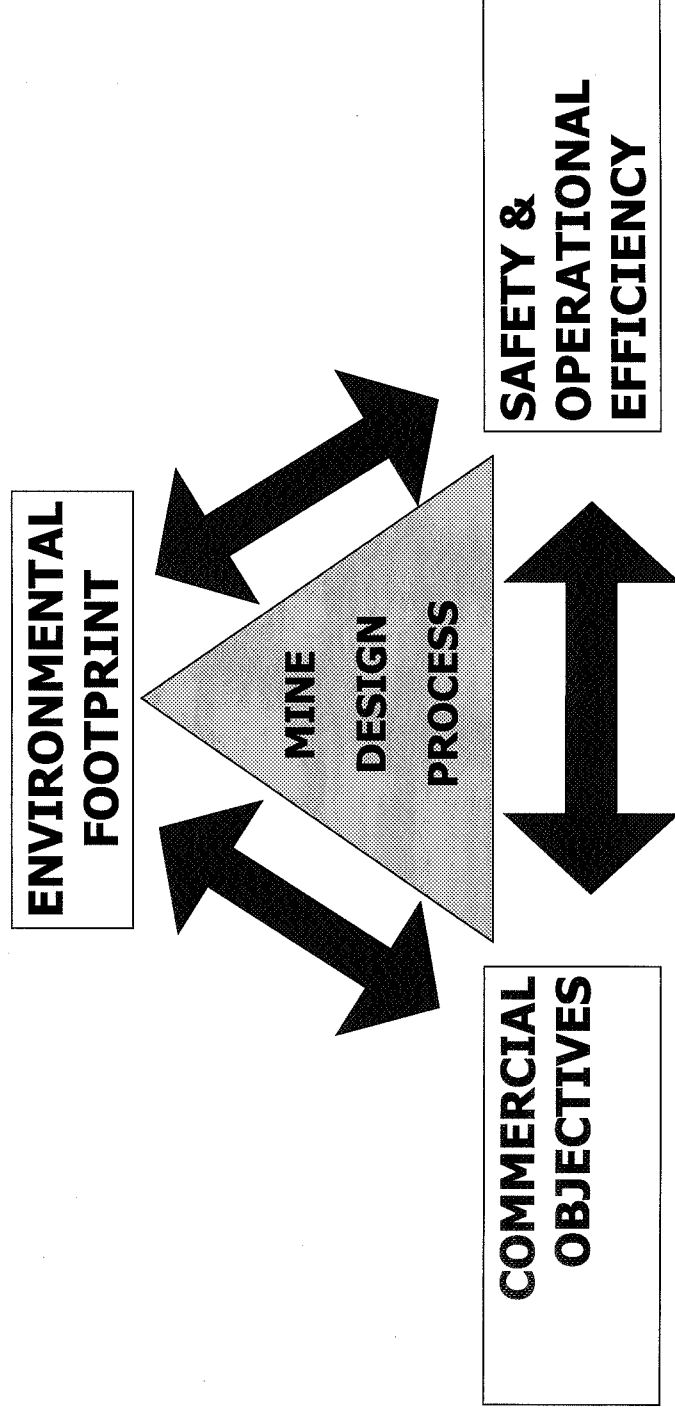
On balance, which site justifies the effort and expense of following the blue arrows?

Increasing
level of
geological
knowledge
and
understanding

Modifying factors

- **Mining** (how to ensure consistency of chemical composition)
- **Markets** (competition, proximity, size, market share – decisions as to kiln capacity)
- **Environmental considerations** (humans and wider environment)
- **Economic** (reducing stockpiling and double handling, efficient working layout, reducing haul distances for raw material clinker and cement)

Mine design – a framework for optimising the modifying factors

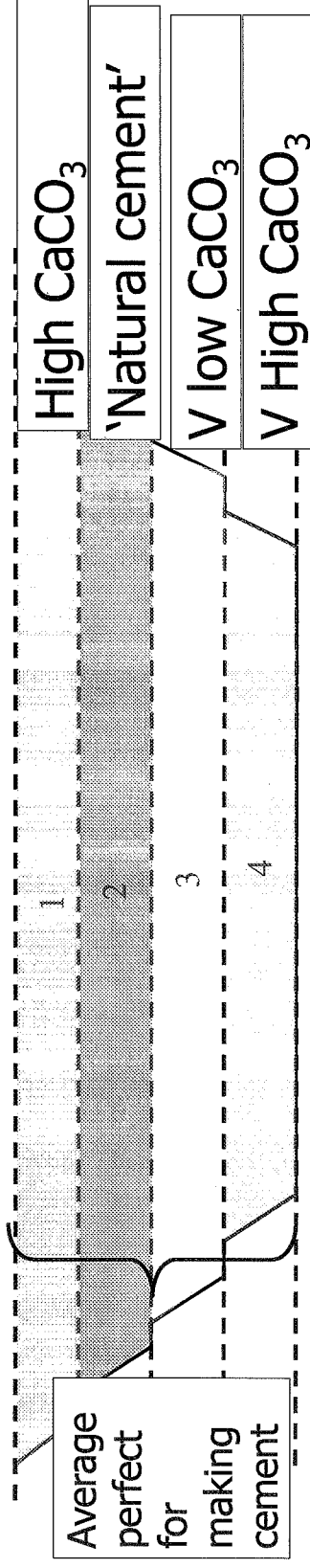


Recurrent questions throughout the design process

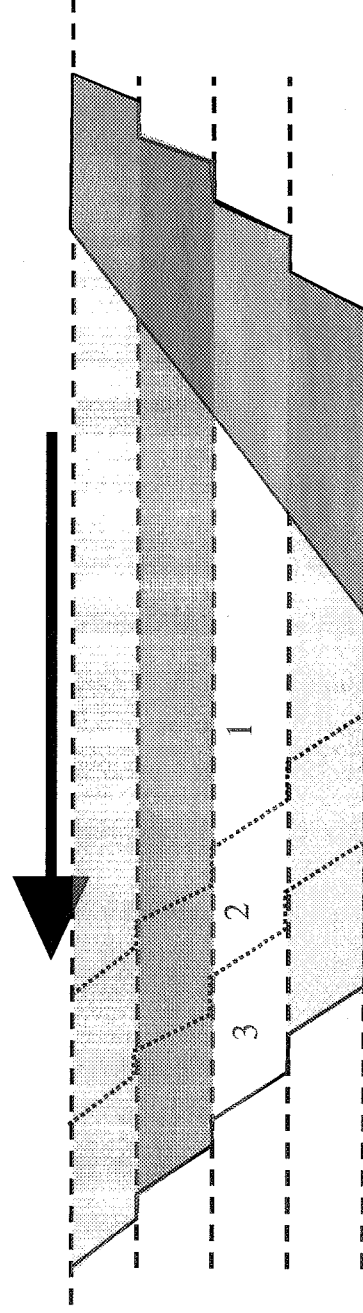
- As more information is gathered throughout the process:
 - ‘given the changes that have been made to meet environmental, planning or health and safety constraints, can we still meet our business objectives at this site?’
 - ‘if not, is it still worth completing the design and applying for a permit to work?’
 - ‘what are our revised business objectives?’

Key features of cement raw material reserves

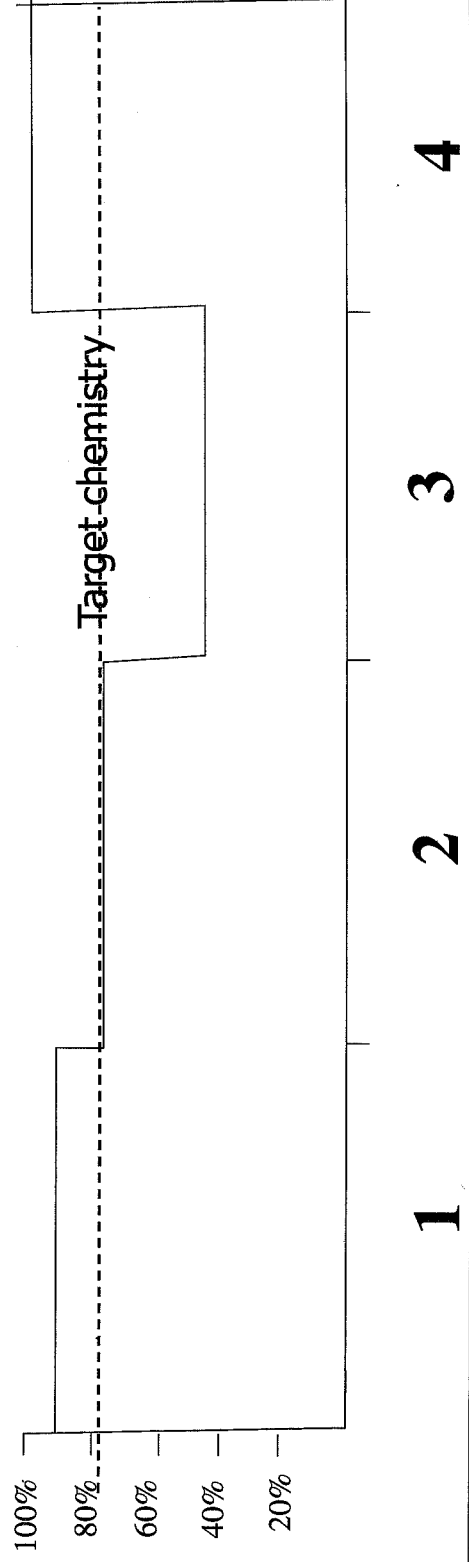
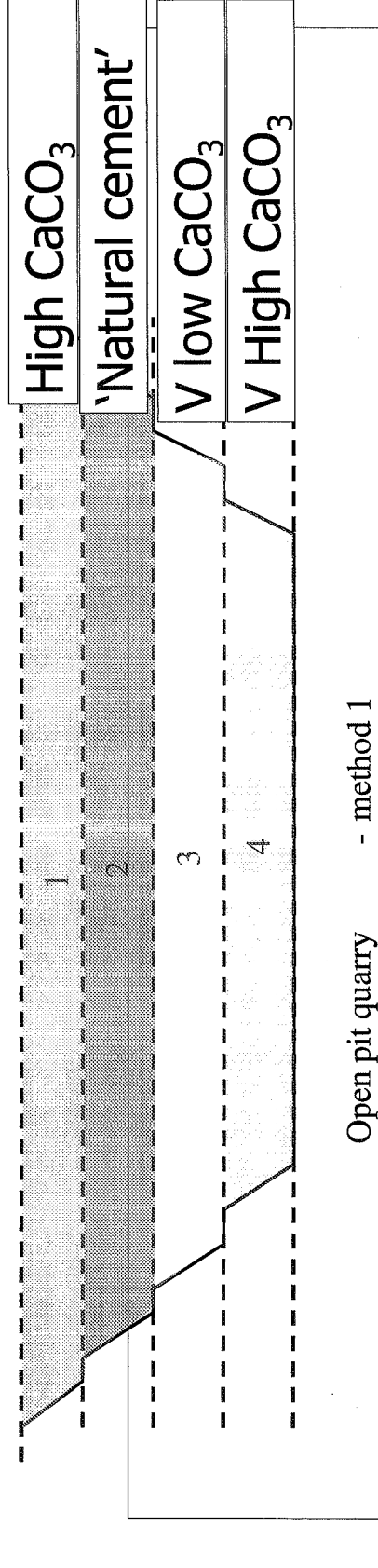
- Chemical consistency of the raw material is important and this needs to be achieved as far as possible through pit design and phasing that yields a consistent product. This avoids or reduces to a minimum the need for blending and homogenising stockpiles (expensive and large) and/or constant 'tweaking' of additives.

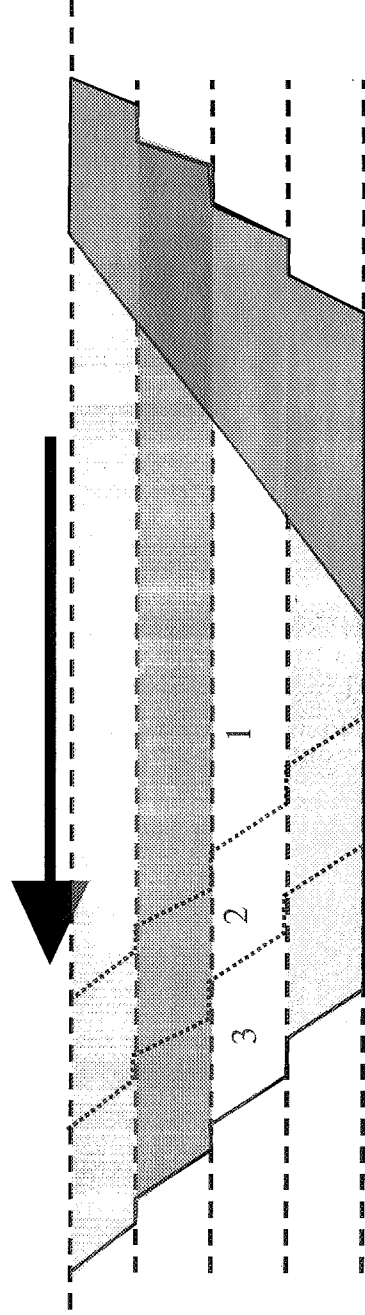
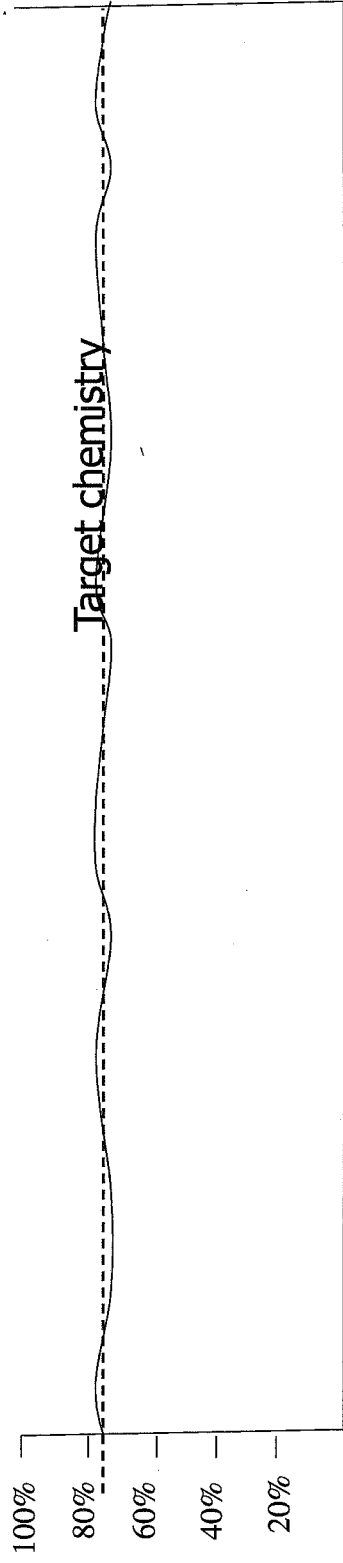


Open pit quarry - method 1



Open pit quarry - method 2

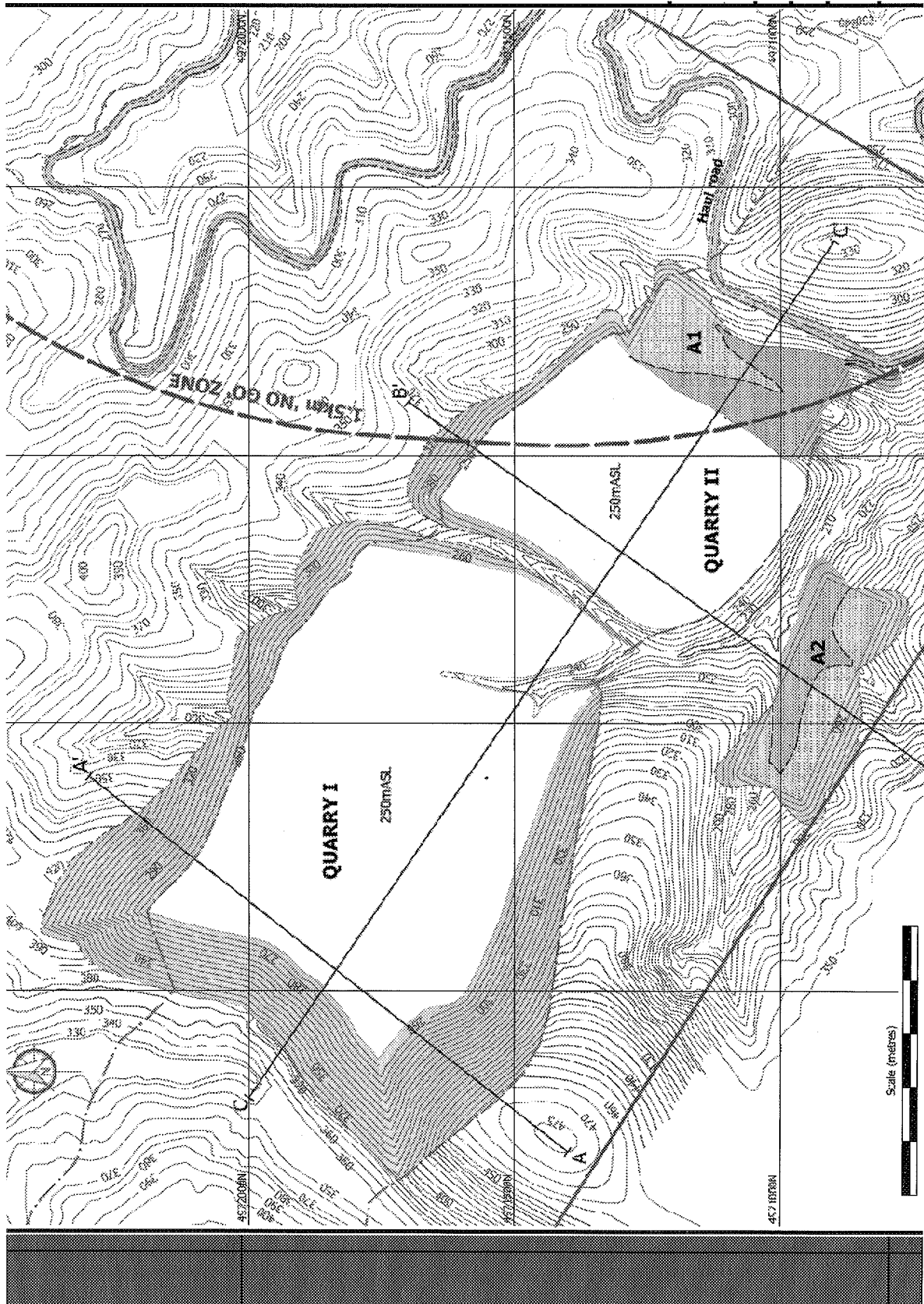


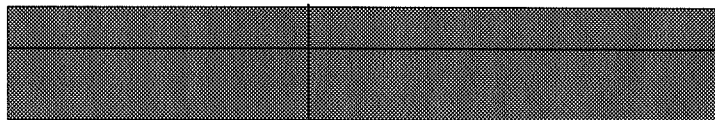


Open pit quarry - method 2

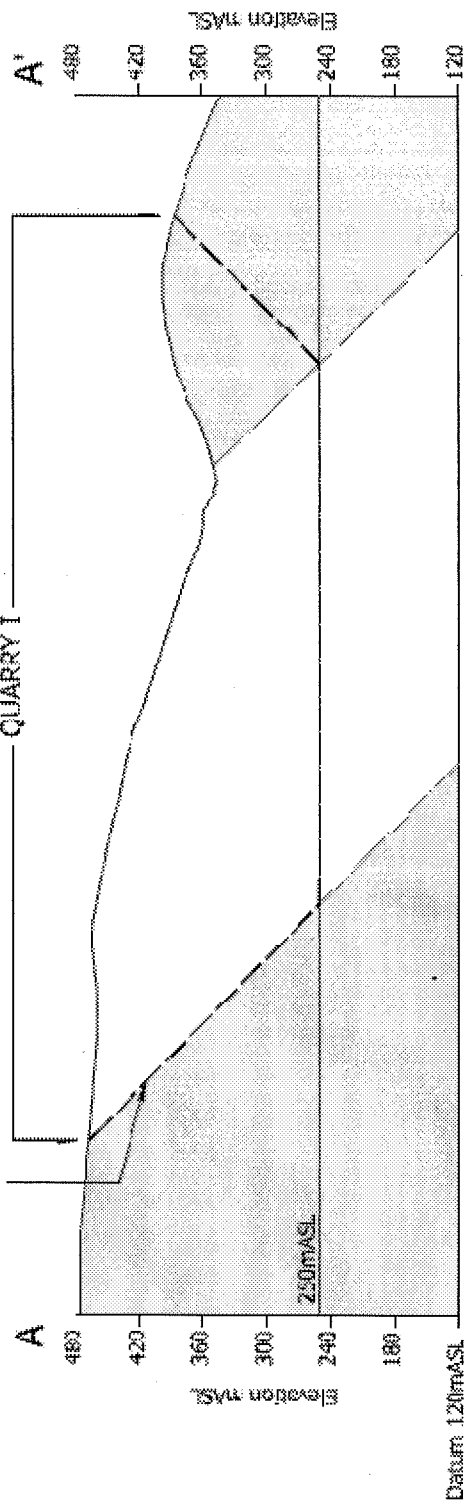
Resource measurement and classification

- Constraints on resource size
 - Geology
 - Geotechnics
 - Hydrogeology
 - Land ownership and permitting
 - Working methods and existing mine layouts
 - Quality release requirements
 - Proximity of local populations
 - Ecological designations



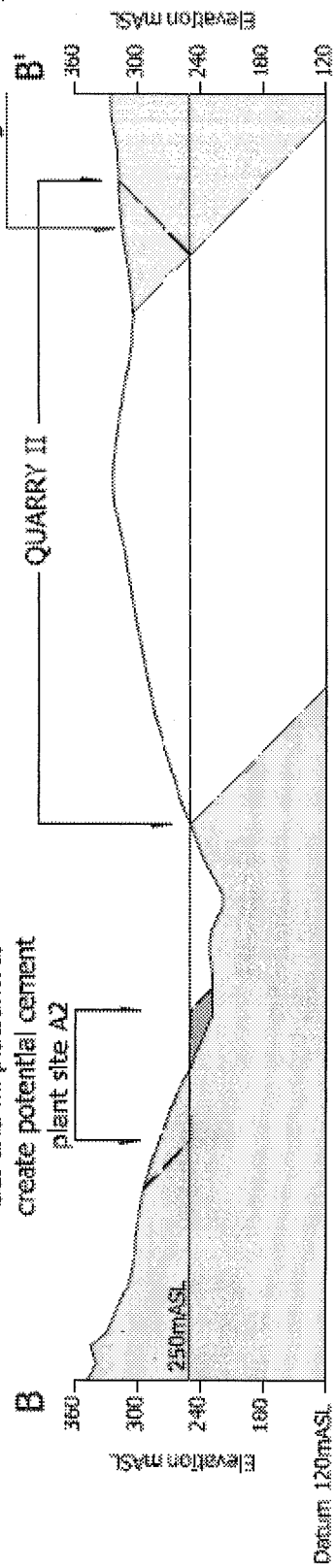


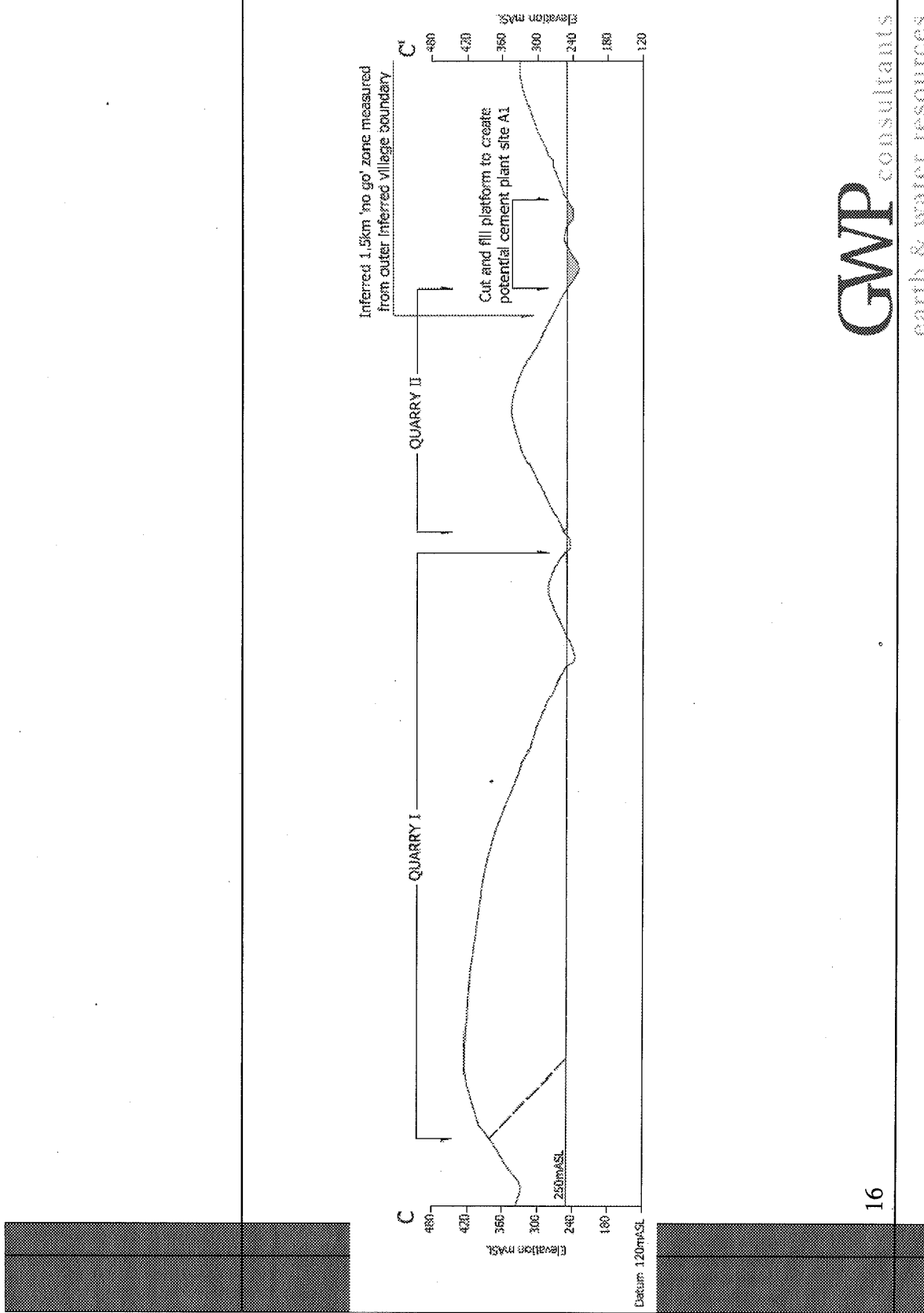
Inclination of South
west quarry faces must
be not steeper than the
inclination of the strata

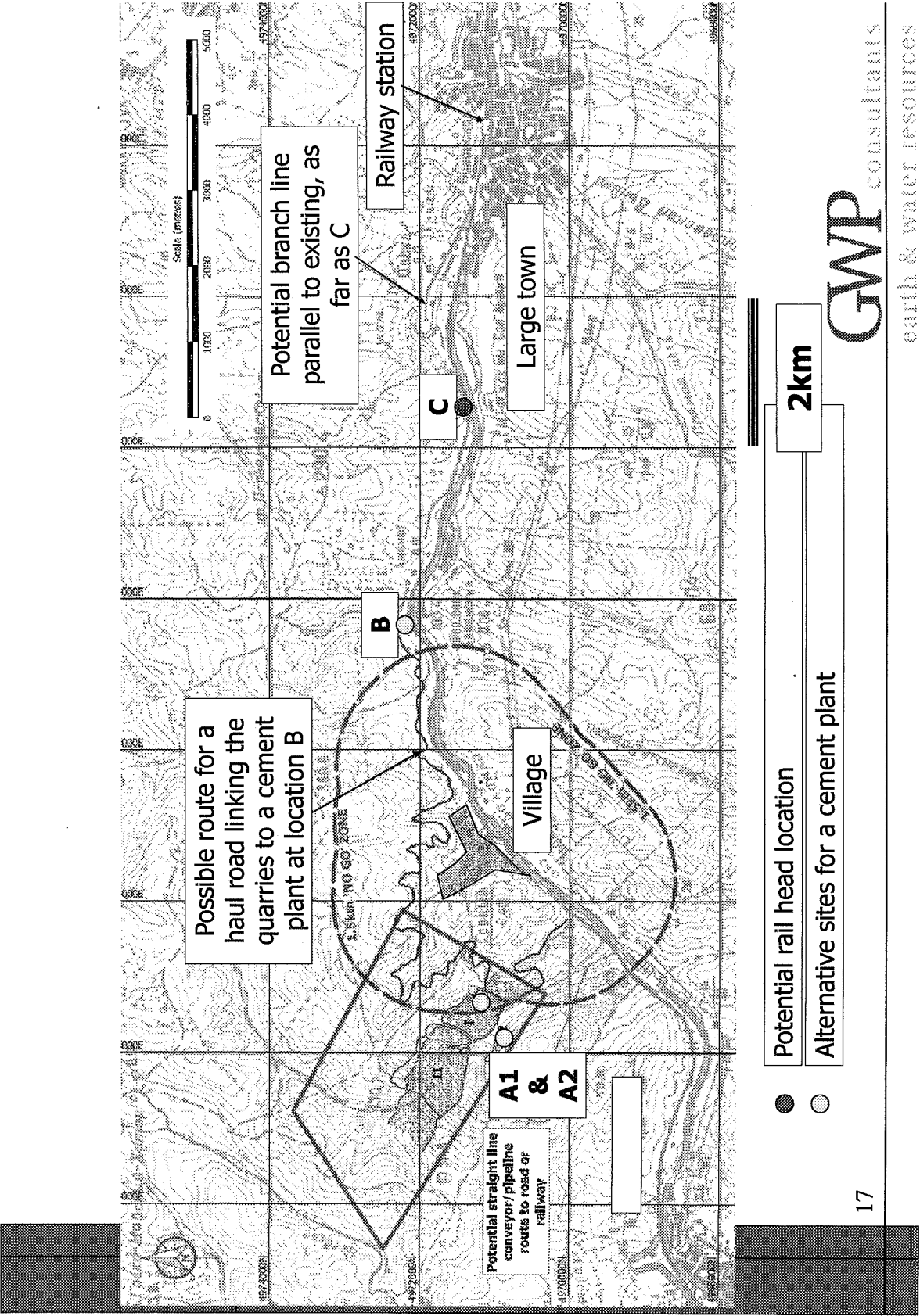


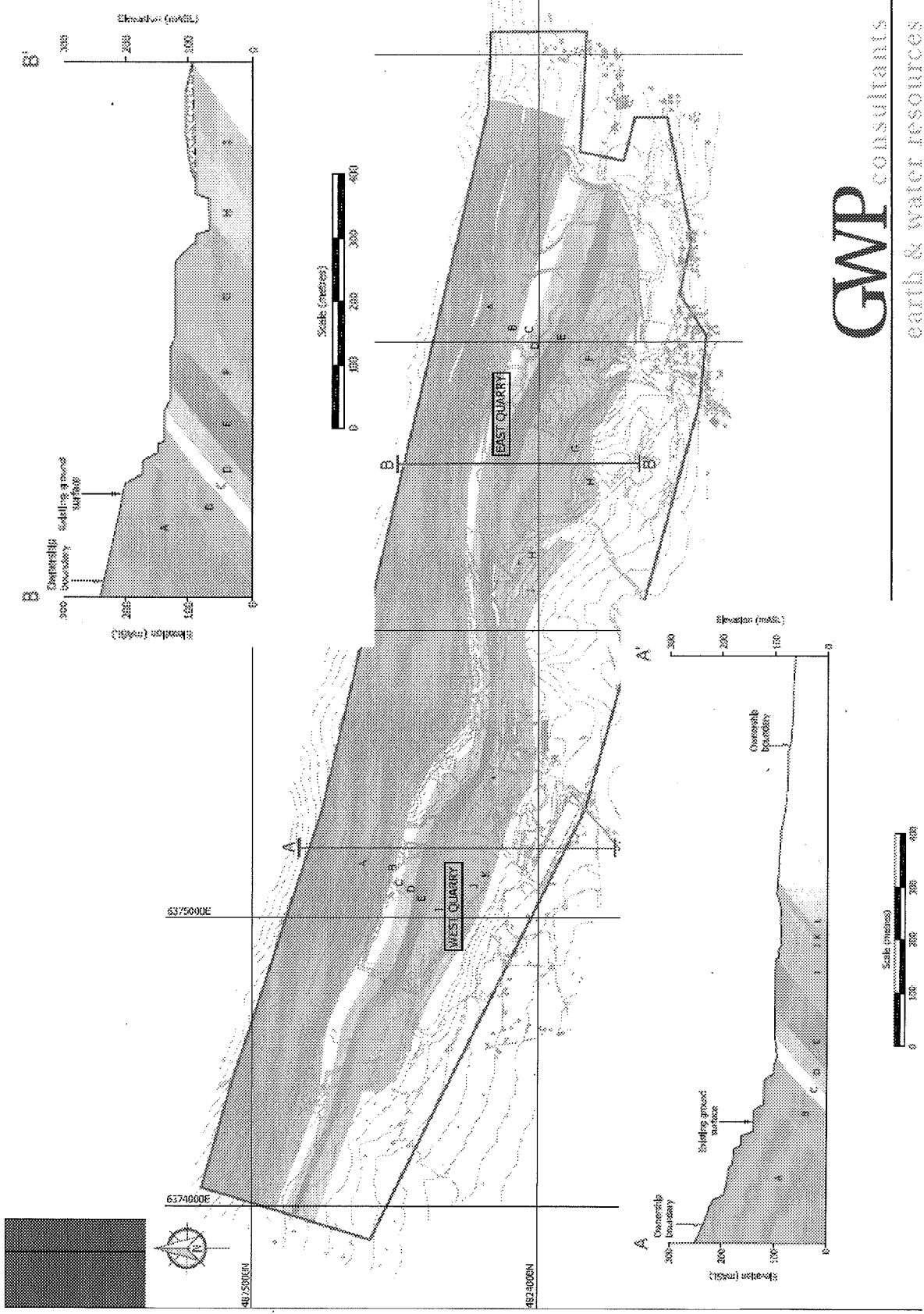
Inferred 1.5km 'no go' zone
measured from outer
Inferred village boundary

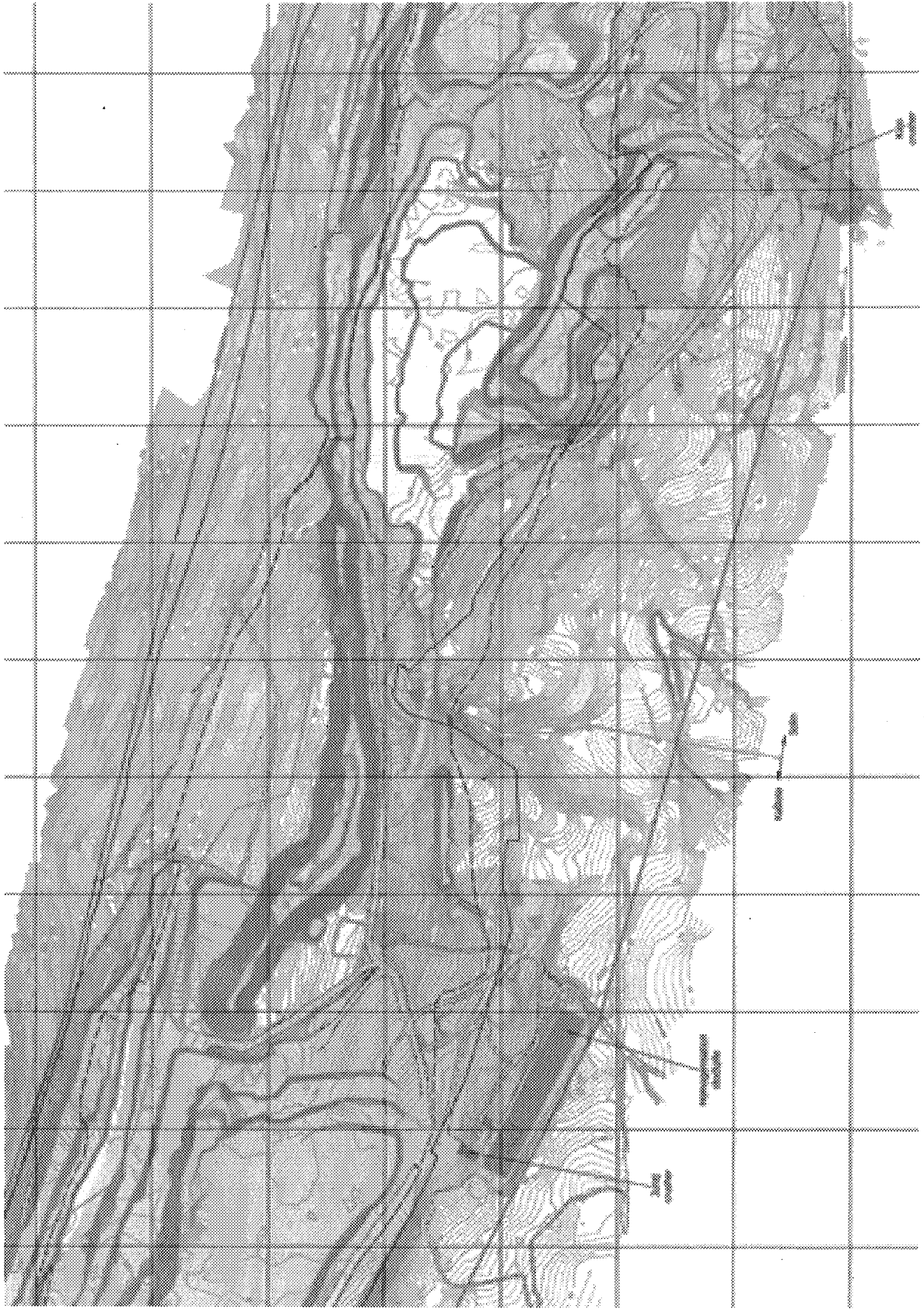
Cut and fill platform to
create potential cement
plant site A2













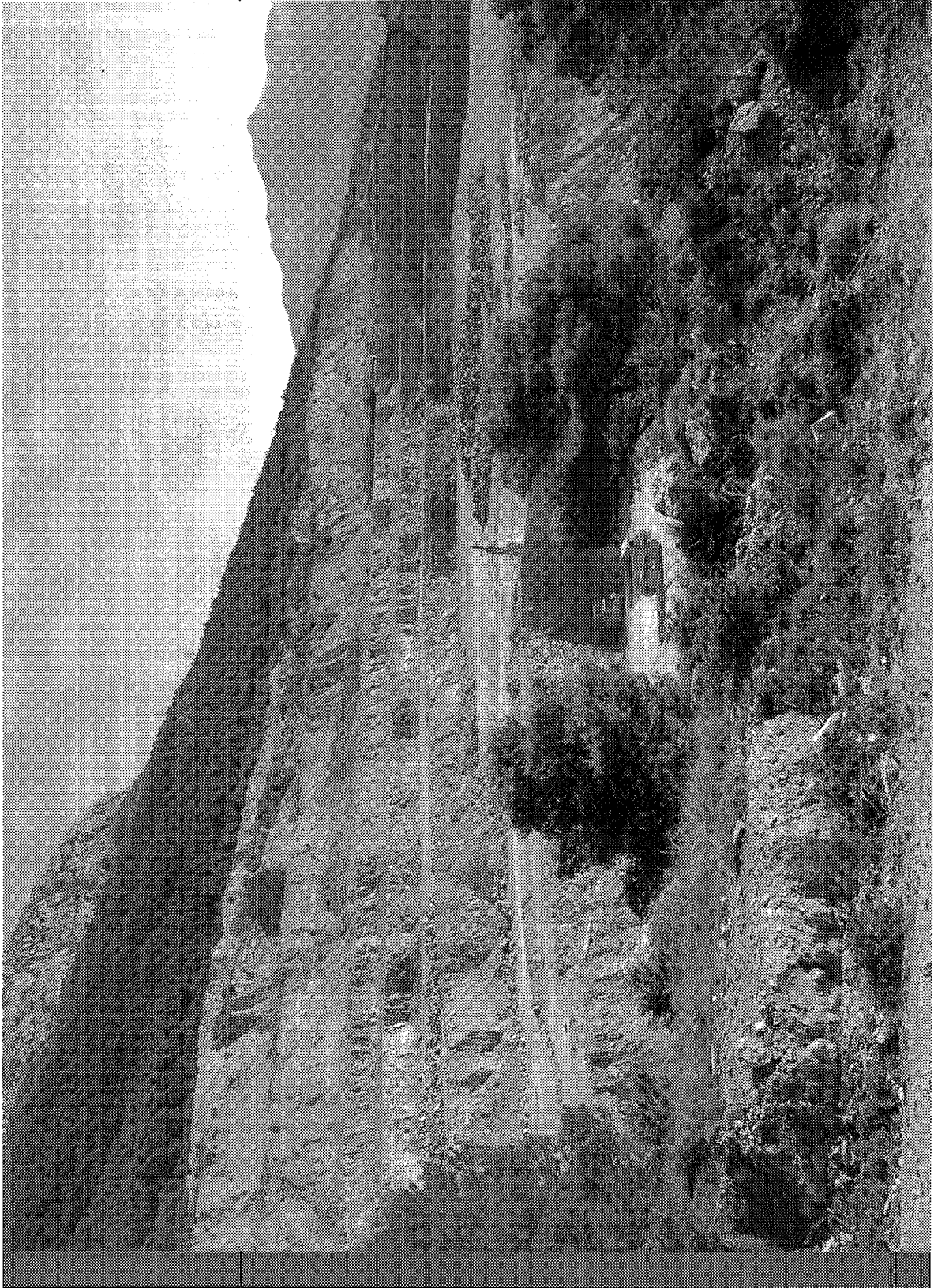
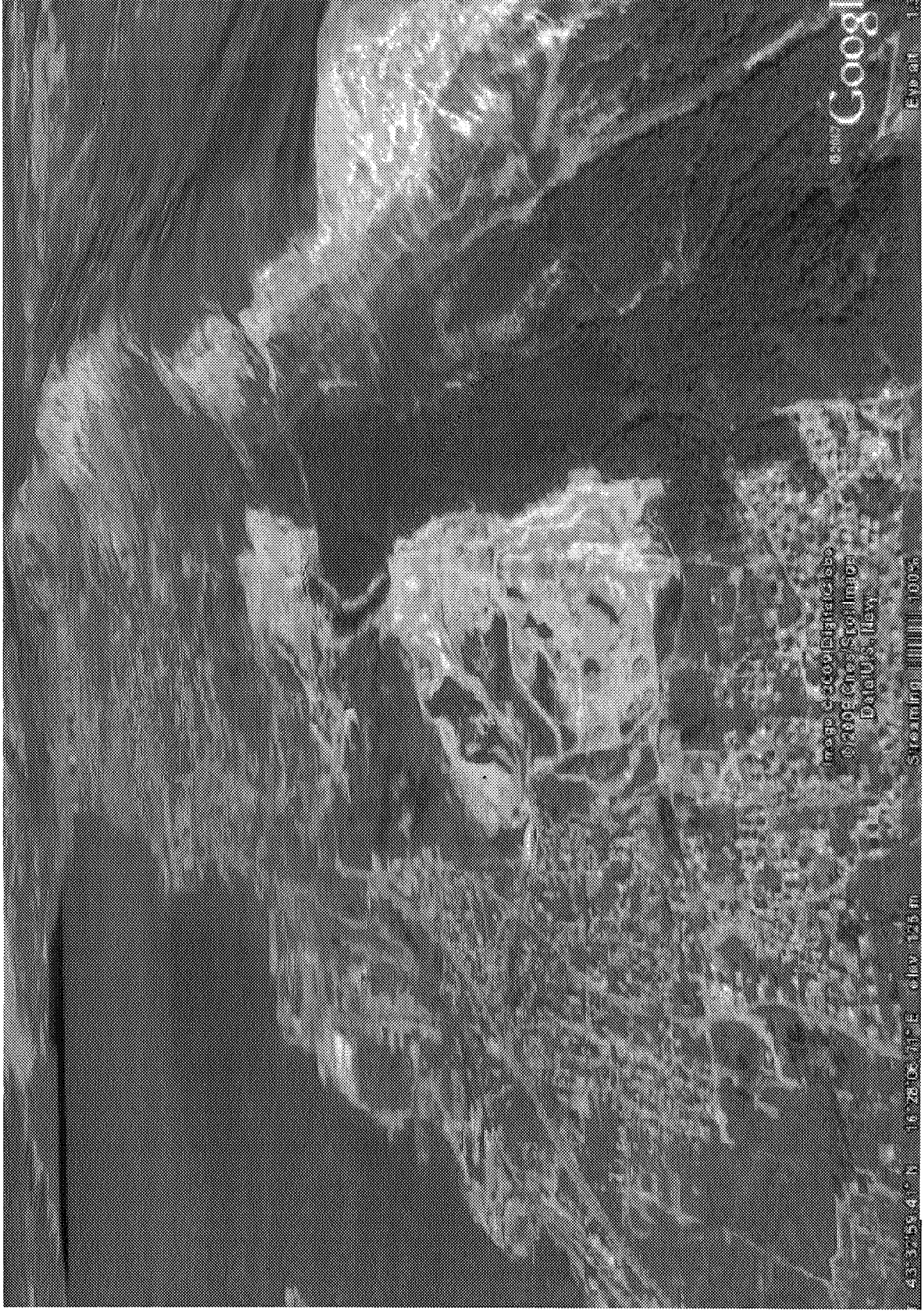






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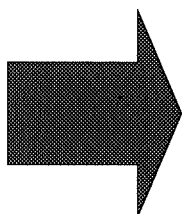
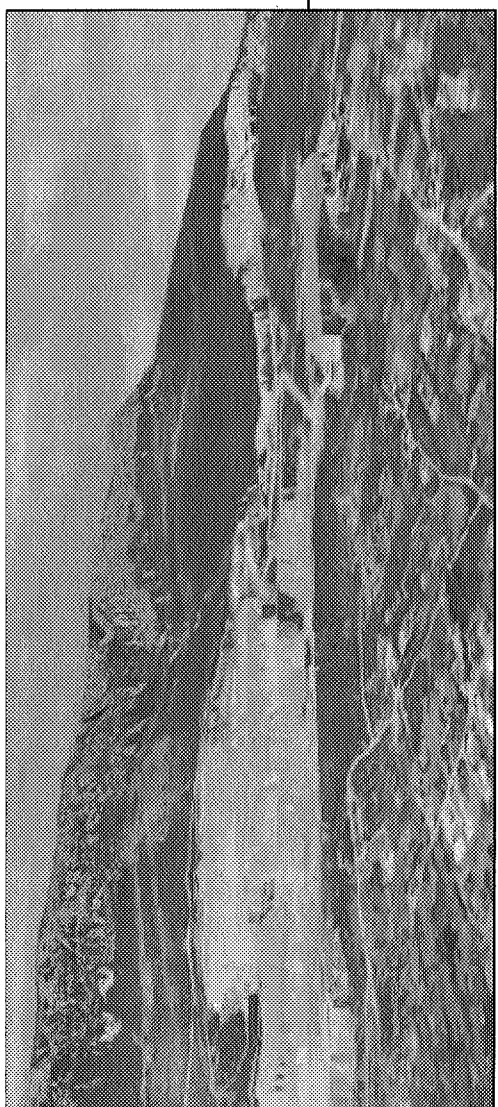
Google

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Data provided by:

Exp. 01

Stream 100%

43° 37' 59" N 16° 28' 06" E Elev. 125 m



GWP consultants
earth & water resources