Accurate prediction of radiation exposures of workers involved in the transport of NORM

Nick Tsurikov, Australia

CALYTRIX
CONSULTING PTY LTD

Transport of NORM study

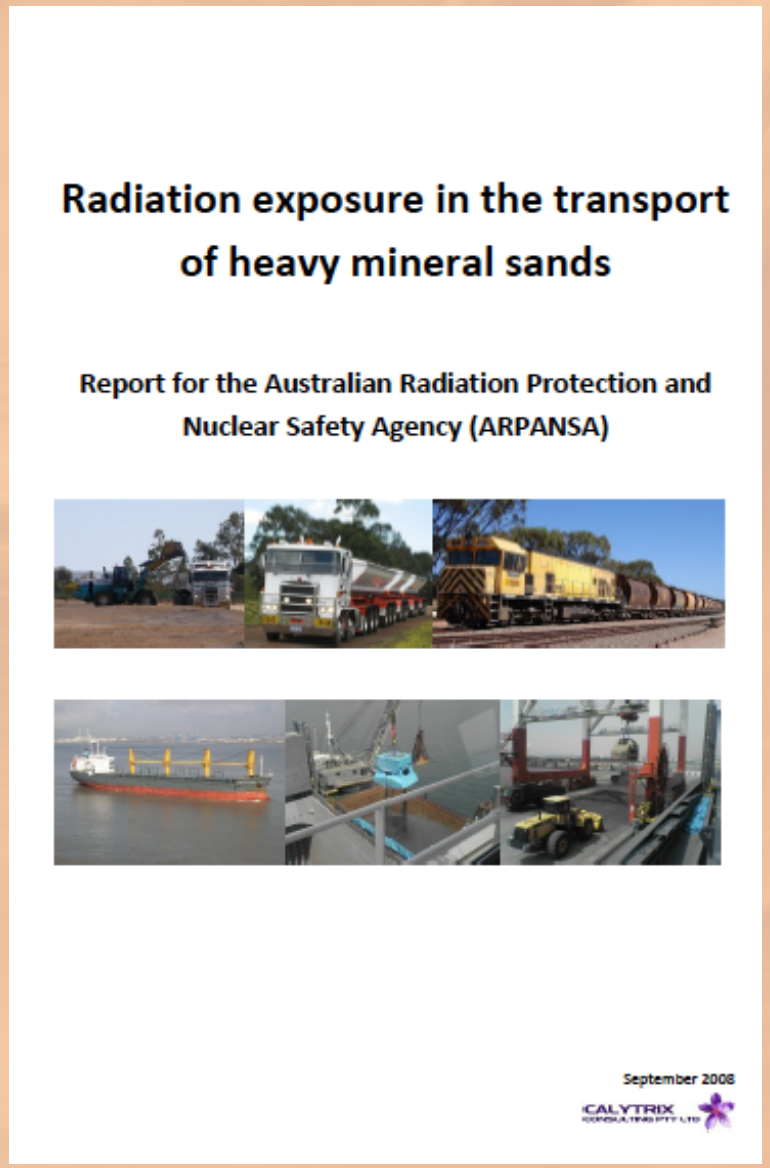
The main subject of the study was thorium and uranium containing minerals and mineral concentrates (such as ilmenite, rutile, zircon, monazite and other minerals) and the study was carried out in three stages:

The first stage involved measurements in Australia and was jointly sponsored by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), mineral sands industry and Calytrix Consulting;

The second stage was focused on obtaining more data from Australian and International transport routes and was jointly sponsored by the mineral sands industry and Calytrix Consulting;

During the last stages additional monitoring was undertaken addressing materials shipped from Australia in bulk and in containers to overseas ports and was done solely by Calytrix Consulting.

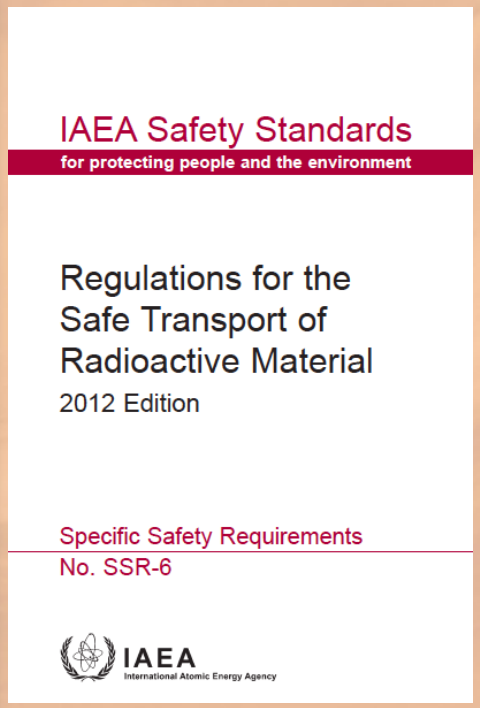
Previous version of the report (2008)



- All data belongs to ARPANSA
- A dependency was established between concentrations of radionuclides and the levels of radiation exposure of workers

- Additional investigations were recommended to monitor and assess modes of transport and exposure pathways not previously checked
- Carried out in 2009 – 2012

Scope of the study



107. The Regulations do not apply to:

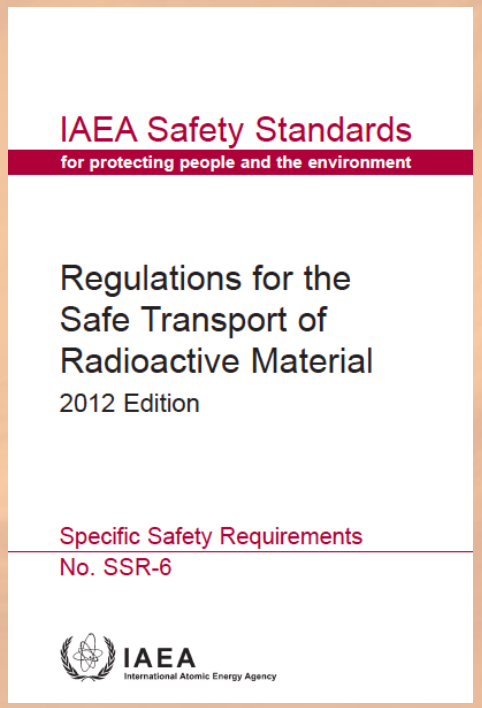
...

(e) Natural material and ores containing naturally occurring radionuclides, which may have been processed, provided the activity concentration of the material does not exceed 10 times the values specified in Table 2, or calculated in accordance with paras 403(a) and 404–407.

Typical activity concentrations in the materials in this study

Material	Th (Bq/g)	U (Bq/g)	Sum (Bq/g)
Heavy minerals concentrate (HMC)	1.6	0.6	2.2
Intermediate products and tailings returned to the mine	5.1	1.7	6.8
Zircon	0.9	3.0	3.9
Ilmenite and synthetic rutile	1.2	0.2	1.4
Monazite concentrate (radioactive)	84 – 94	9 – 14	~100

Scope of the study – an important consideration



What is very often forgotten:

106. Transport comprises all operations and conditions associated with, and involved in, the movement of radioactive material; these include the design, manufacture, maintenance and repair of packaging, and the ***preparation, consigning, loading****, carriage including* ***in-transit storage, unloading and receipt at the final destination*** *of loads of radioactive material and packages.*

What was studied and assessed

- Transport of primary concentrate to a secondary concentrator, two road routes;
- Transport of heavy minerals concentrate (HMC) from mine sites to the separation plants, five road routes (including three with return of the tailings to a mine site), one rail route, one marine route; transport of tailings from the plant back to the mine site – one road route;
- Transport of final products from a separation plant to a wharf, three road routes; assessments of radiation exposures for wharf workers were also carried out;
- Transport of final products to a customer overseas, six marine routes.

Gamma-radiation: portable monitors, electronic dosimeters and TLD badges,

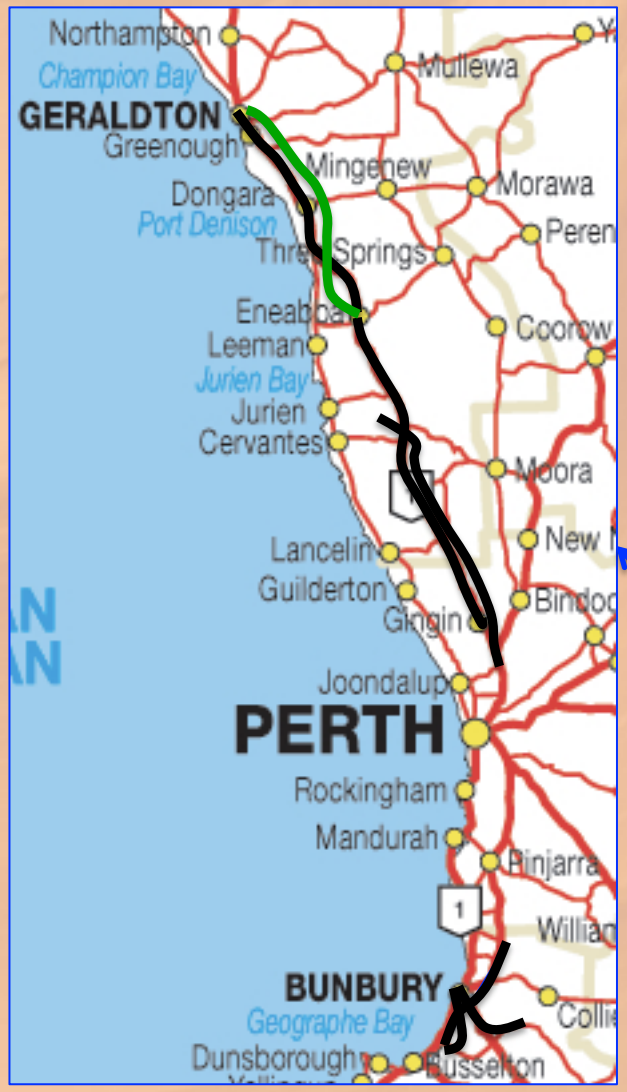
Airborne dust: using personal and area dust samplers,

Radon (^{222}Rn) and thoron (^{220}Rn): portable electronic radon/thoron monitor,

Occupational time factors were recorded for the purpose of dose assessments.

Comparison of distances in Australia

Studies in Western Australia



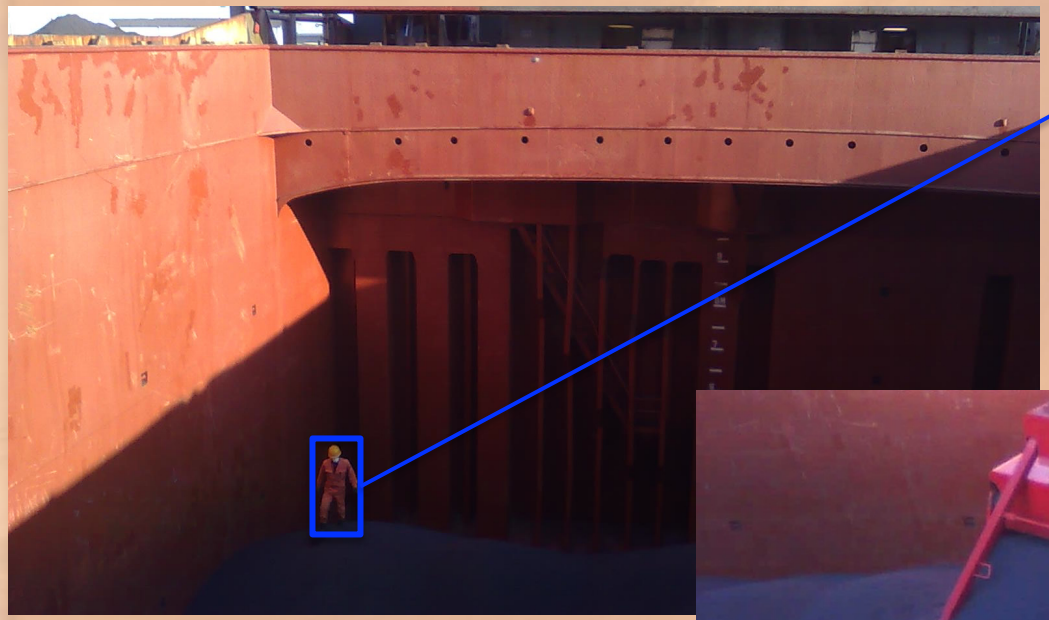
Studies in Australia

Marine transport studies

Monitoring – ship in the port

Monitoring – TLD badges

Monitoring – unloading process



Monitoring – unloading process

Mineral loss in the process of bulk shipments

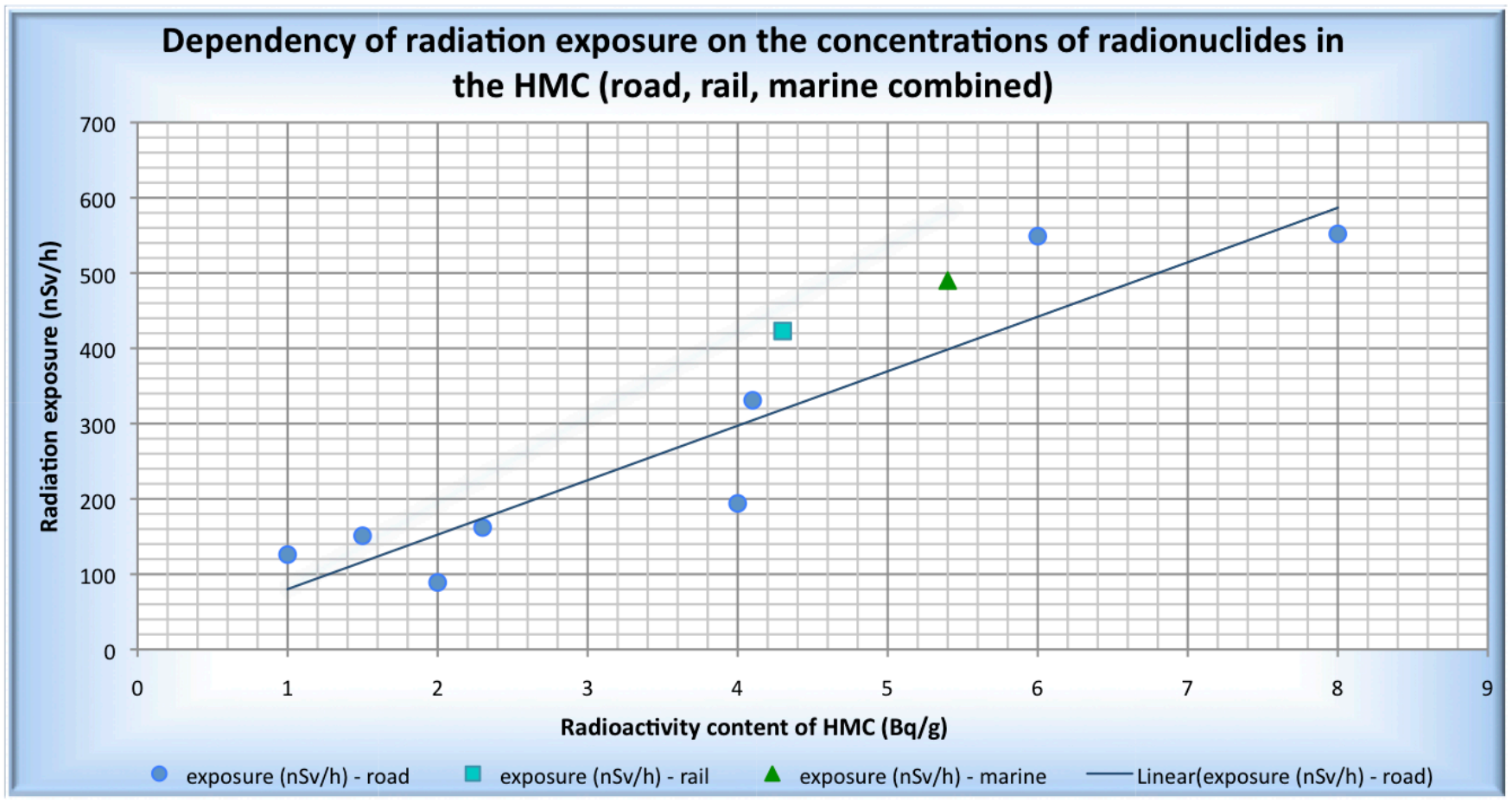
Mineral loss in the process of bulk shipments

Truck monitoring system

Additional complication – high background levels in some ports

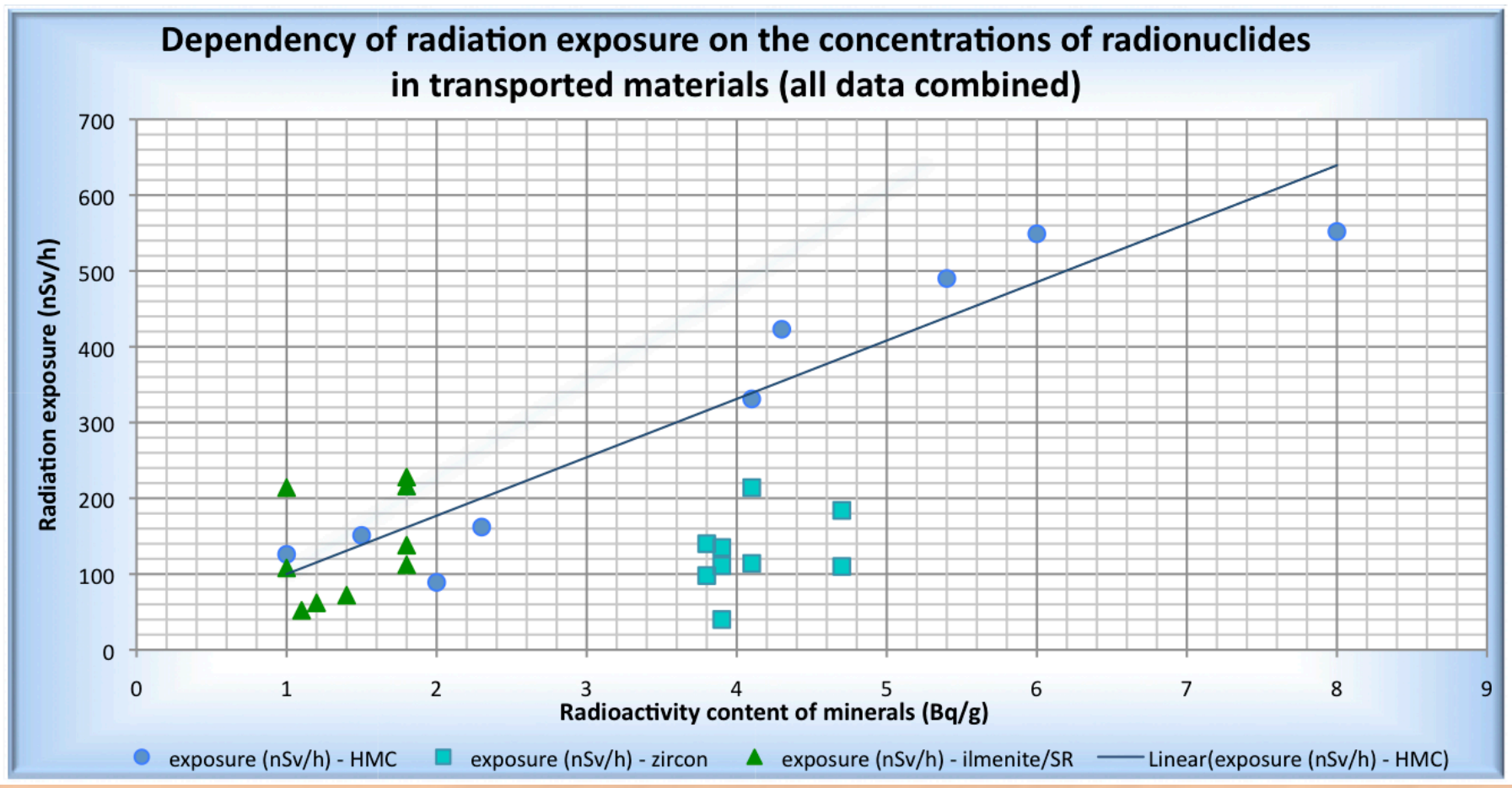
Findings

Heavy Mineral Concentrate (HMC) transport: data for road, rail and marine transport



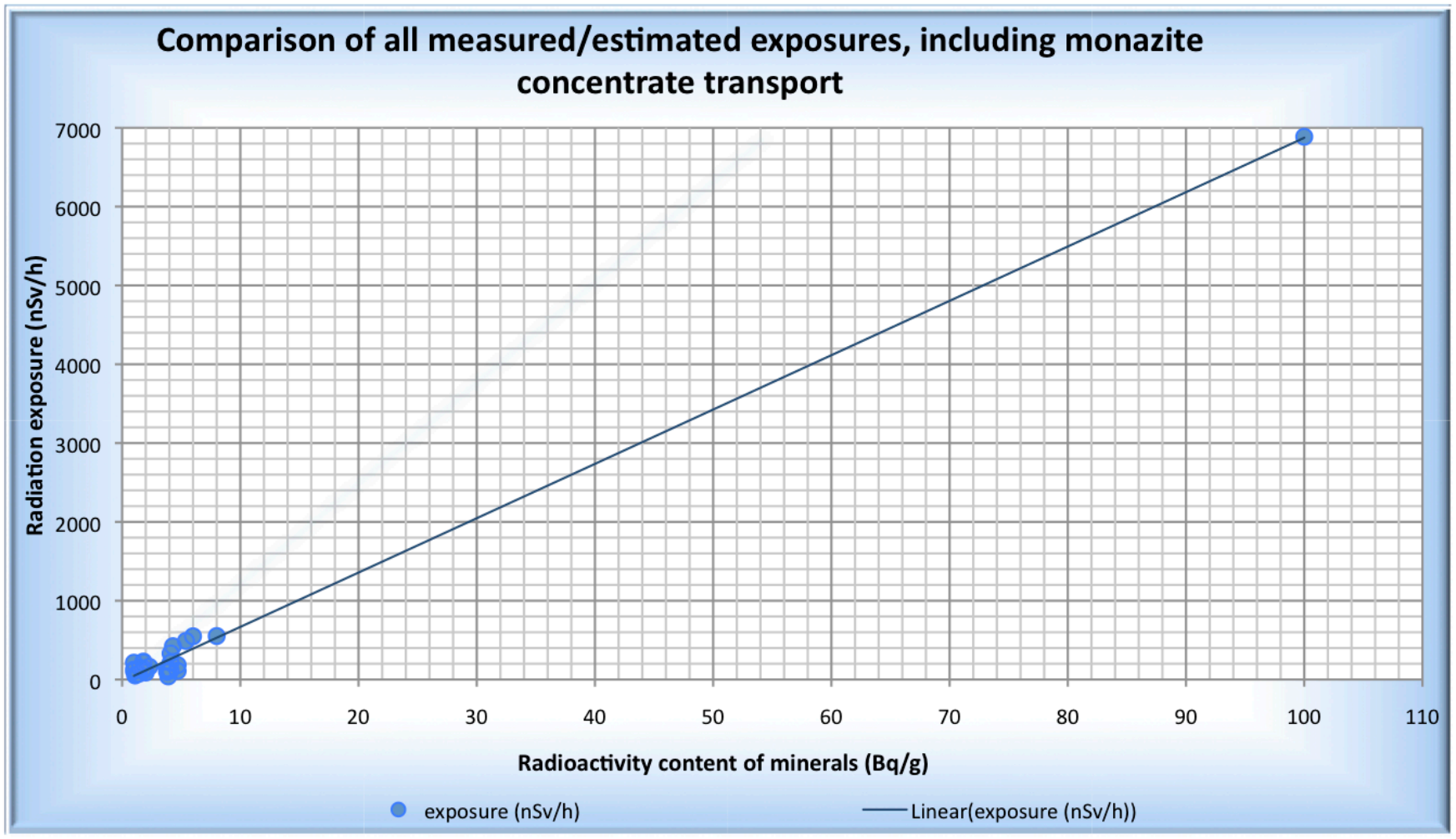
Findings

All monitoring data combined



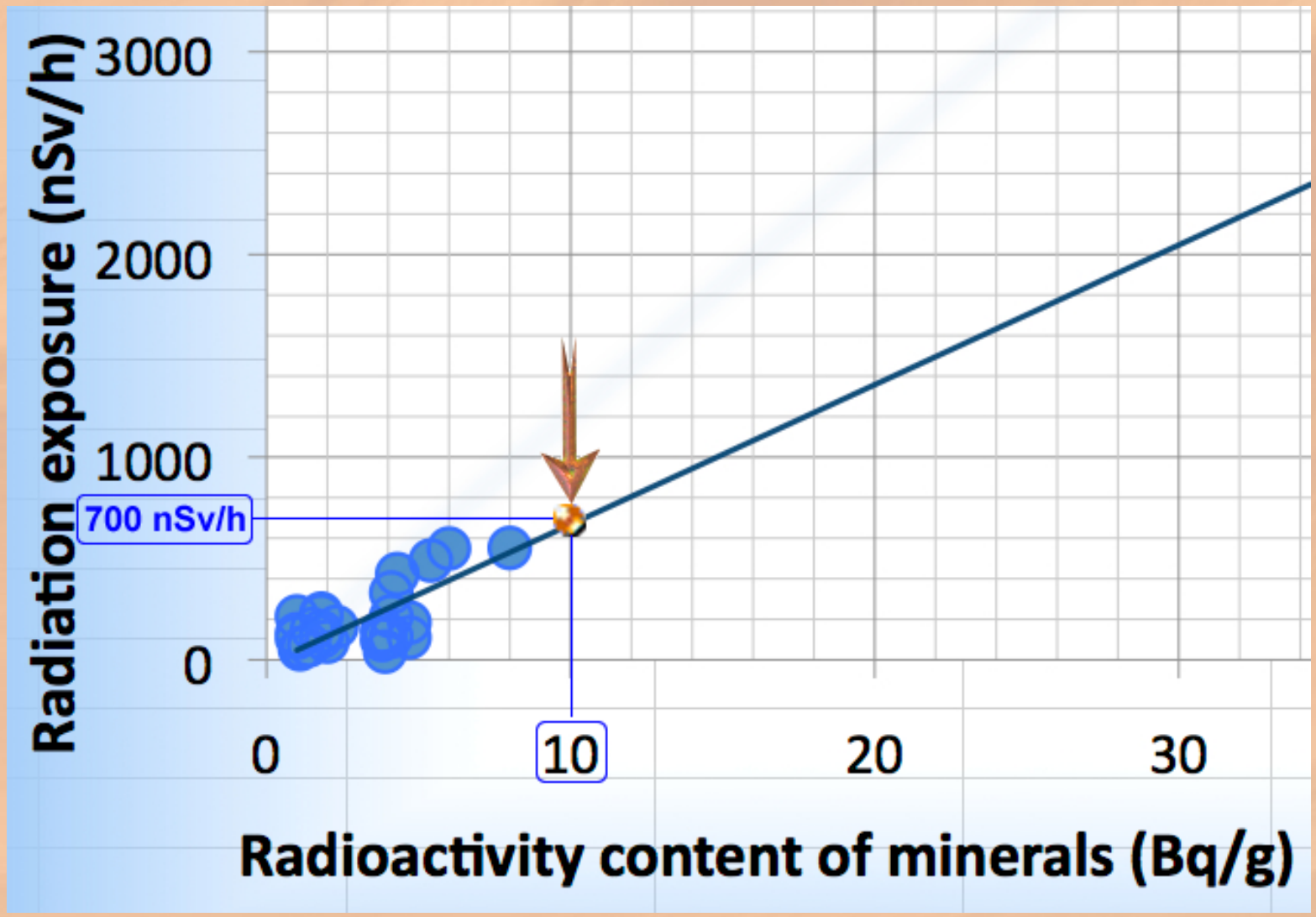
Findings

All monitoring data combined (data for monazite concentrate added)



Findings

A ‘close-up’ of the region of interest of the above chart



Conclusions

The transport of materials in heavy mineral sands industry does not pose a significant risk to the workers and members of the general public.

The use of the 'exclusion factor' of 10 is entirely appropriate for the heavy mineral sands industry and should be maintained, but this value cannot be increased to 15.

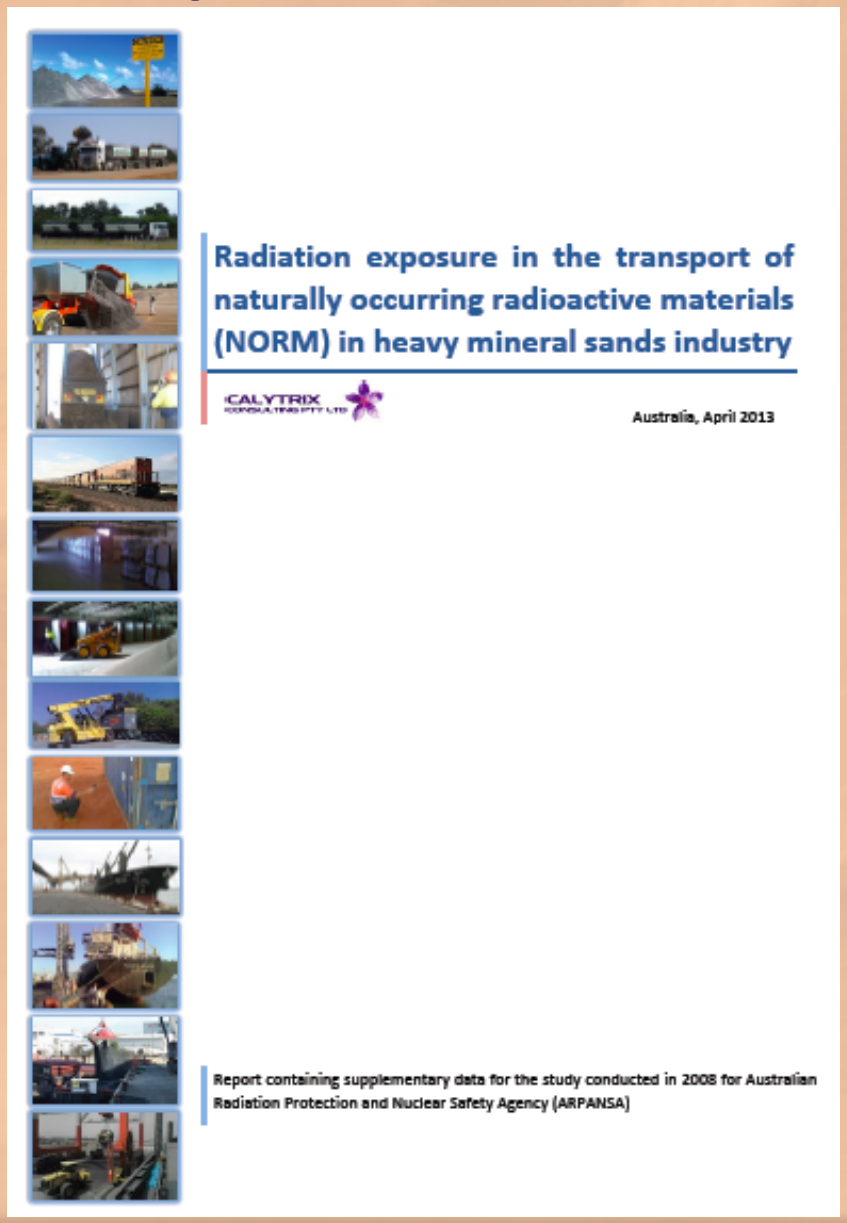
The radiation exposure in the case of the bulk transport of zircon is expected to be significantly lower in comparison with the exposure in cases of the transport of HMC and titanium minerals with the similar activity concentrations.

The highest 'per hour' values were registered for loader operators inside the sheds at different wharves. Due to the fact that in these situations a potential exposure to radon and thoron is more significant than the exposure to airborne dust and to the external gamma radiation, the establishment of regular monitoring programs is advisable.

Predicted radiation exposure levels

Activity concentration (Bq/g)	Predicted radiation exposure level in nSv/hour
Ilmenite, synthetic rutile, heavy mineral concentrate with activity concentrations less than 10 Bq/g (expected variance of ±10%)	
1	100
2	180
3	260
4	330
5	410
6	490
7	560
8	640
9	720
Typical zircon (expected variance of ±15-20%)	
3.5	140
4.0	170
4.5	200
5.0	230
Ilmenite, synthetic rutile, heavy mineral and monazite concentrates with activity concentrations over 10 Bq/g (expected variance of ±15%)	
10	700
20	1400
30	2100
40	2700
50	3400
60	4100
70	4800
80	5500
90	6100
100	6900

A complete text of the report



Link to the complete report (80 pages) on the internet:
http://calytix.biz/papers