

ELFORSK



DAMMSÄKERHET – Bennett Dam

**Echo sounding technology for inspection of earth-
and rockfill embankment dams**

Rapport 99:27

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Förord

BC Hydros W.A.C. Bennett damm i British Columbia, Kanada, är en 183 m hög och ca 2000 m lång jorddamm som dämmer upp en ca 30 mil lång sjö med en regleringsvolym av 70 miljarder m³ vatten.

Två sjunkgropar uppstod under juni respektive september 1996 i Bennett-dammen. Man beslöt tillsammans med delstatens dammsäkerhetsmyndighet att magasinsnivån omedelbart skulle sänkas. Därefter startade omfattande undersökningar av dammen både med mer beprövade metoder samt med nyare metoder som legat i forskningens framkant.

Hösten 1996, i anslutning till det inträffade, beslöts det att ett utvecklingssamarbete skulle starta mellan BC Hydro och svensk kraftindustri med inriktning på utvecklingsmekanismer för inre erosion och sjunkgropar och reparationsmetoder.

Genom detta utbyte har ett antal rapporter tagits fram, bl.a. den föreliggande. I detta samarbete har Urban Norstedt, Vattenfall Vattenkraft, och Gunnar Sjödin, Vattenregleringsföretagen, utgjort styrgrupp för VASO Dammkommitté och kraftindustrin och finansierande företag har varit alla medlemmar i Svenska Kraftverksföreningen.

Stockholm i september 1999

VASO Dammkommitté

Elforsk AB

Summary

Vattenfall Hydropower AB has as contractor for Vattenfall Vattenkraft AB performed an investigation of the possibilities to make a detailed survey of the upstream slope of earth and rockfill embankment dams with modern echo sounding technology. This work includes a study of repeatability of measurement at two different occasions.

The result of the investigation shows that it today is possible to make a detailed high resolution map even if the surface is rough. We have also established that the error in the repeatability between two different measurements was 0.5-1.0 % of actually depth. According to the supplier of the equipment there are possibilities to halve the error in future measurements.

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A	RESULT OF MEASURE - MESSAUREDAM
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1 Background

Since 1987 Vattenfall has investigated the possibilities to make cross sections of the upstream slope of earth and rockfill embankment dams with echo sounding technology. Opening tests started in Suorva 1987. 1988 started a detailed survey of the Messaure dam. This measurement was performed with a special echo sounder with a small opening angle of 1 deg and a very accurate positioning system.

Depending on roughness of the dam surface the result showed big variations between adjacent cross sections. We could also establish that the technology gave a detailed picture of the dam in each measured line

The echo sounding gives a map over measured area. If the contour lines on the map has regular partition there is no settlement in the dam. This technology give us no possibility to see what happened with the dam in the area between measured cross sections

In the autumn of 1995 Vattenfall performed new measurements in Messaure. The purpose was to investigate repeatability of measurement with existing echo sounding equipment and the possibility to detect changes on the dam surface.

It is only possible to compare two measurements, different only in time, if the position is exactly the same. It is very complicated to navigate a boat in exact the same track. A comparison of the Messaure measurements showed good agreement. The result from this evaluation is that our existing echo sounding equipment gives very good repeatability between measurements if we can perform measurements in the same position.

We have found out that a reliable determination of damages on the dam surface demands very detailed measurements. It is probably necessary to perform measurement with a distance of 1 meter between each measured line. This is a time consuming work but realistic to achieve.

1.1 New technology

Vattenfall invested in our existing echo sounding equipment about ten years ago. Until this day the development of echo sounding technology has done big progress. According to the supplier it has now become possible to make a detailed high resolution map with this new technology. This new technology is called multi beam system. Within a 90 deg sector, 60 beams, 1.5 deg x 1.5 deg each are measured simultaneously 20 times each second. This new type of echo sounding system require not as many survey lines as the old one to cover same area. The result from a survey of a dam can be presented as three-dimensional picture.

2 ACCOMPLISHMENT OF TEST

In the autumn of 1996 Vattenfall performed measurements in Messaure dam with the multi beam system. The purpose was to investigate accuracy and repeatability in the new technology. One important part in the dam control program is to look for changes on the dam slope over a further period of time. That is the reason why it is very important to confirm repeatability between two different occasions of measurement.

In this work we have also studied the communication between our existing positioning system and the new echo sounding system and how the new equipment manage active-service handling.

3 RESULT

The communication between our existing positioning system and the new echo sounding system worked excellent after some adjustments and calibration. The conclusion is that the question of communication is solved. The new equipment is constructed to manage active-service handling.

The result from our measurement with the new echo sounding system is presented in attachment 1. The repeatability between two different measurements was 0.5-1.0 % of actually depth. The wave height was between 0.5 and 0.6 meter during the test. According to the supplier of the equipment refined calibrations and adjustments could hake the error in future measurements. A halving of the error also demands low wave height during the measurement.

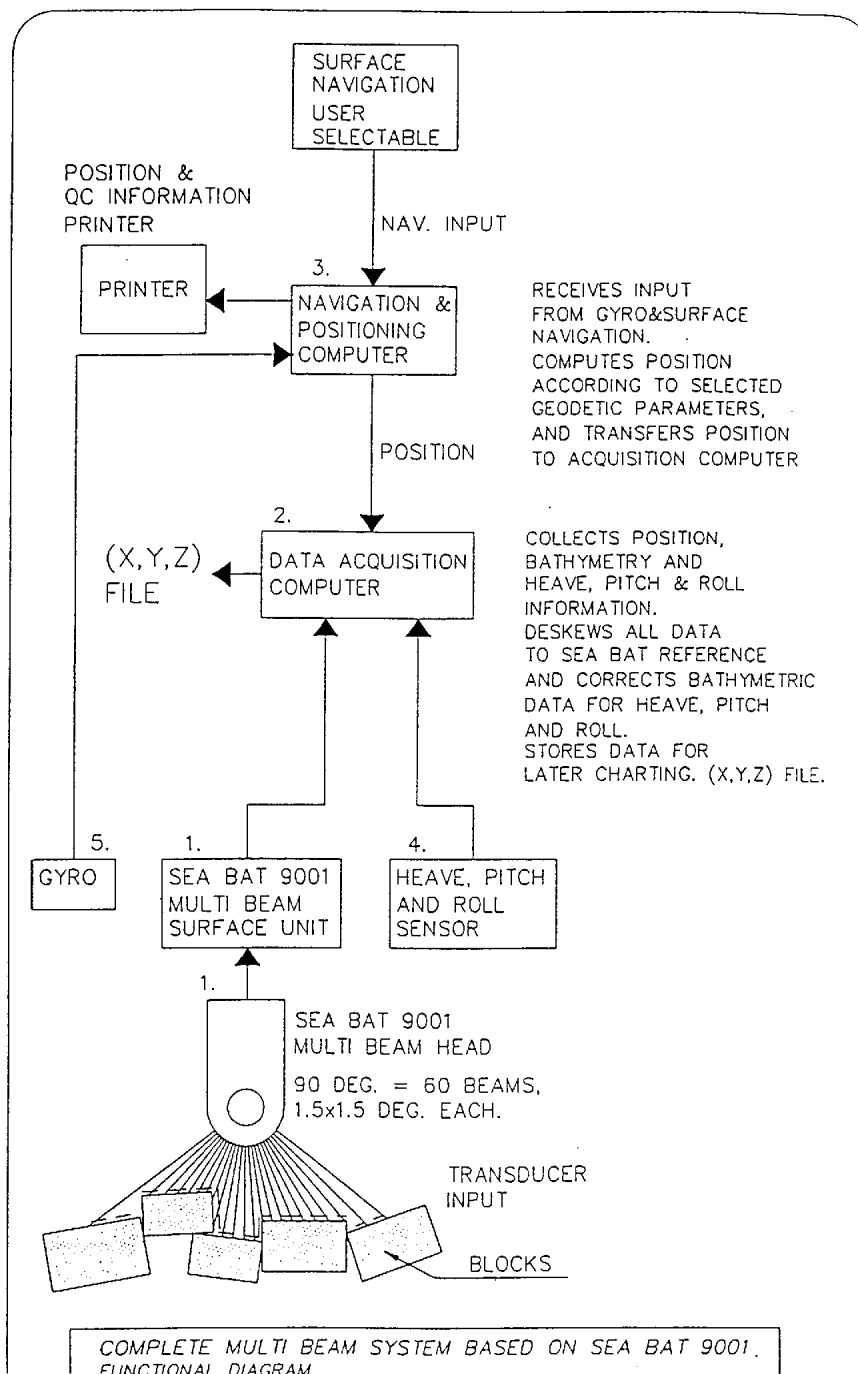
The result of the investigation shows that it today is possible to make a detailed high resolution map on earth- and rockfill embankment dam slopes With this new technology it is possibly to repeat a measurement with great accuracy in position and depth. We can use the technology to determine changes on the surface on earth and rockfill embankment dam slopes between two different occasions of measurement.

Attachments

A Result of Measure - Messauredam

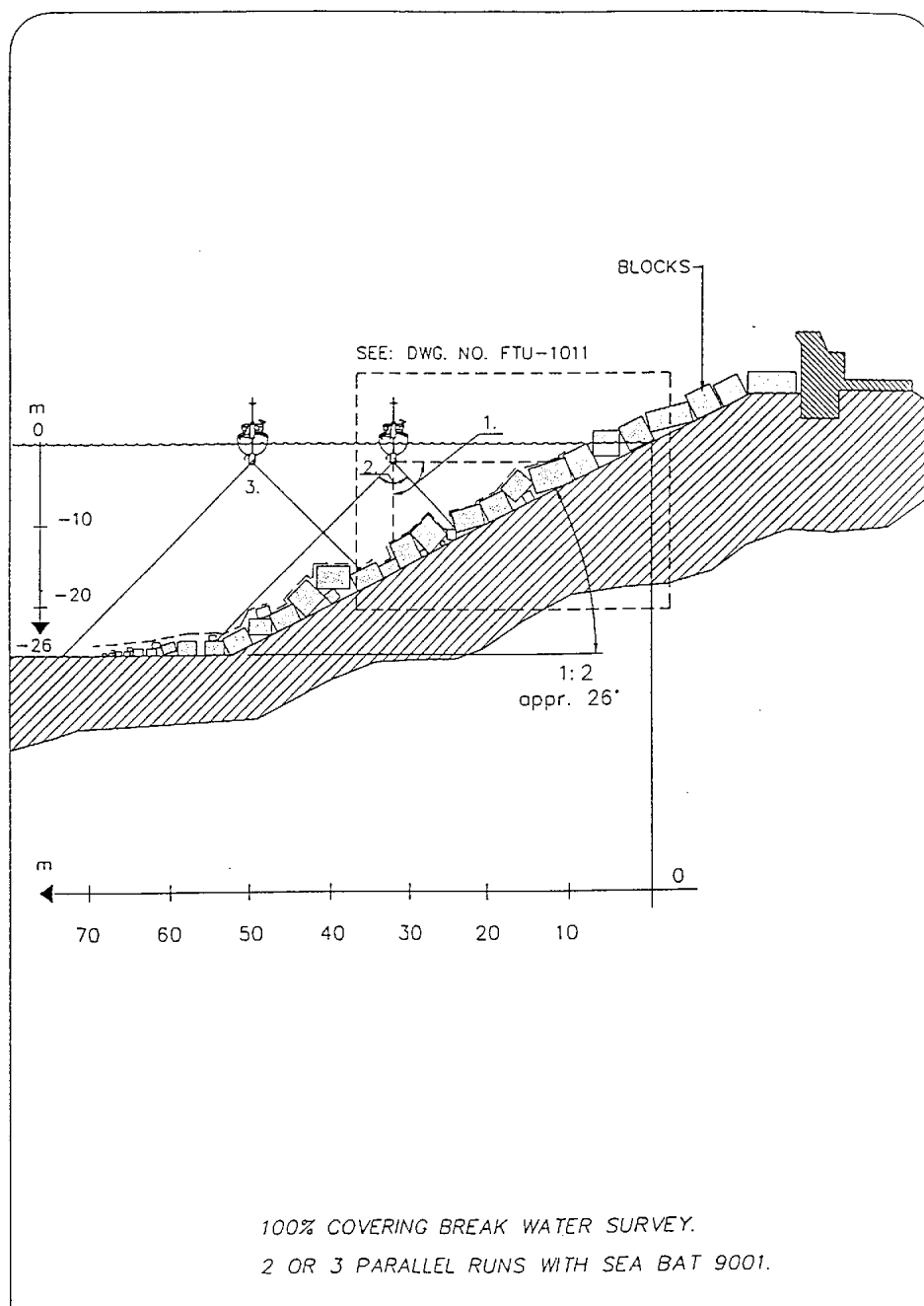
Attachment 1

1(8)



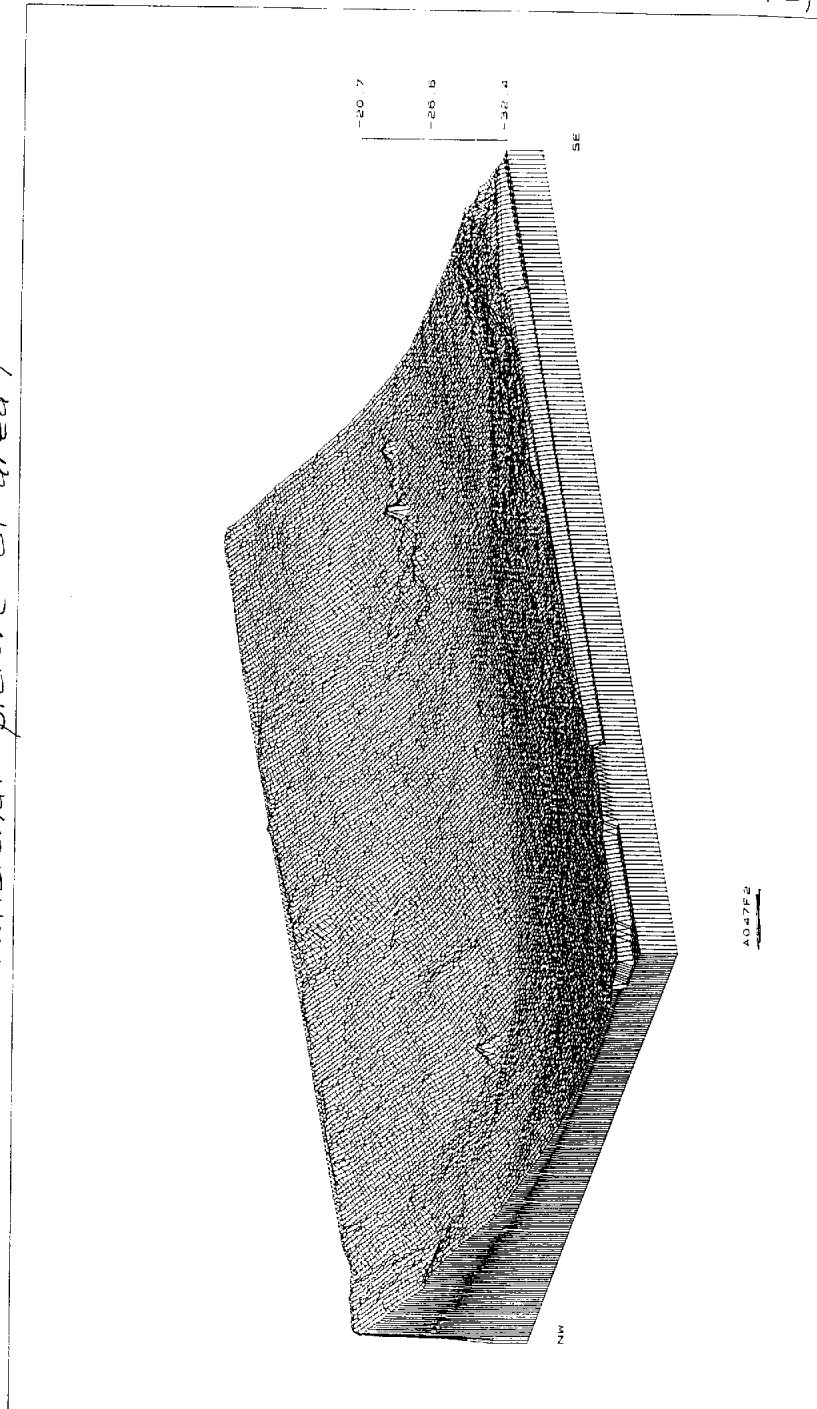
Attachment 1

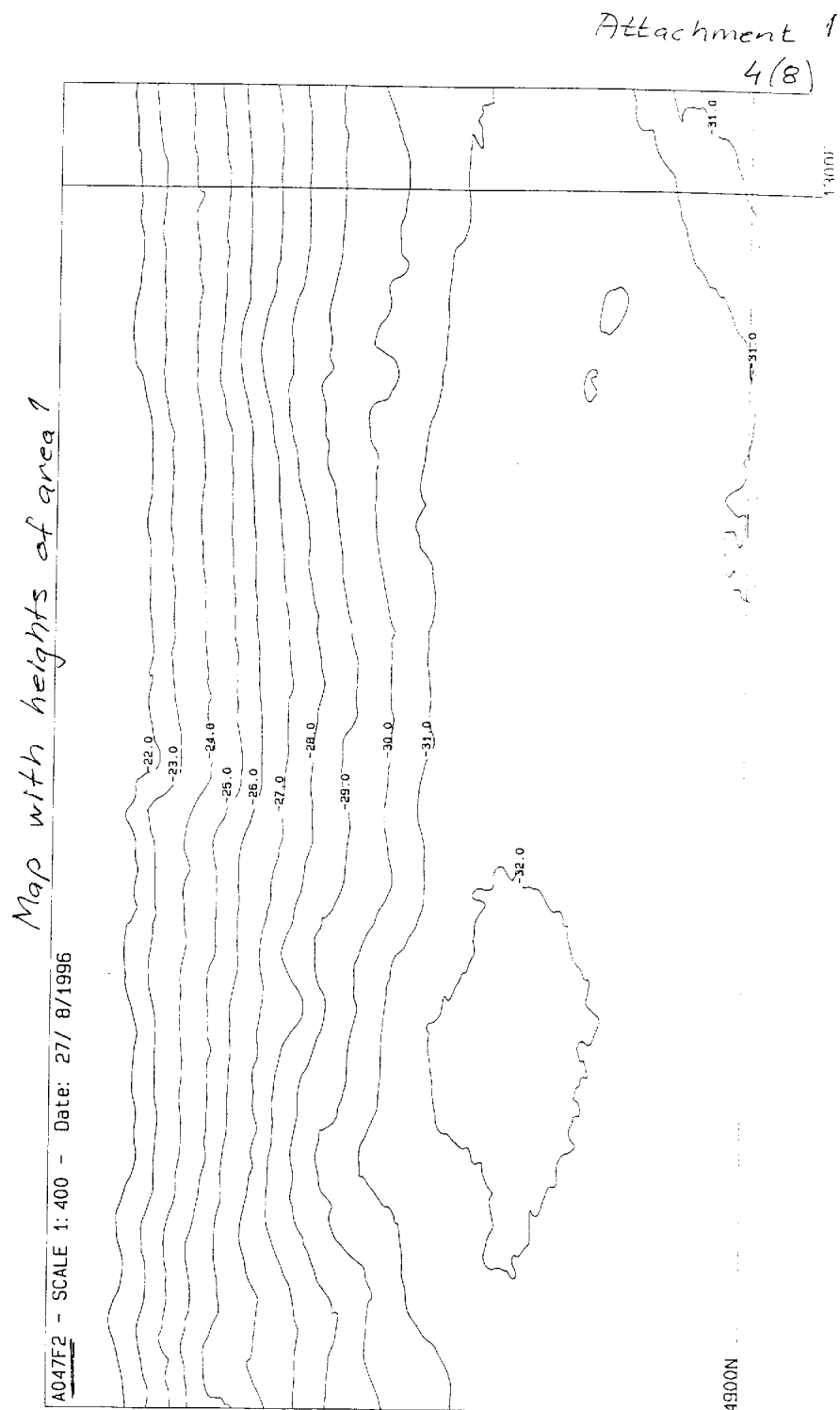
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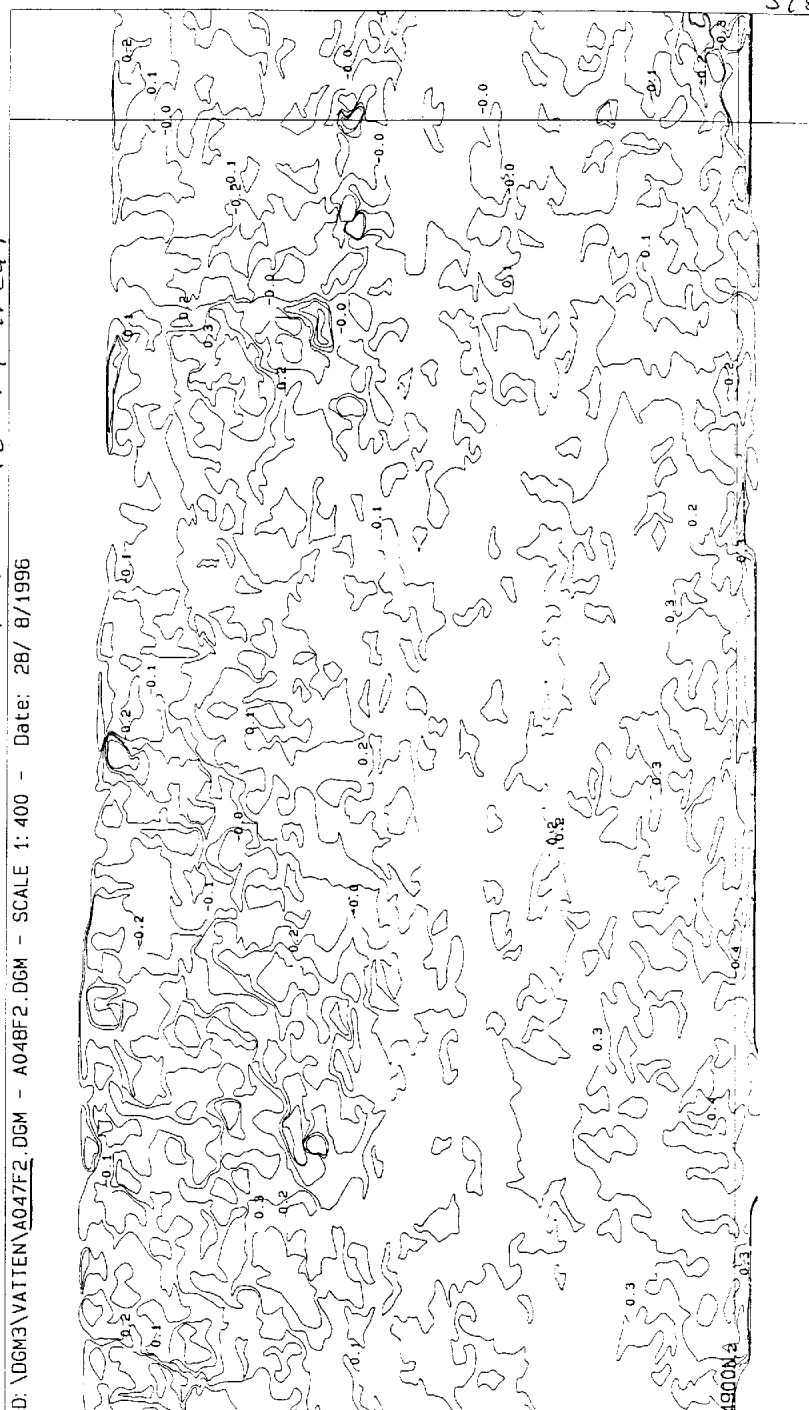
Attachment 1
3(a)

3-dimensional picture of area 1



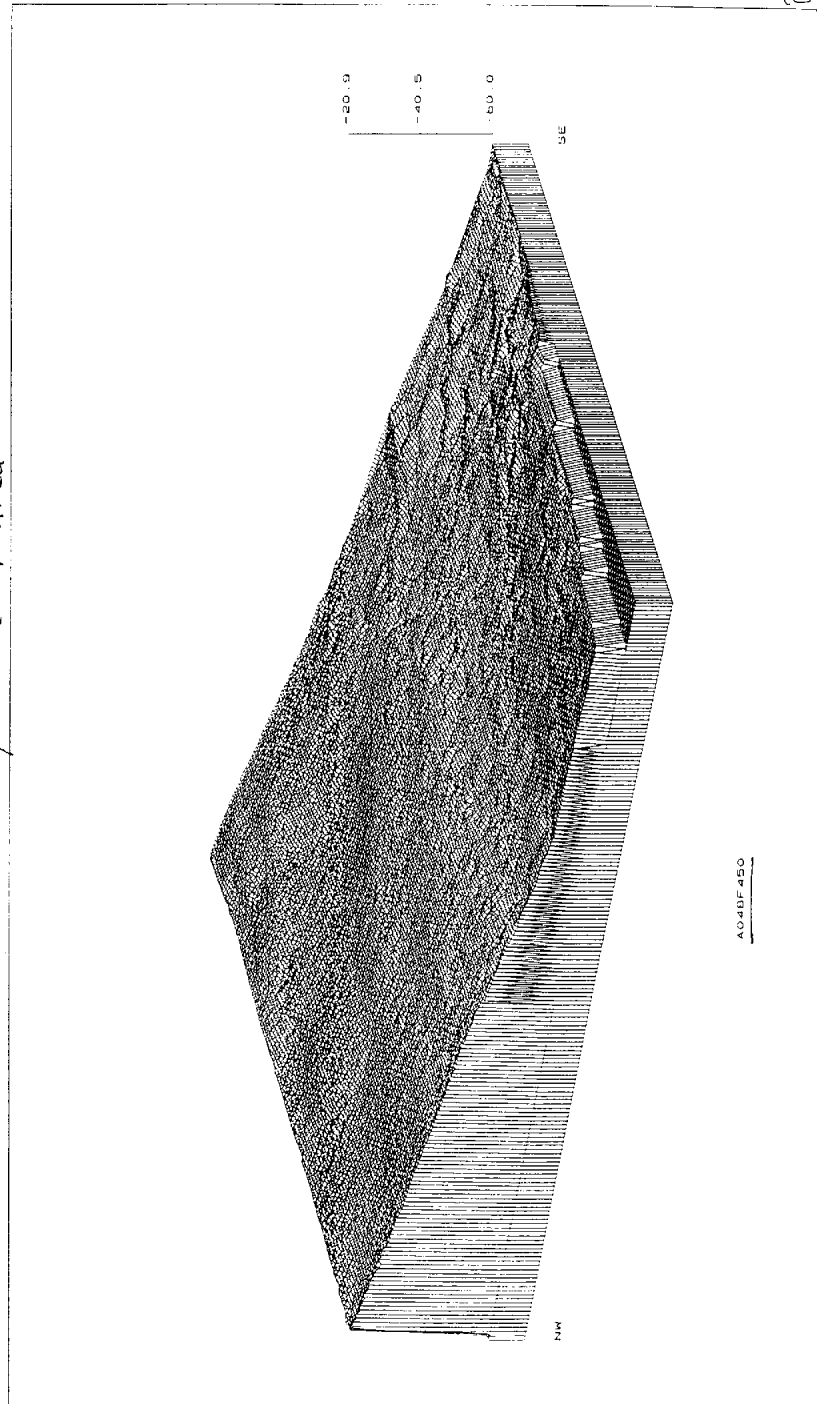


*Shows the difference between
two occasions of measurement in area 1*

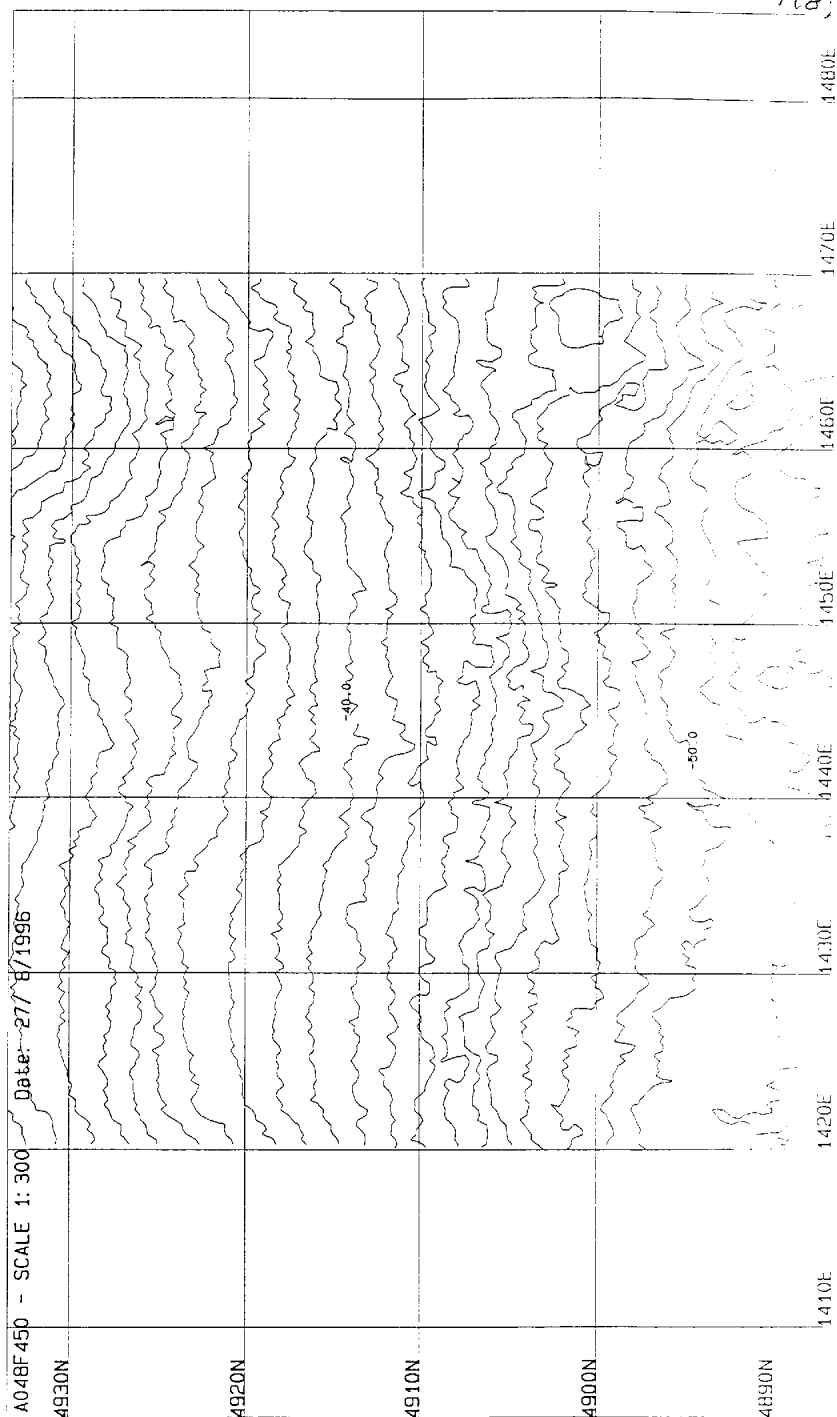


Attachment 1
6(8)

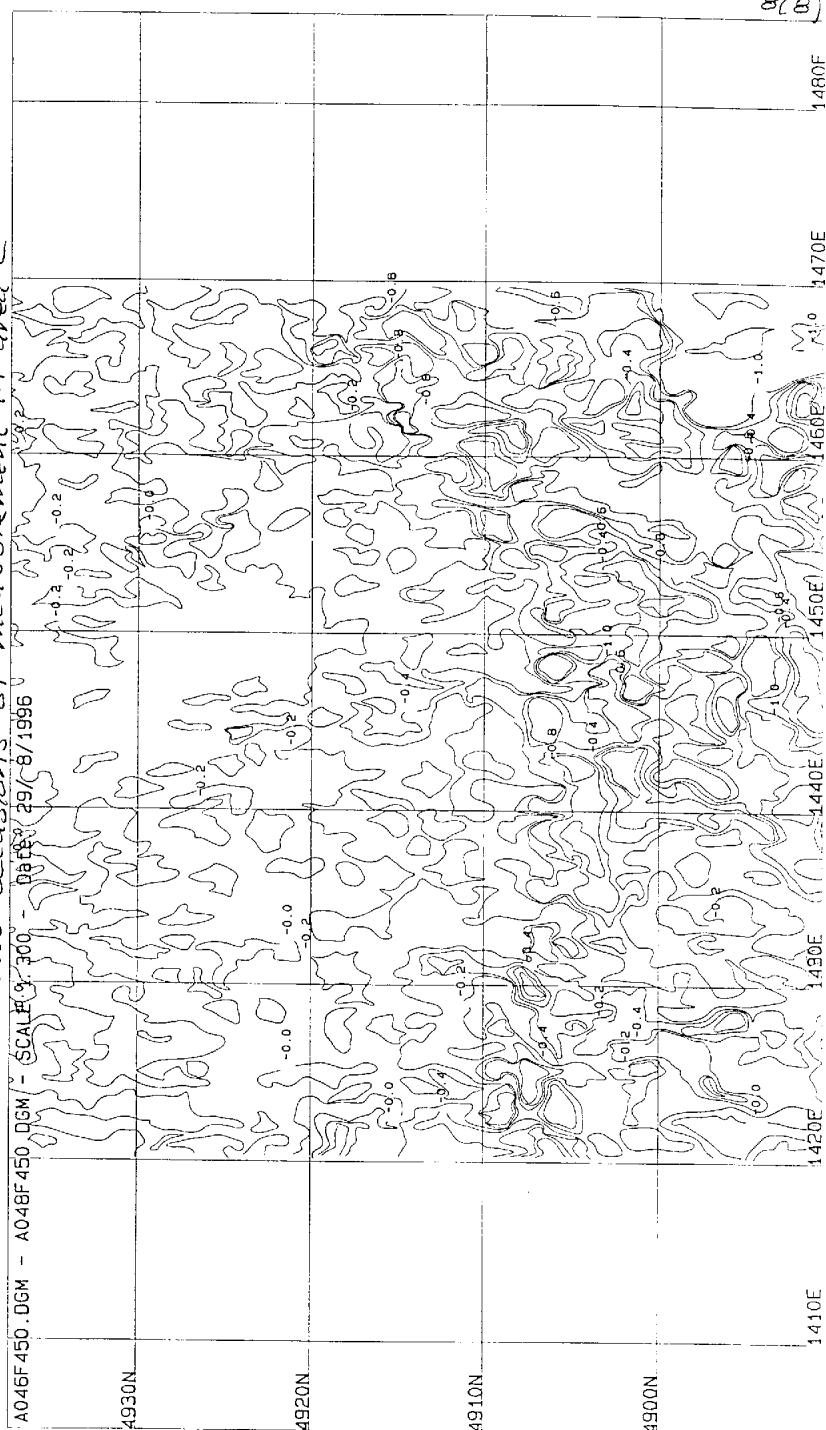
3-dimensional picture of area 2



Map with heights of area 2



Attachment 1
7(a)





ELFORSK

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