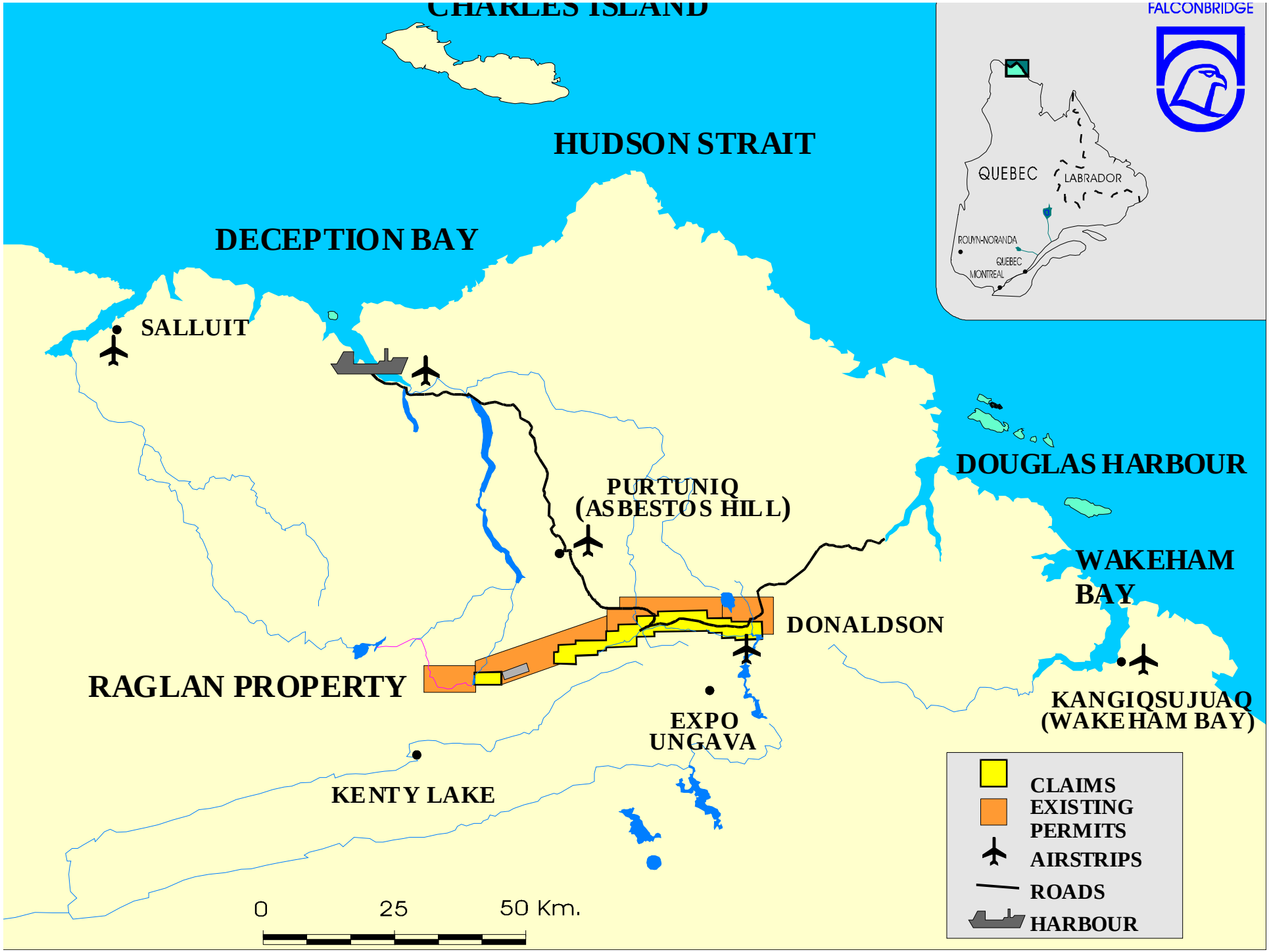
Cover Material Requirements for the ARD Tailings at Raglan

Falconbridge Limited

Denis J. Kemp
Director Environmental Performance
Noranda Inc/Falconbridge Limited


CHARLES ISLAND
HUDSON STRAIT
DECEPTION BAY
SALLUIT
DOUGLAS HARBOUR
PURTUNIQ
(ASBESTOS HILL)
WAKEHAM
BAY
DONALDSON
RAGLAN PROPERTY
EXPO
UNGAVA
KANGIQSUJUAQ
(WAKEHAM BAY)
KENTY LAKE
0
25
50 Km.
FALCONBRIDGE
QUEBEC
LABRADOR
ROUYN-NORANDA
QUEBEC
MONTREAL
CLAIMS
EXISTING
PERMITS
AIRSTRIPS
ROADS
HARBOUR

Fundamental Principles

- Must prevent ARD formation
- Short term costs cannot drive the design
- No ongoing maintenance 5 yrs post closure
- Must allow for progressive reclamation
- Must consider climate change
- Must withstand long term erosion
- Must integrate with surrounding landforms

Brief History of Design Work

many design studies since 1990

conceptual & feasibility studies of options, lab and field experiments, thermal modeling conceptual through detailed designs

Initial selection - filtered tailings disposal

approved on a trial basis for later confirmation or change based on testing

AMEC retained in January 2000

re-evaluate options, thermal modeling, detail design of cover, deposition plan, field/lab experiments

design optimization process continues

base analytical & design work complete, ongoing 'observational' method adopted for material, freezing point depression, global warming

full-scale field experiments for optimization

instrumented test pad since 2001 & final construction of the north-east corner berm/ditch

Brief History of Design Work (cont)

the 2000 studies of options included:

- conventional tailings disposal (30% slurry, dams)
- thickened (55-65%), paste (70-75%) and filtered (85%) tailings
- various tailings disposal sites, including Purtuniq pit (closed asbestos operation)
- freezing or permanent water cover options

and:

accounted for the experience from the demonstration phase (1997-200) and current tailings disposal practice

the review study concluded:

- the deposition of filtered tailings (85%) is a viable option
- the permanent freezing of the tailings stack is feasible
- the disposal-closure design concept results in the lowest risk
- this concept presents the best option given conditions at Raglan

Design Criteria

disposal: filtered tailings, water returned to process

no tailings/water retention dams, no return water, transport by truck, stack shaped by dozer and compactor

surface water: seasonal collection & treatment

system of ditches/berms, collection pond and pumping facility

chemical stability at closure: no O_2 diffusion

compaction and maintain tailings stack permanently frozen, tolerate a 1:100 year warm year event to prevent ARD

physical stability at closure: rockfill cover

mimic local landforms and ground cover, erosion resistance (frost & rain)

Design Criteria (cont)

reclamation: progressive & compatible with operation

including stack form and runoff management

construction method and equipment

simple construction techniques, equipment operability

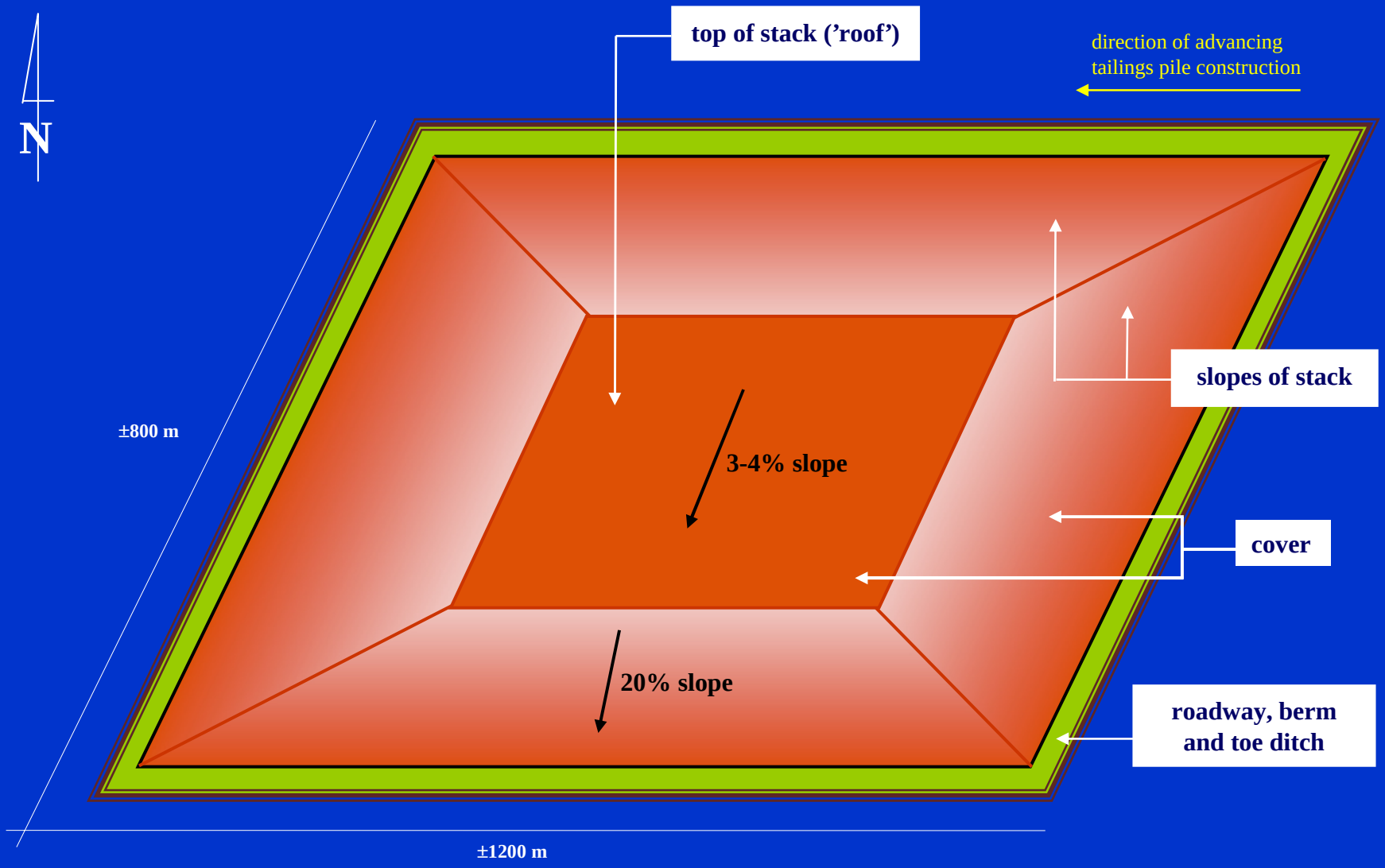
maintenance free for the long term – only monitoring

after design performance is confirmed

closure designs subject to ongoing optimization

allow for adjustments (thermal regime, materials, construction techniques)

Configuration of Stack - closure




1997


1998

Special Design Considerations

the operation-closure concept is unprecedented;

an observational approach is highly advantageous

the use of construction materials must be optimized;

crushed esker, rockfill, other materials, asbestos tailings

global warming must be accounted for in designs;

must be flexible to account for the state of knowledge at the time of mine closure

freezing point depression must be designed for;

FPD needs be investigated and appropriate input data adjusted, as required

Global Warming

Nixon Geotech (Dr. Derrick Nixon) retained in 2000

studied both 'local' and 'global' picture

- 5 out of 7 stations at Ungava Peninsula indicated climate cooling (M. Allard)
- global warming mean annual *most probable* estimate: +2.5°C (AES, 1990-2100)
- global warming mean annual extreme estimate: +4.5°C (AES, 1990-2100)

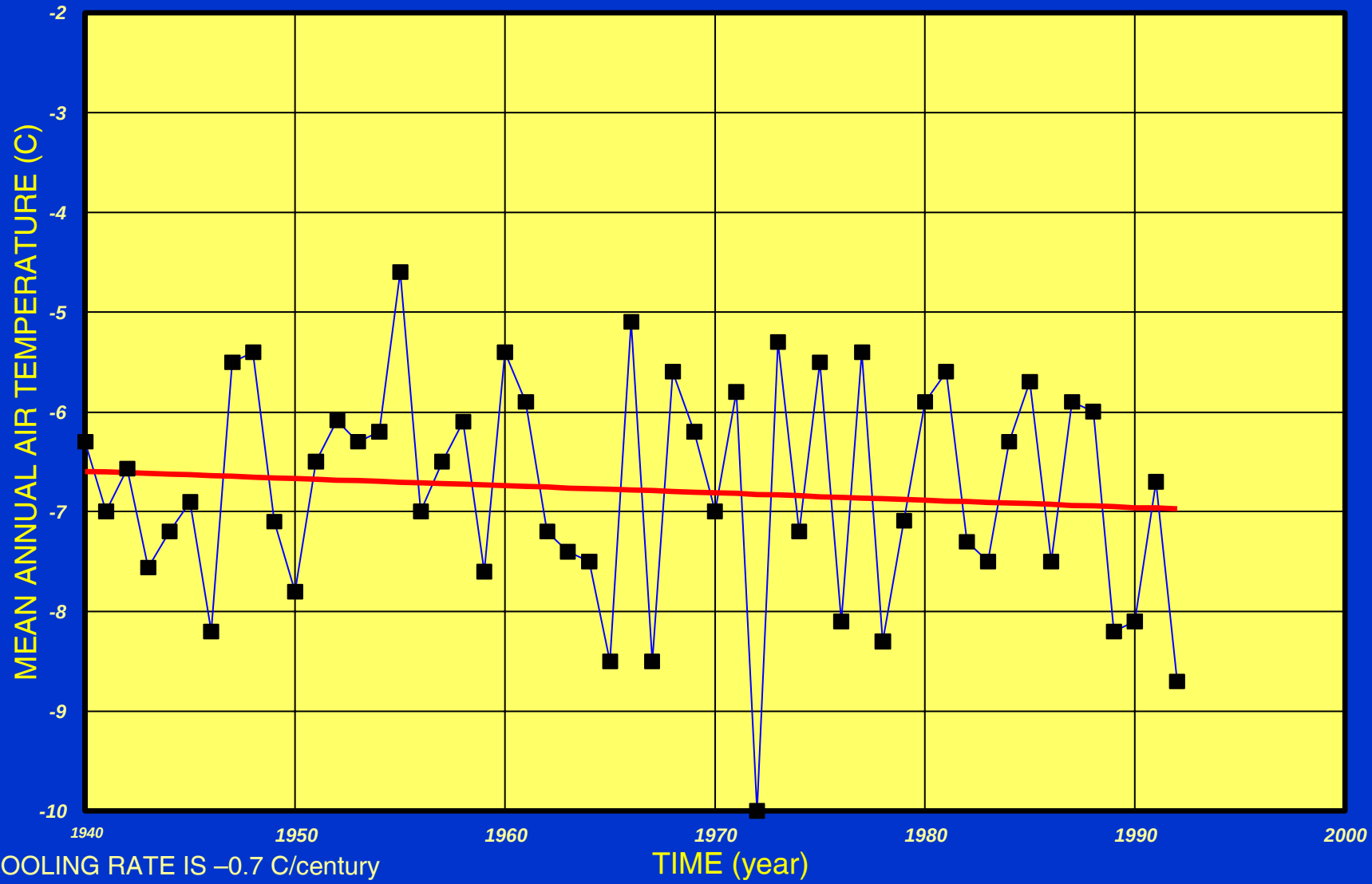
reclamation cover design (2001)

- accounting for global warming (most probable est.) ➔ 0.5 m additional rockfill

re-evaluation in 2002

- confirmed a more recent *warming* trend at Ungava Peninsula if 1993-2001 data added to the long-term database (M. Allard)

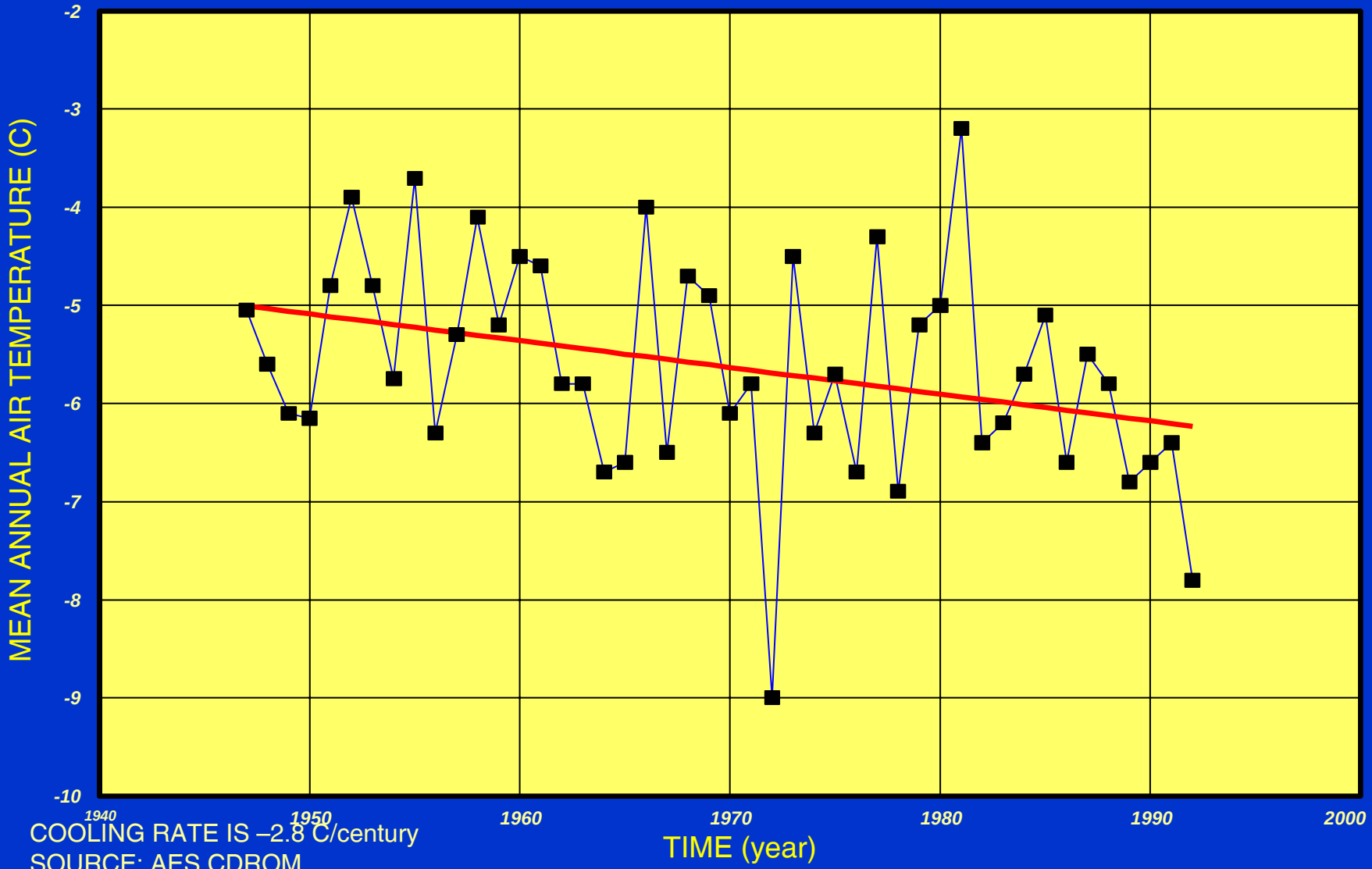
Global Warming



COOLING RATE IS –0.7 C/century
SOURCE: AES CDROM
[After D. Nixon (2000)]

LONG TERM MEAN AIR TEMPERATURES FOR INUKJUAK

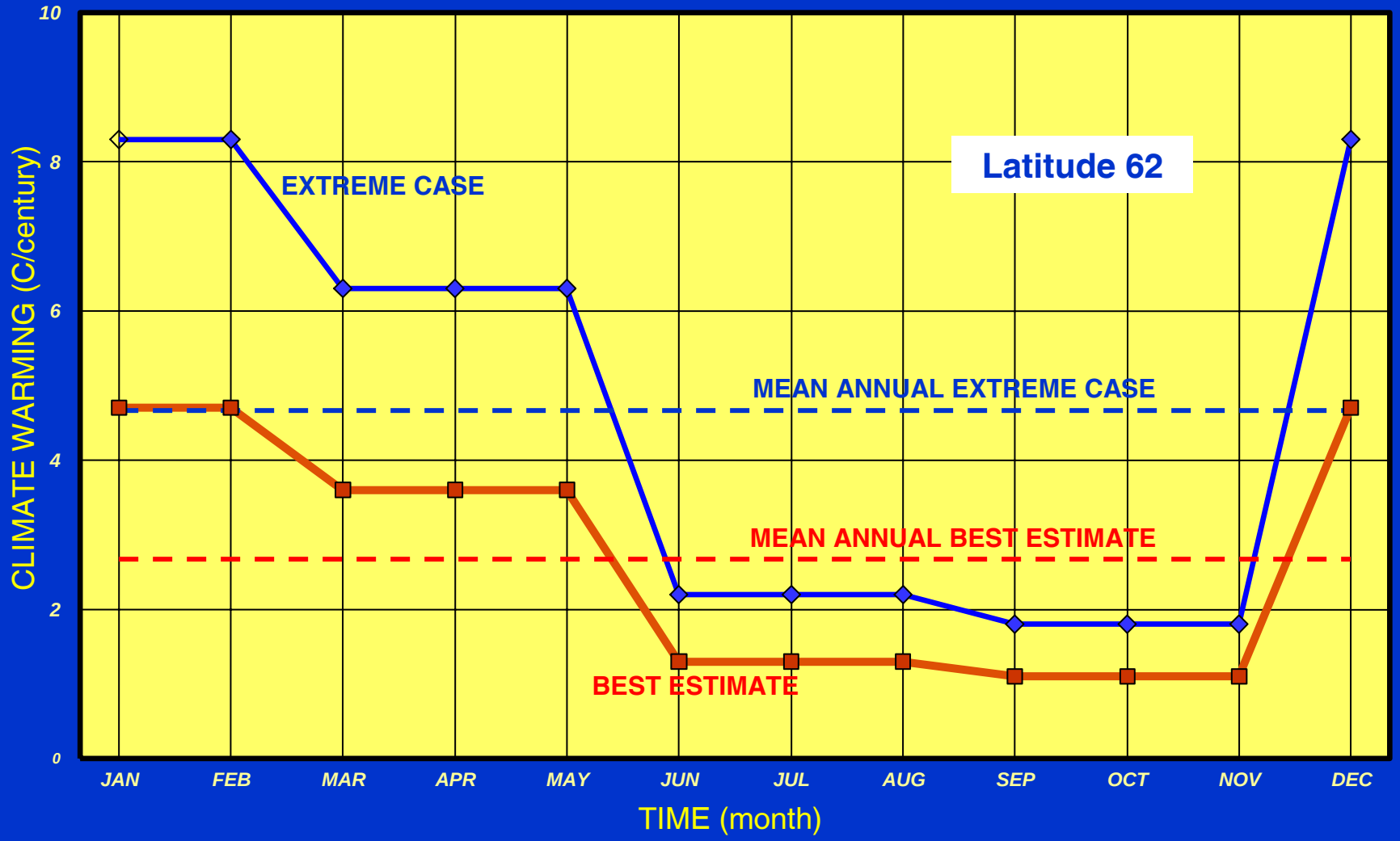
Global Warming



COOLING RATE IS –2.8 C/century
SOURCE: AES CDROM
[After D. Nixon (2000)]

LONG TERM MEAN AIR TEMPERATURES FOR KUUJJUAK

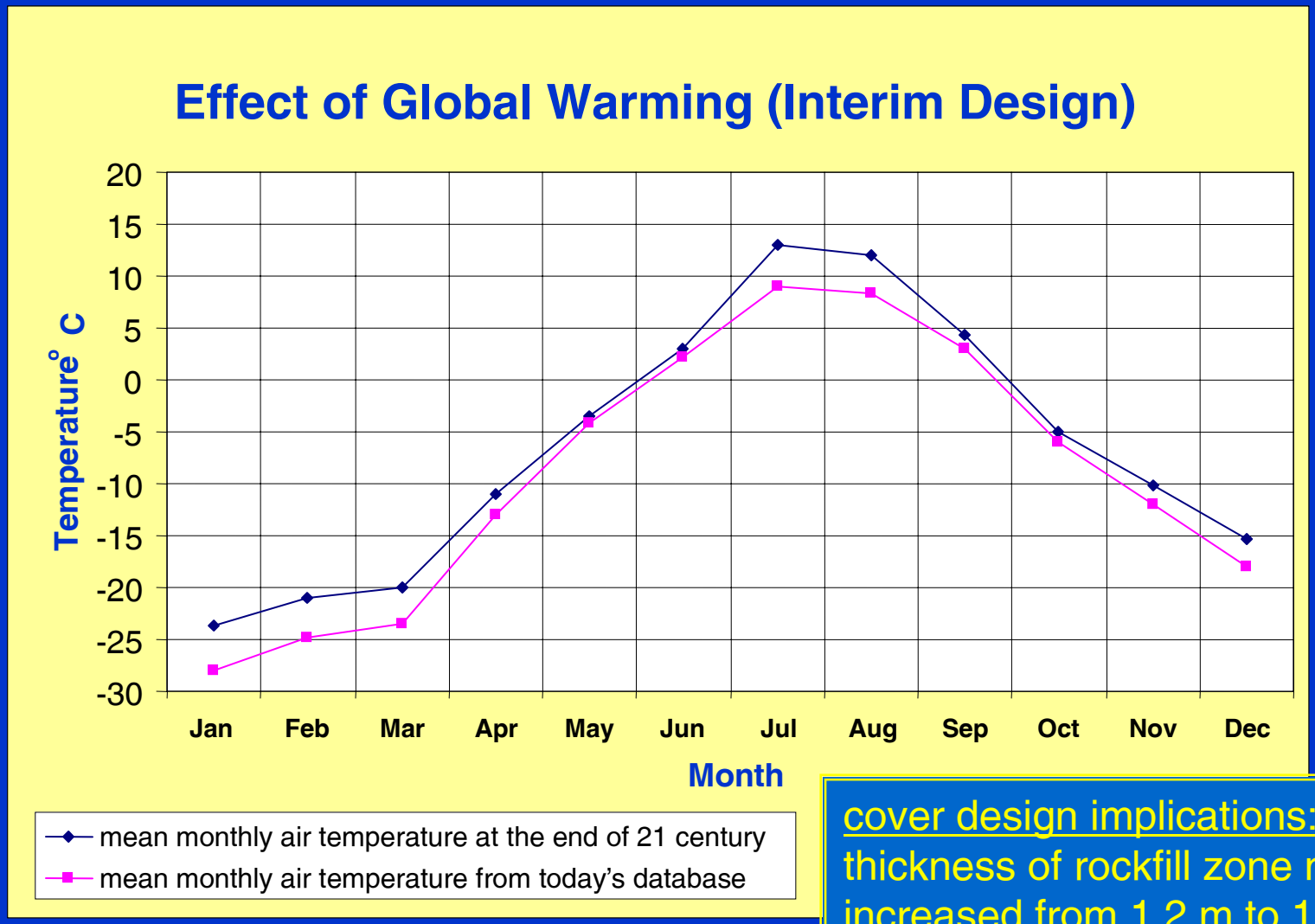
Global Warming



SOURCE: AES (1998)
[After D. Nixon (2000)]

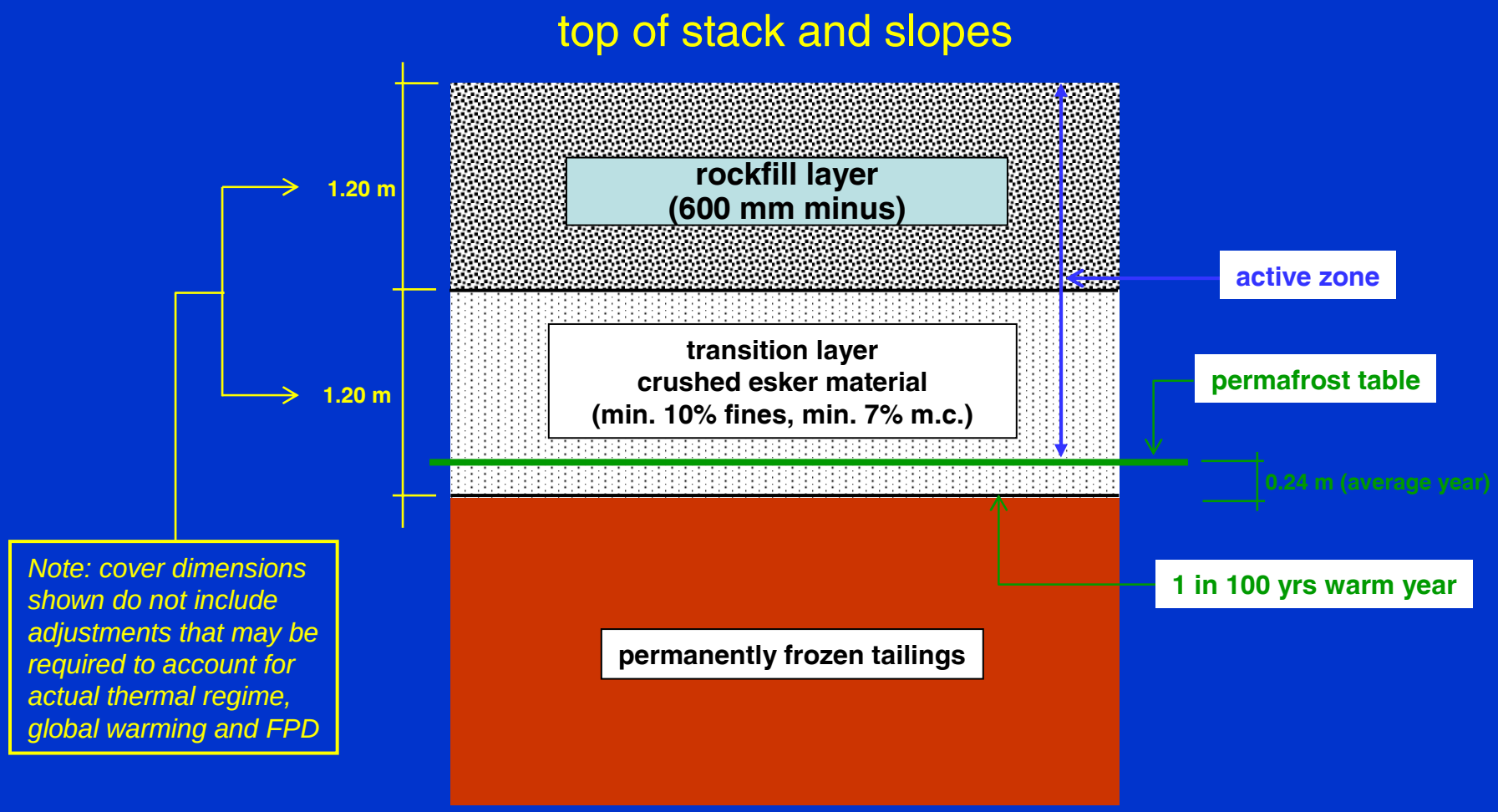
GLOBAL WARMING EFFECT ON AIR TEMPERATURES

Global Warming

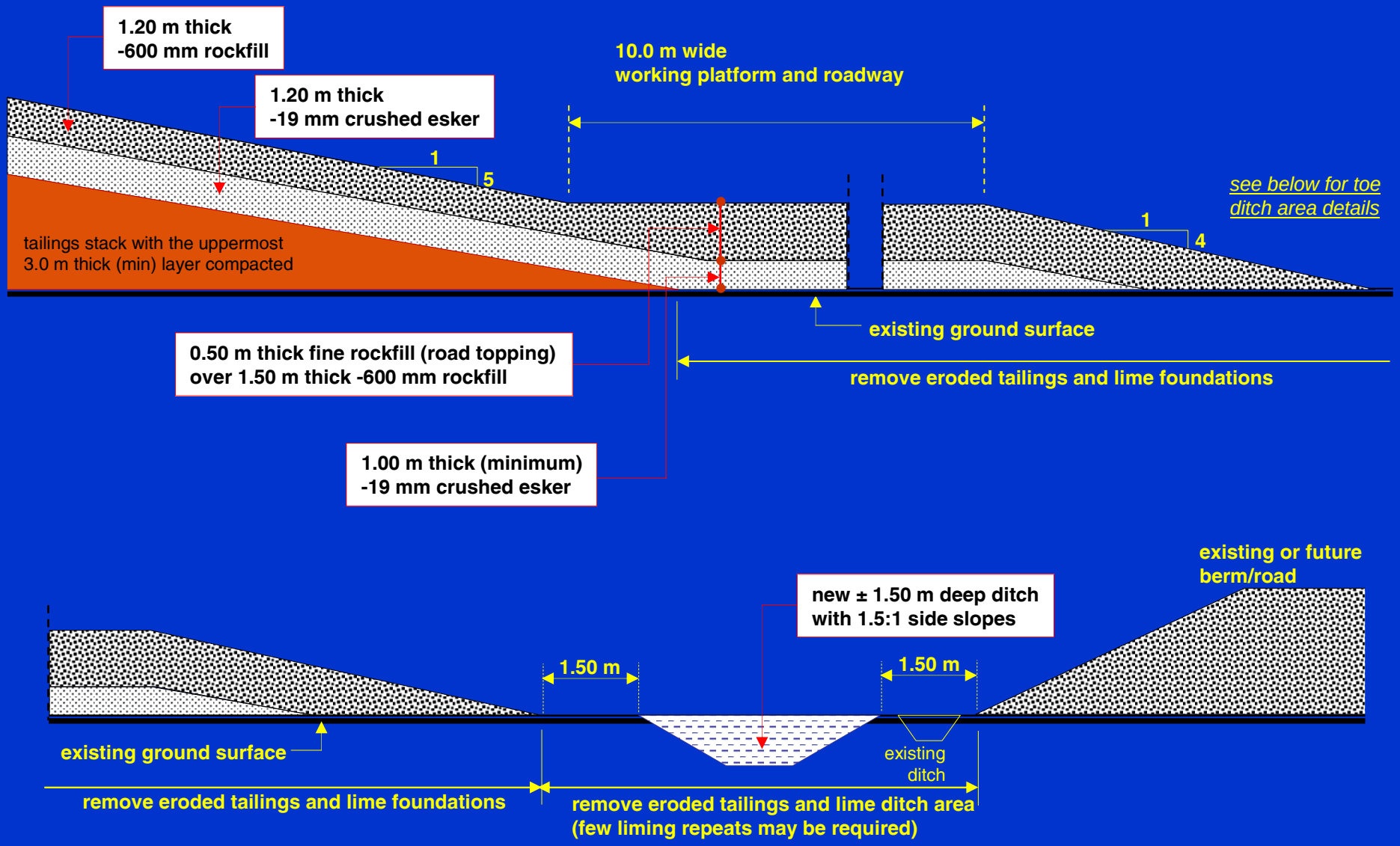


cover design implications:
thickness of rockfill zone must be increased from 1.2 m to 1.7 m

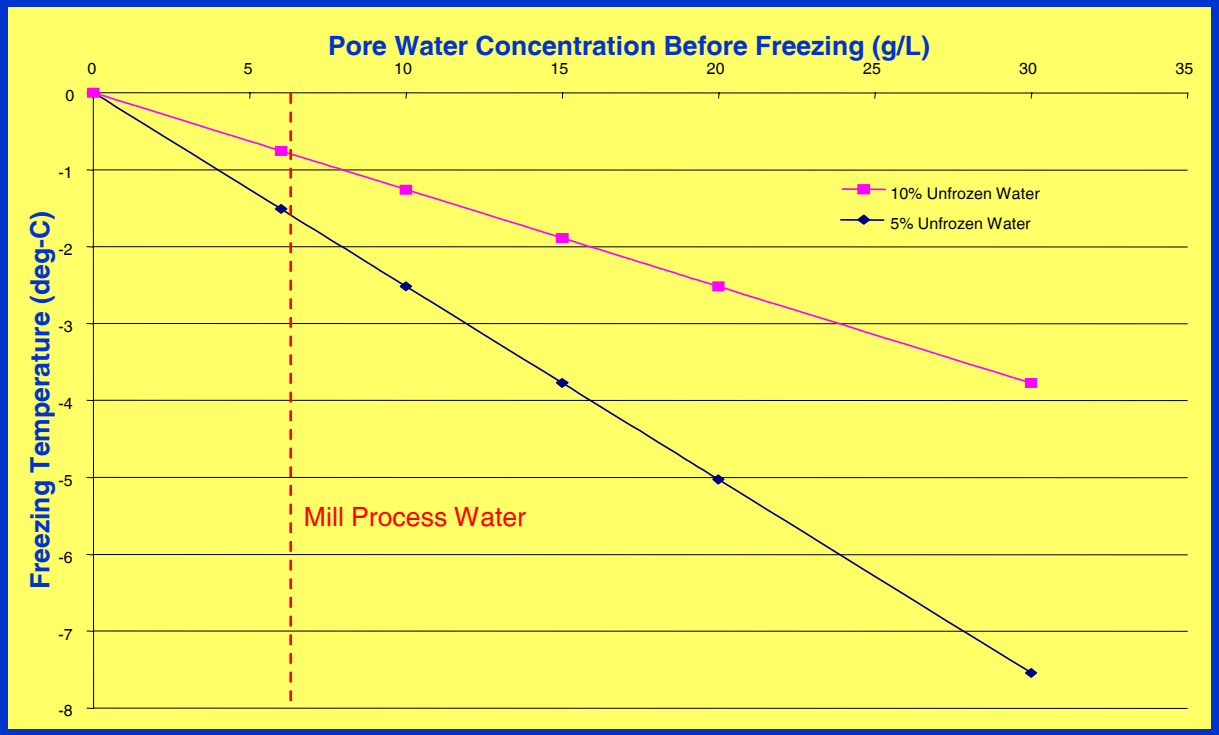
Closure Design - cover



Toe of Stack - details



Freezing Point Depression



- evaluations conducted by R. Nicholson (Stantec)

- modeling has been done assuming FPD at –0.5°C

- further analyses & testing will be on-going

Freezing Point Depression

Case	Crushed Esker Thickness (m)	Rockfill Thickness (m)	Total Cover Thickness (m)	Maximum Thaw (m)					
				average year			1:100 warm year		
				isotherm (°C)					
				0	-0.5	-1.0	0	-0.5	-1.0
S-1	0.3	1.0	1.3	1.59	1.65	1.84	1.82	1.93	2.10
S-2	0.6	1.0	1.6	1.60	1.79	1.96	1.92	2.01	2.18
S-3	0.9	1.0	1,9	1.79	1.95	2.13	2.02	2.13	2.30
S-4	0.9	1.5	2.4	2.05	2.20	2.46	2.25	2.39	2.62
S-5	**1.2**	**1.0**	**2.2**	1.90	**2.05**	2.30	2.10	**2.29**	2.46
S-6	1.5	1.0	2.5	1.95	2.17	2.40	2.25	2.40	2.65
S-7	**1.2**	**1.5**	**2.7**	2.10	**2.32**	2.55	2.35	**2.55**	2.80
S-8	1.5	1.5	3.0	2.15	2.40	2.65	2.50	2.70	2.91

- the base result of thermal analyses:

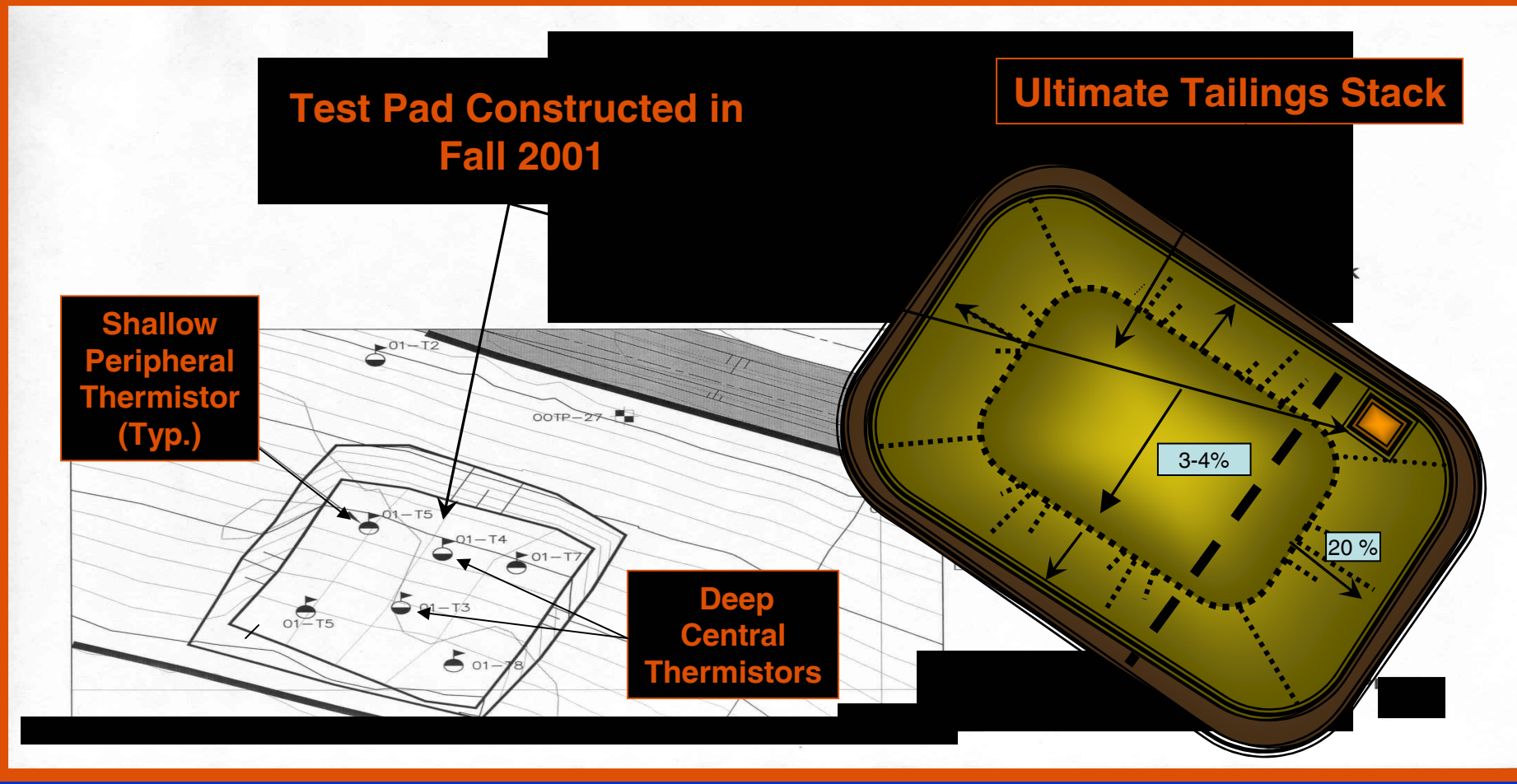
  1.2 m esker + 1.2 m rockfill (+0.5 m rockfill)

- further ‘refinement’ analyses will be on-going

TEST PAD AND INSTRUMENTATION

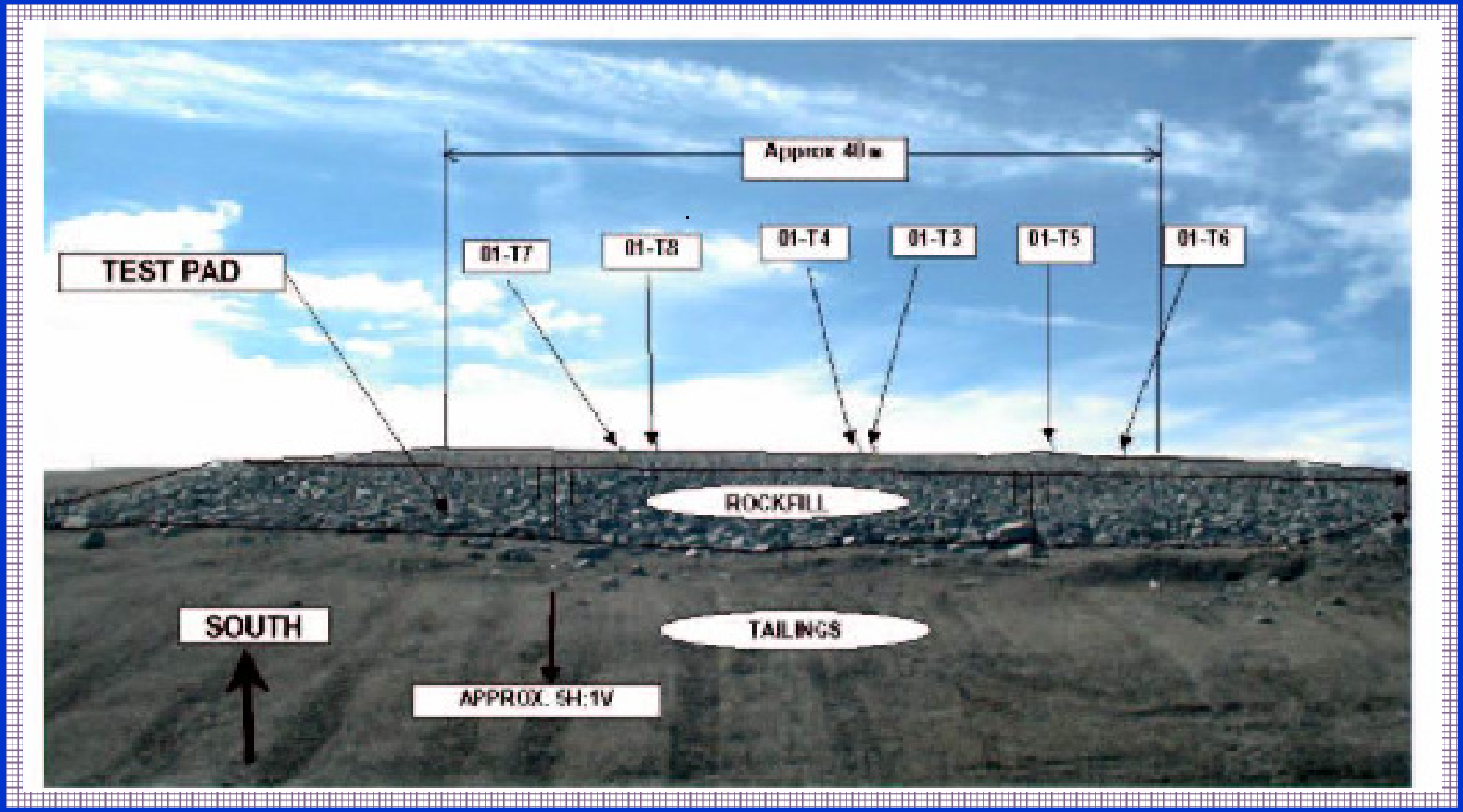
Thermal analyses models are subject to inherent uncertainties.

Confirmation by field monitoring is required.

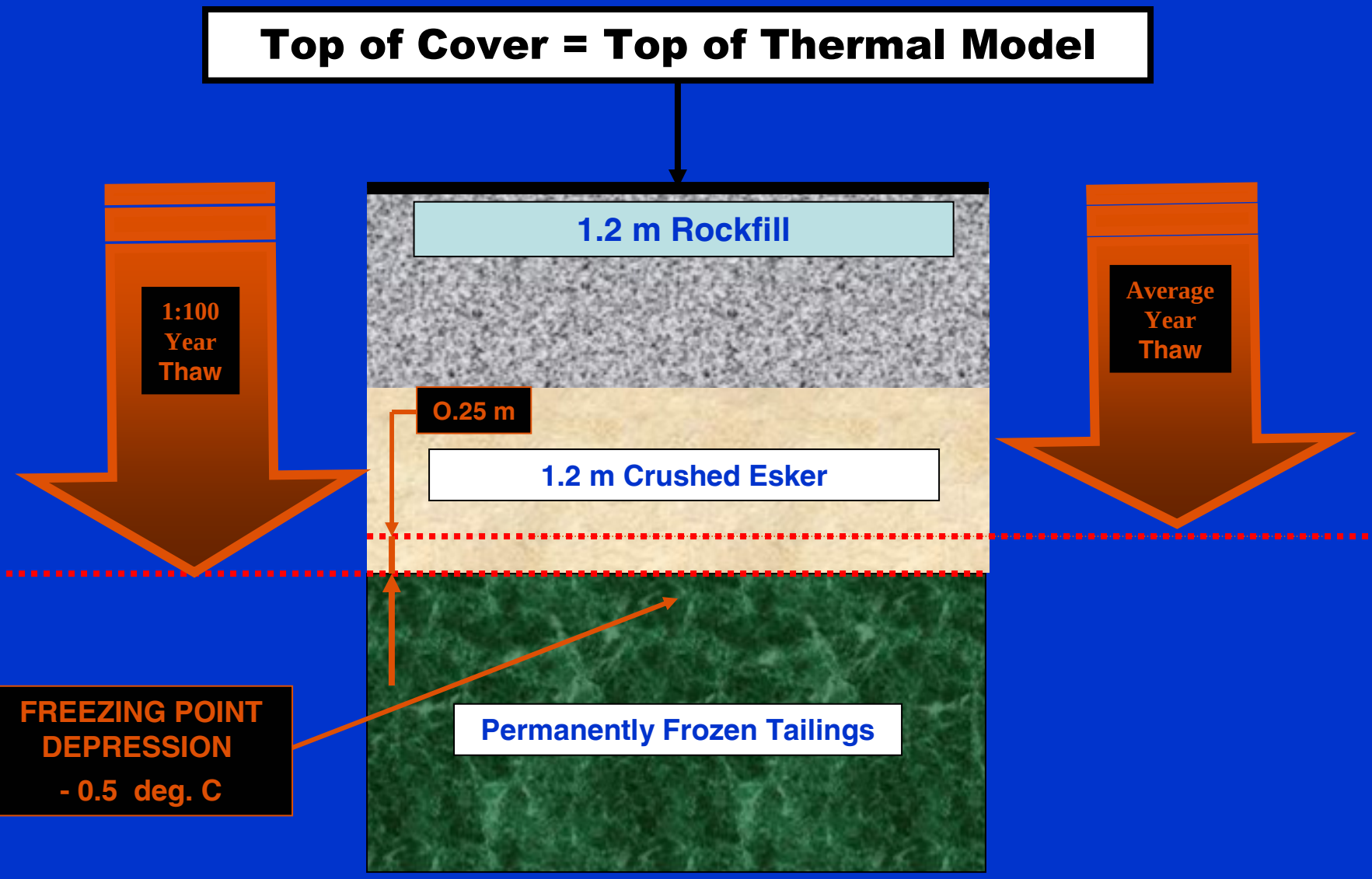


SOUTH VIEW OF TEST PAD

Raglan has monitored ground / air temperatures since the end of November 2001.

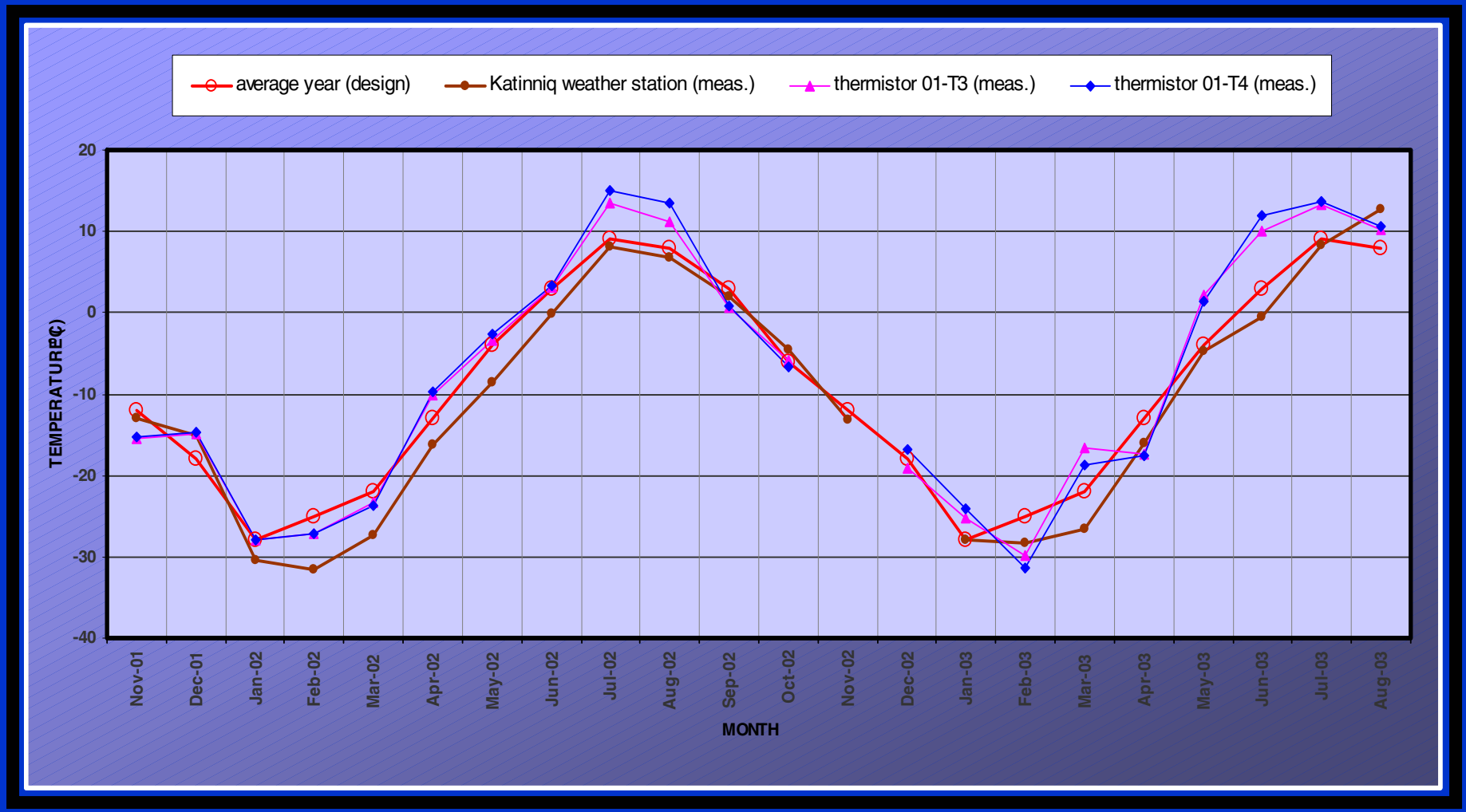


COVER CONFIGURATION AT TEST PAD BASED ON EXTENSIVE THERMAL MODELING

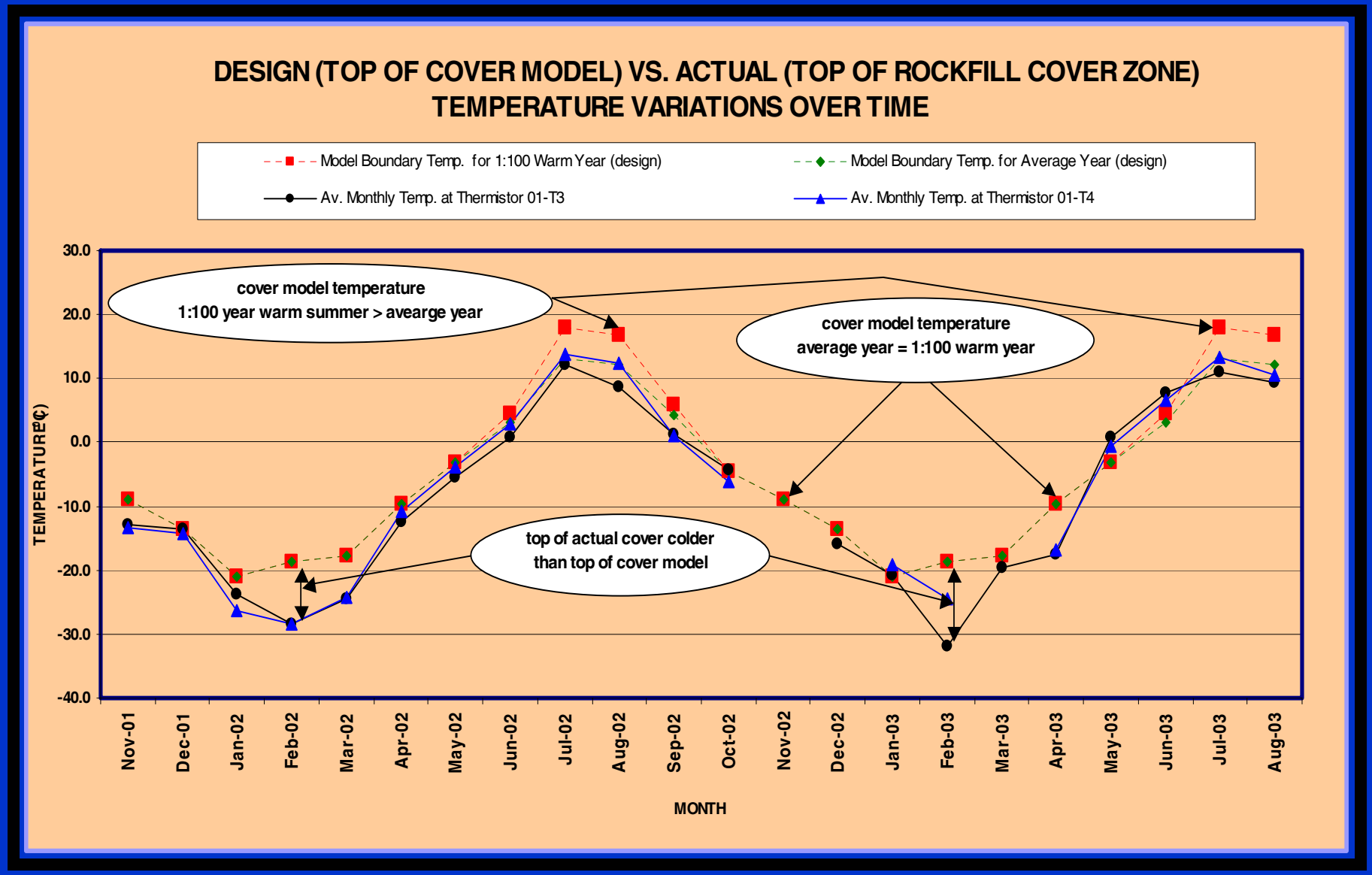


AVERAGE MONTHLY AIR TEMPERATURES NOVEMBER 2001 – AUGUST 2003

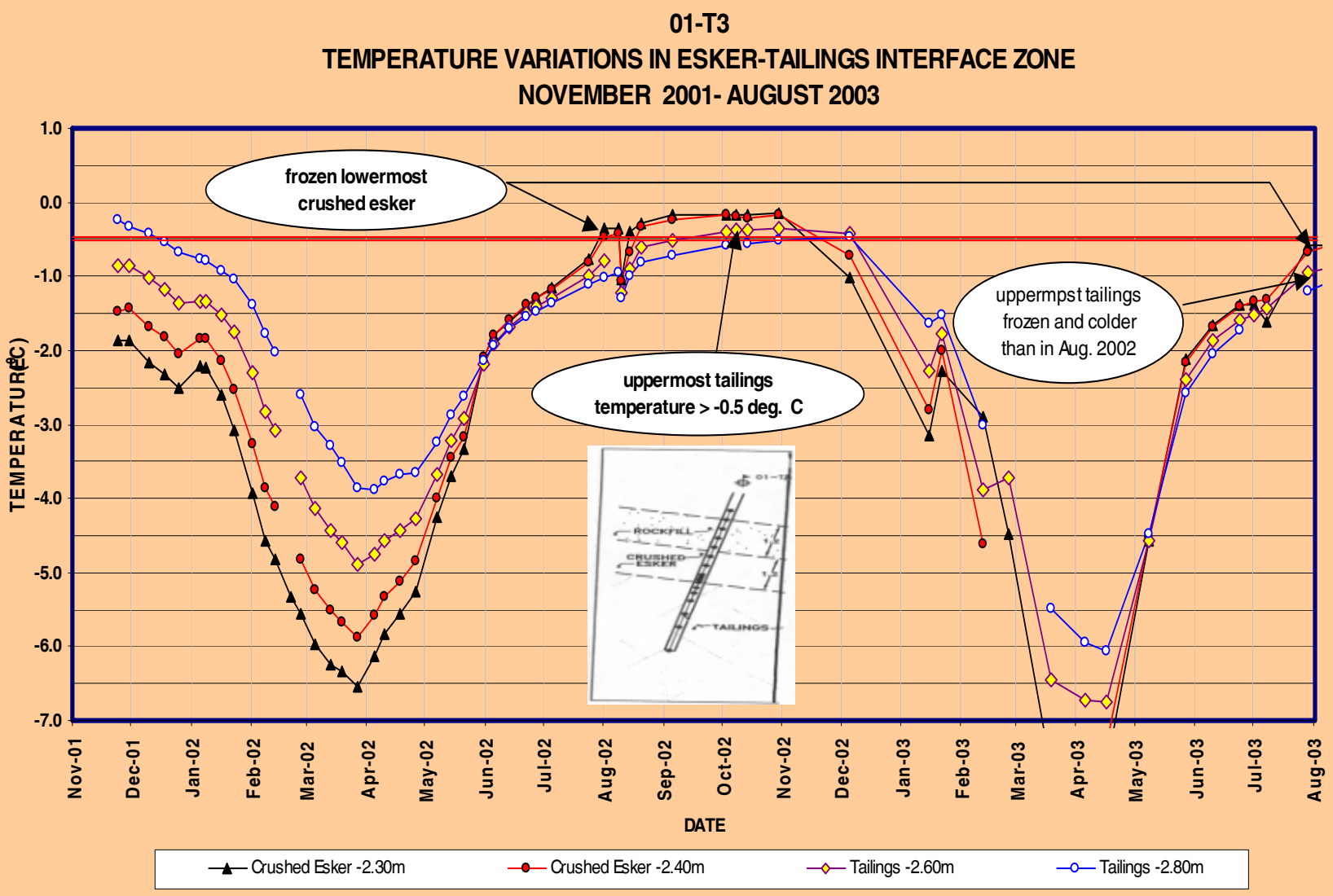
It is reasonable to assume that the 2001 –2003 period was not far from typical (‘average)’ year



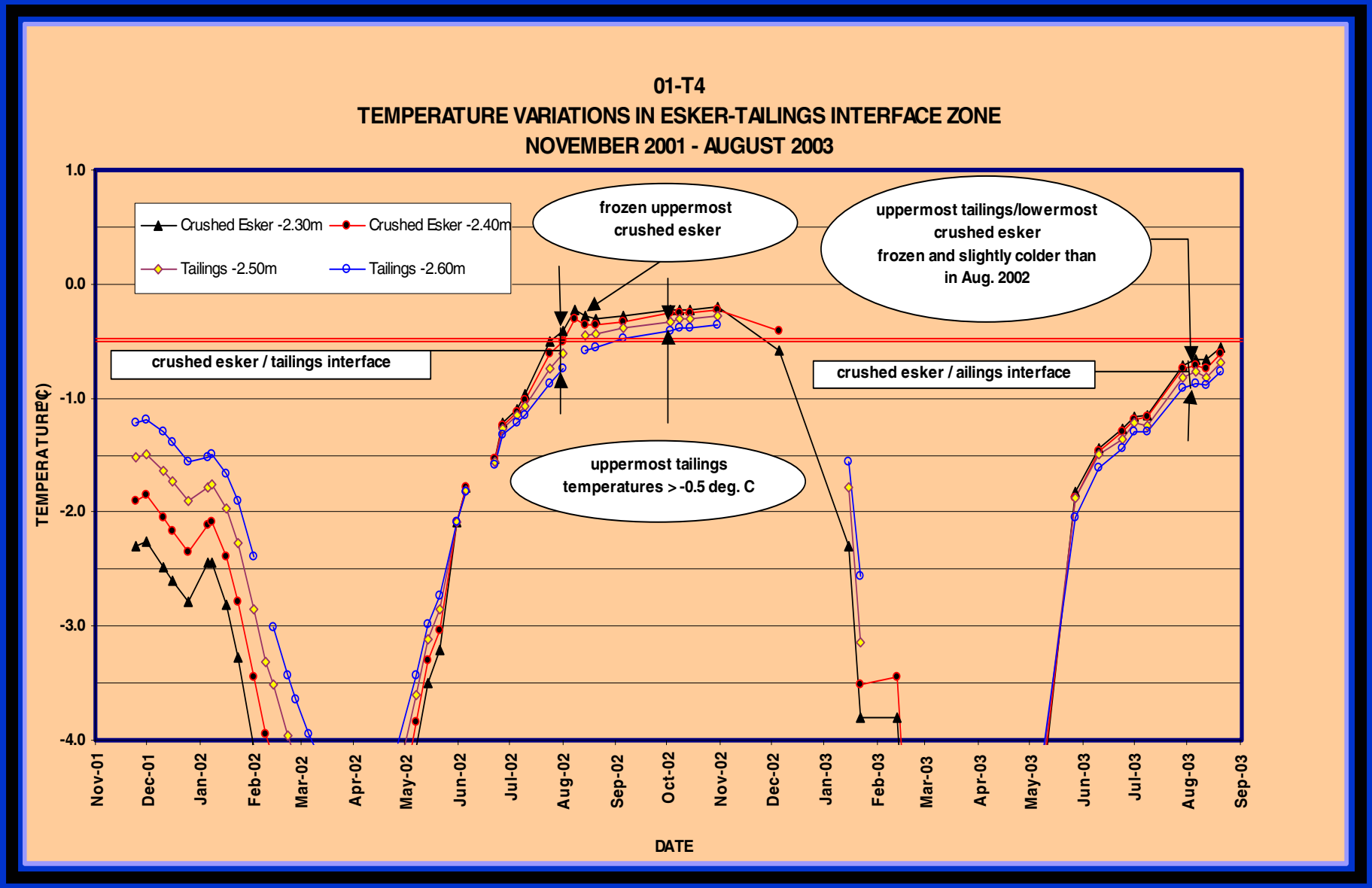
COVER DESIGN FIELD VERIFICATION



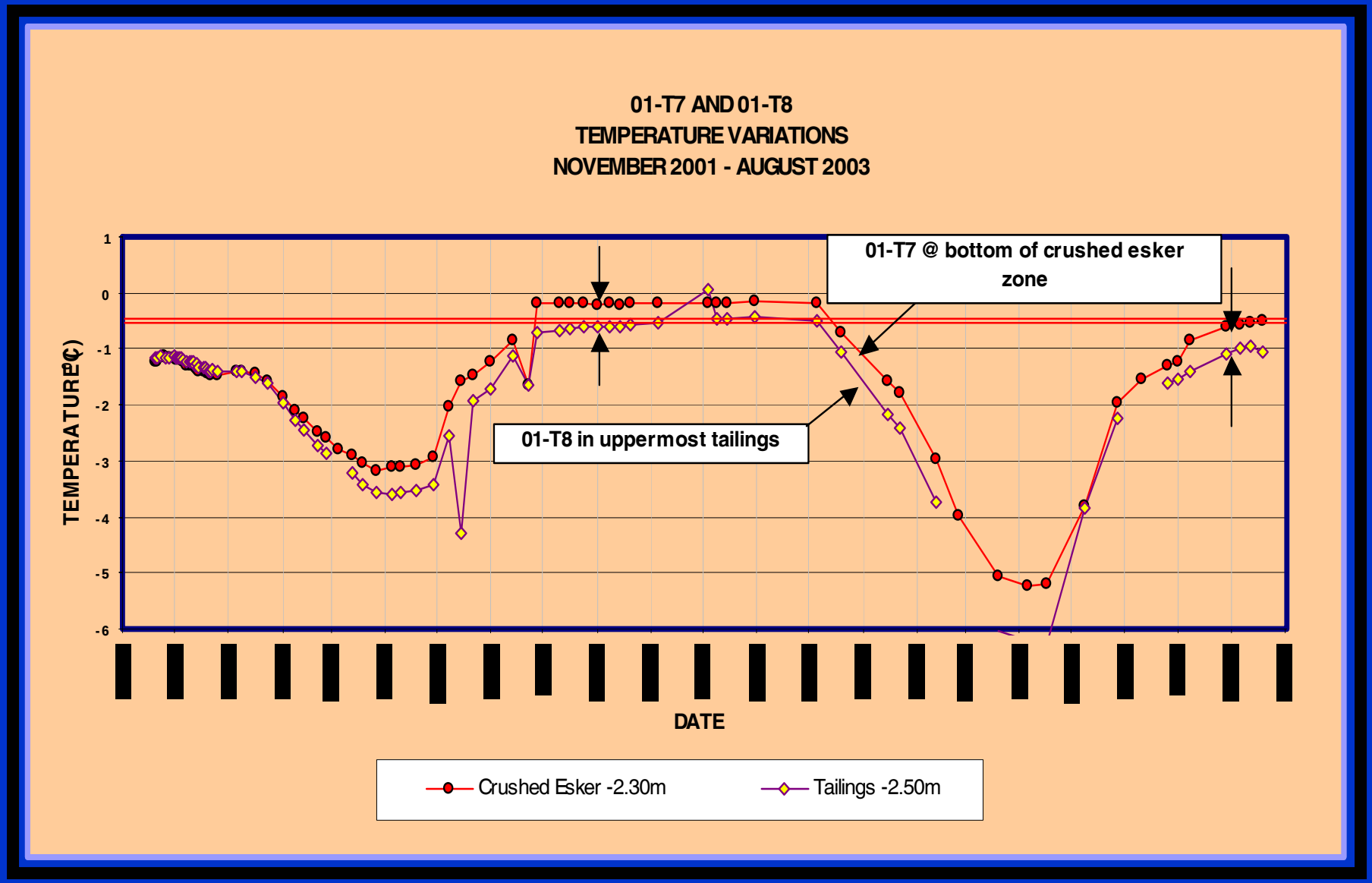
COVER DESIGN FIELD VERIFICATION (CONT)



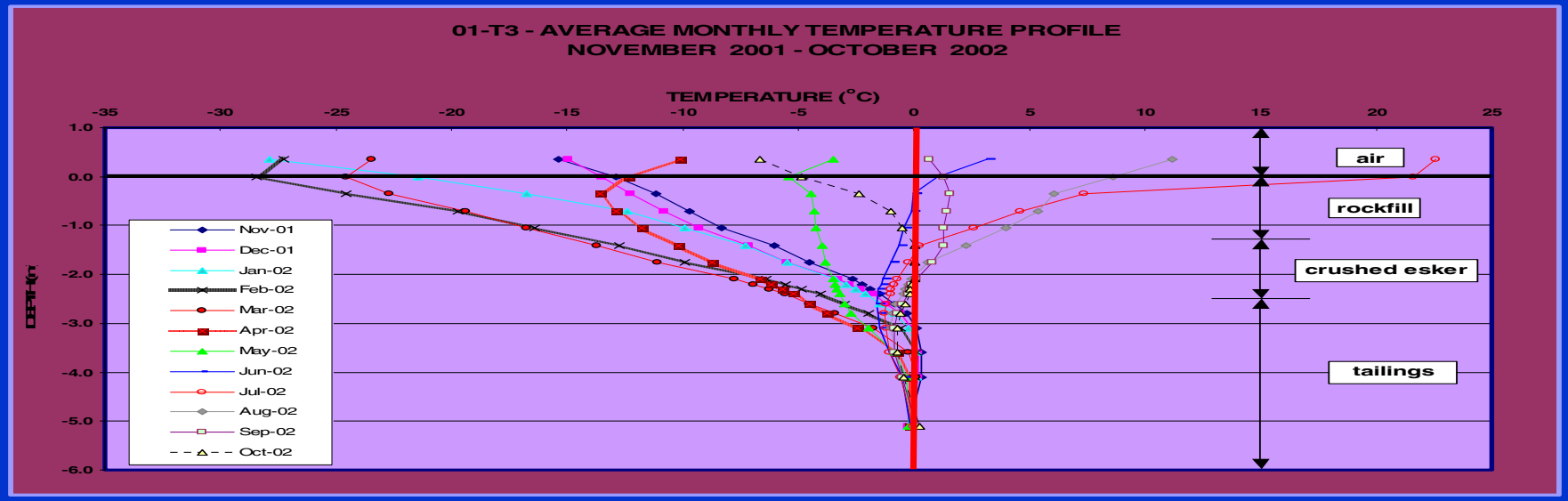
COVER DESIGN FIELD VERIFICATION (CONT)

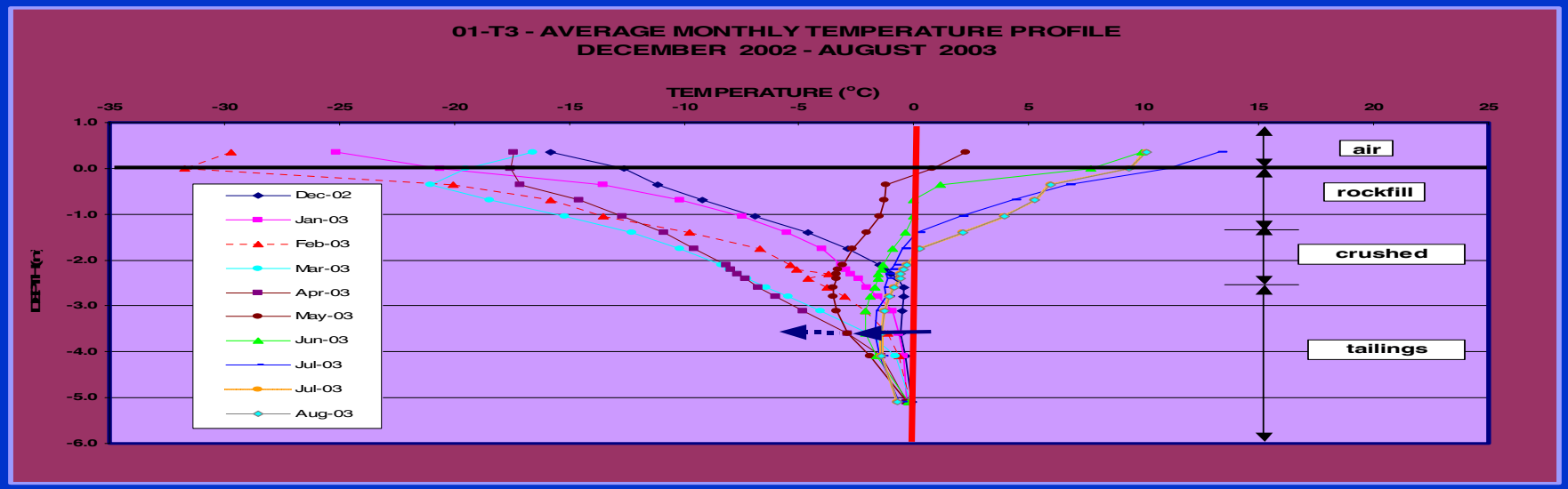


COVER DESIGN FIELD VERIFICATION (CONT)

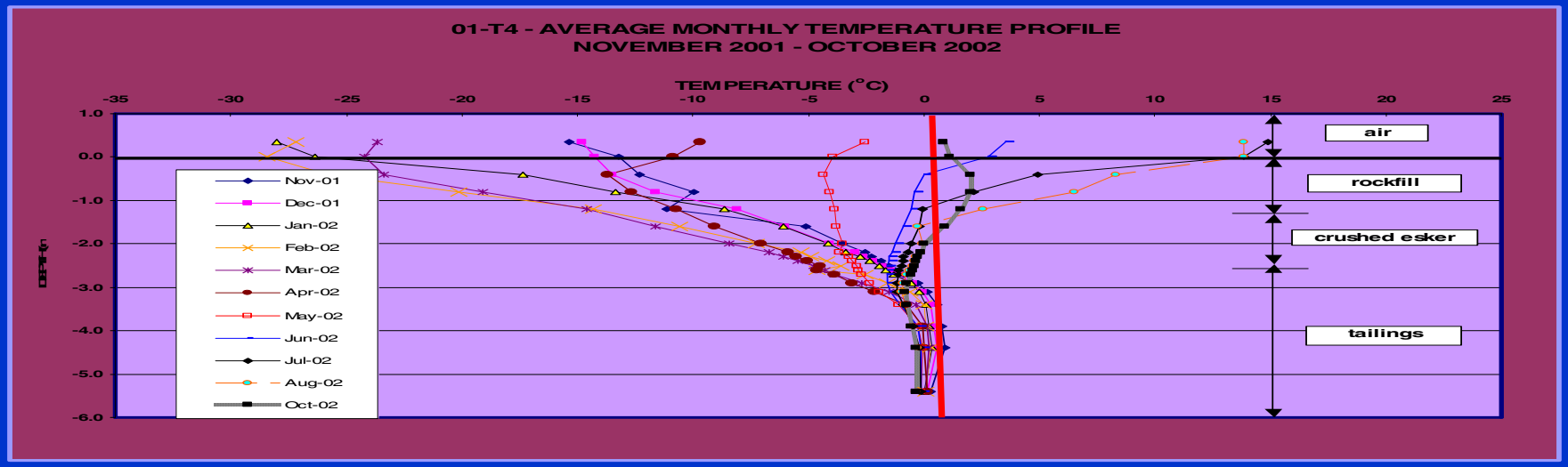


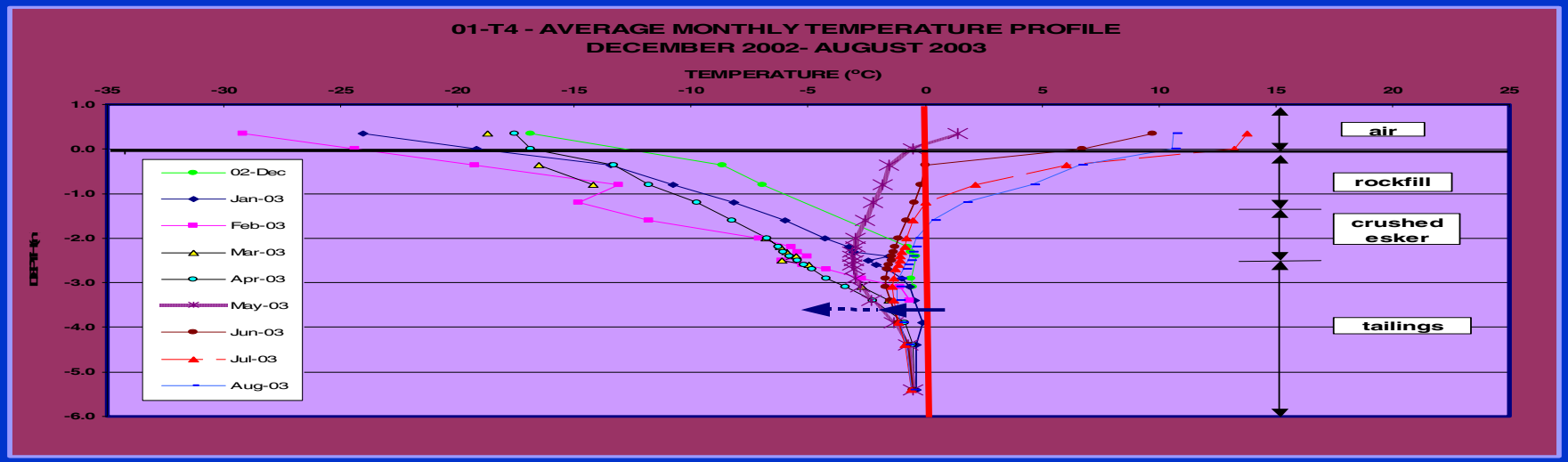
COVER DESIGN FIELD VERIFICATION (CONT)





COVER DESIGN FIELD VERIFICATION (CONT)






2003

Conclusions

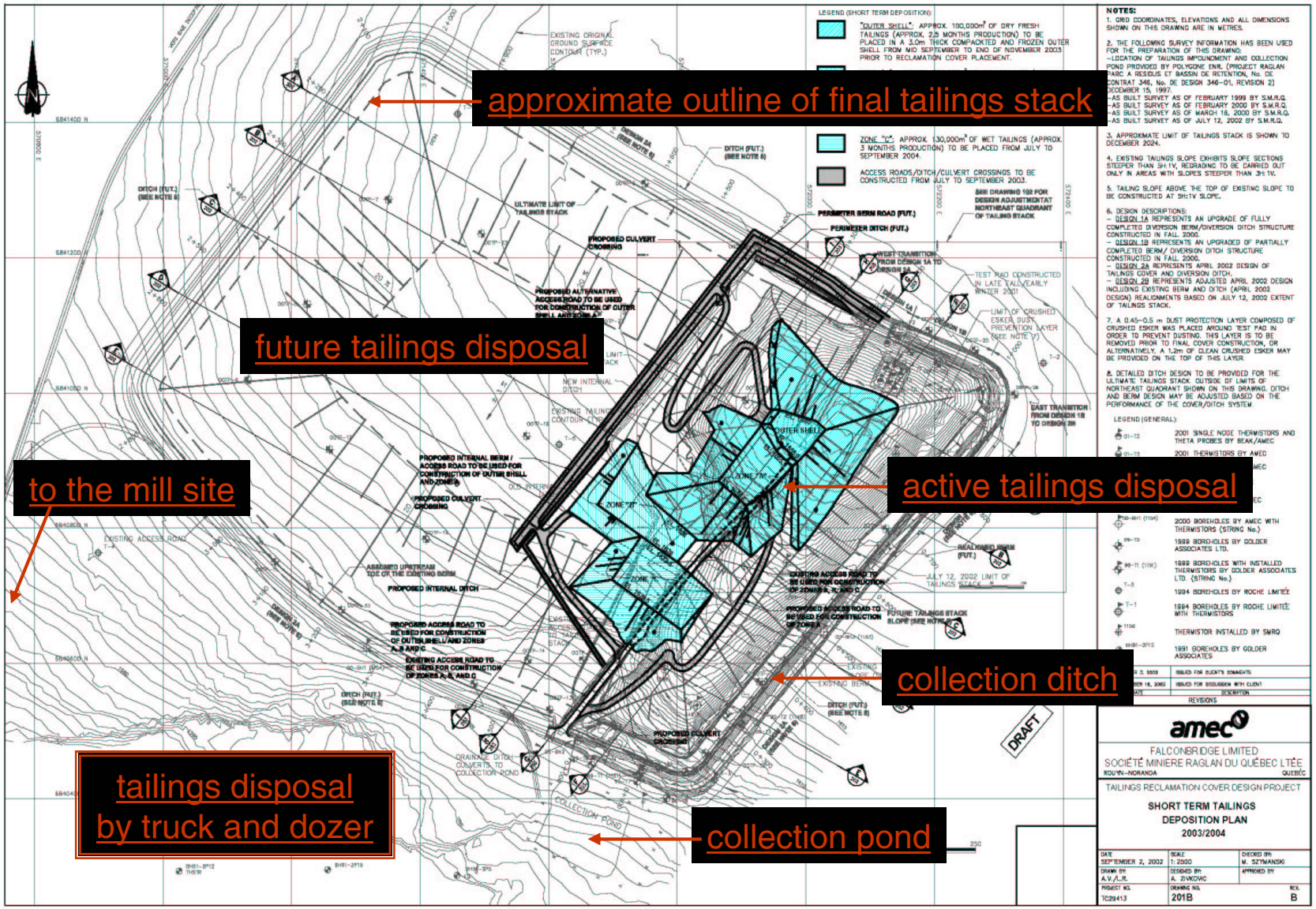
- **Active zone was contained within the cover (>0.2 m of frozen esker in 2002-2002 and > 0.3 m in 2002 –2003).**
- **Freezing of deeper tailings zone has advanced.**
- **Based on the modelling, reaching steady-state thermal regime will take some 50 years.**
- **Early winter test pad construction over freshly placed tailings with frozen crust is feasible.**
- **For the current purposes, there seems to be no reason indicating that an adjustment to the cover design would be necessary.**

Summary

Conclusions from studies:

- disposal of filtered tailings is effective and compatible with site closure concept and runoff management
- permanent freezing of the tailings is feasible and a superior sustainable closure option for the Raglan tailings site, with lower risk
- there are no major limitations on the size/height of the stack
- construction of the cover using local materials is feasible
- progressive reclamation can be practiced
- construction of the cover is simple and robust
- cover design includes allowance for future adjustments
  [FDP, global warming, cover materials, other parameters]
- to-date monitoring data confirms the design assumptions

Tailings Stack Plan (2003-2004)




THANK YOU
QUESTIONS?