MINISTRY OF MINES AND ENERGY

GEOLOGICAL SURVEY OF NAMIBIA

Division of Engineering and Environmental Geology

SOIL CONTAMINATION MAPPING AND LANDUSE PLANNING: A CASE STUDY FOR TSUMEB, NAMIBIA

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PRESENTATION OUTLINE

- Introduction
- History of copper smelting in Tsumeb
- Geology
- Previous work
- Sampling and analysis
- Contamination situation (Arsenic)
- Landuse categorization
- Possible health effects of chronic Arsenic exposure
- Conclusion and recommendations

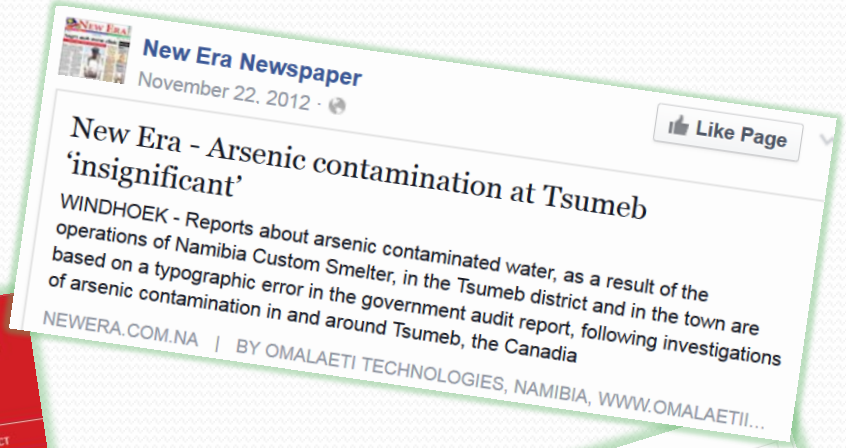
INTRODUCTION

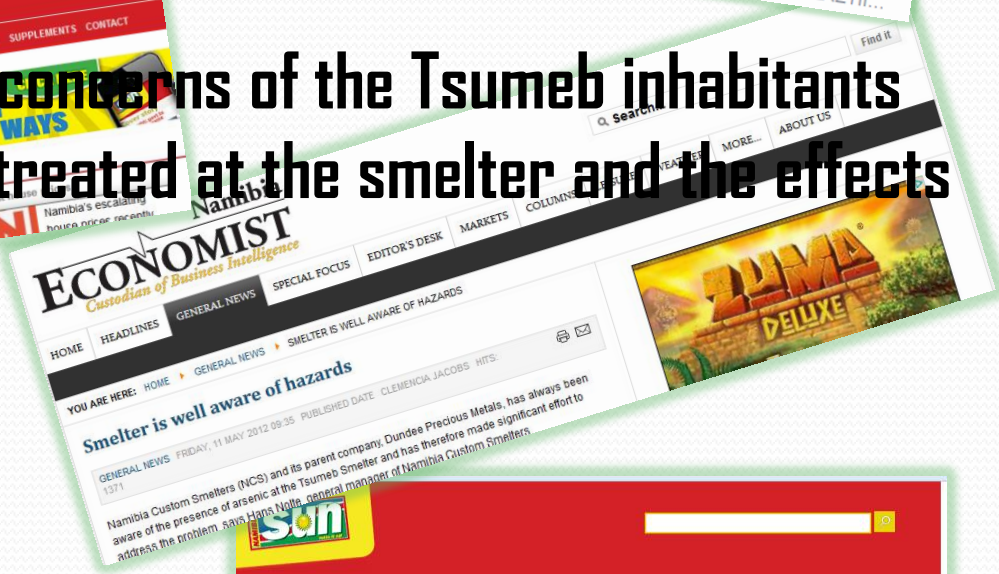
The town of Tsumeb, located in the northern area of Namibia has a long history of copper mining and ore smelting activities dating back to the early 1900s.

These activities created a legacy of heavy metals contamination, which today pose a risk to human health and the environment.

Prior to Namibia's independence (before 1990) mining and ore processing was done with little or no regard for the environment, as Environmental friendly Mining regulations were non-existence until 1990.

In September 2012, the Division of Engineering and Environmental Geology under a **cabinet directive**, aimed at investigating health and environmental effects caused by the Tsumeb Smelter, undertook a field trip to Tsumeb, to investigate soil contamination and thereafter create guiding landuse maps for the town.

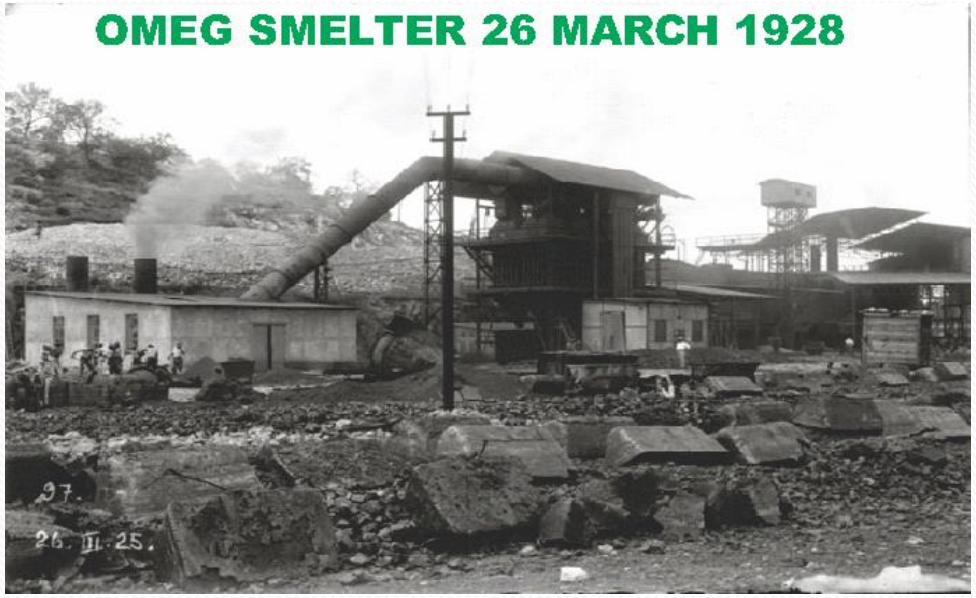


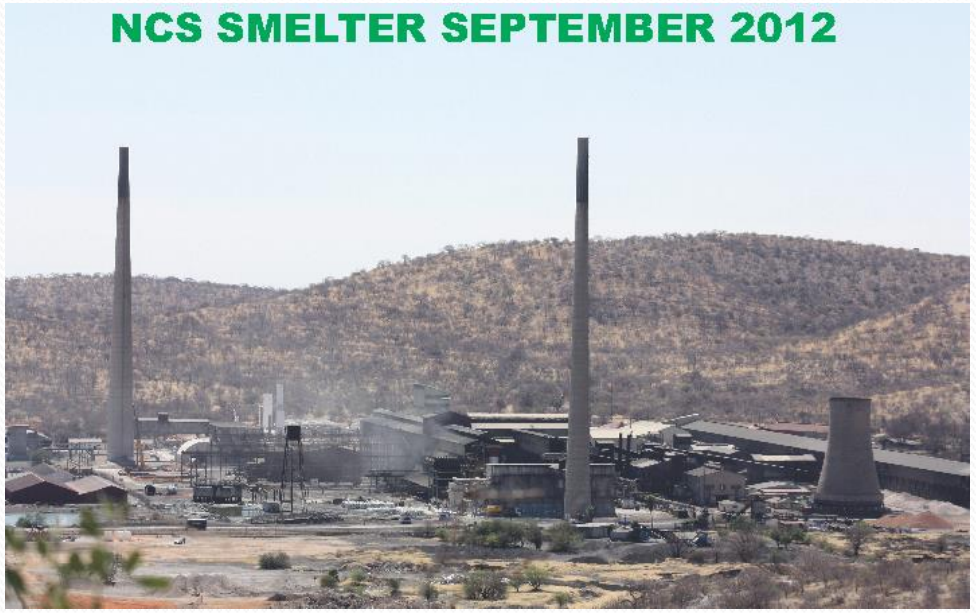


The directive was prompted by concerns of the Tsumeb inhabitants regarding high As copper ores treated at the smelter and the effects these may have on their health

HISTORY OF COPPER (Cu) SMELTING IN TSUMEB

- **1907**:- two Pb-Cu blast furnaces were built to smelt local sulphide ores (chalcocite, enargite, galena, sphalerite)
- **1963:-** new Cu and Pb smelters were built
- **1980's:-** a slag mill built to re-process old Cu reverbatory slag
- **Currently:-** the smelter imports ore from Bulgaria, Chile, Peru, Greece, Zambia and South Africa (Kaira, 2009).



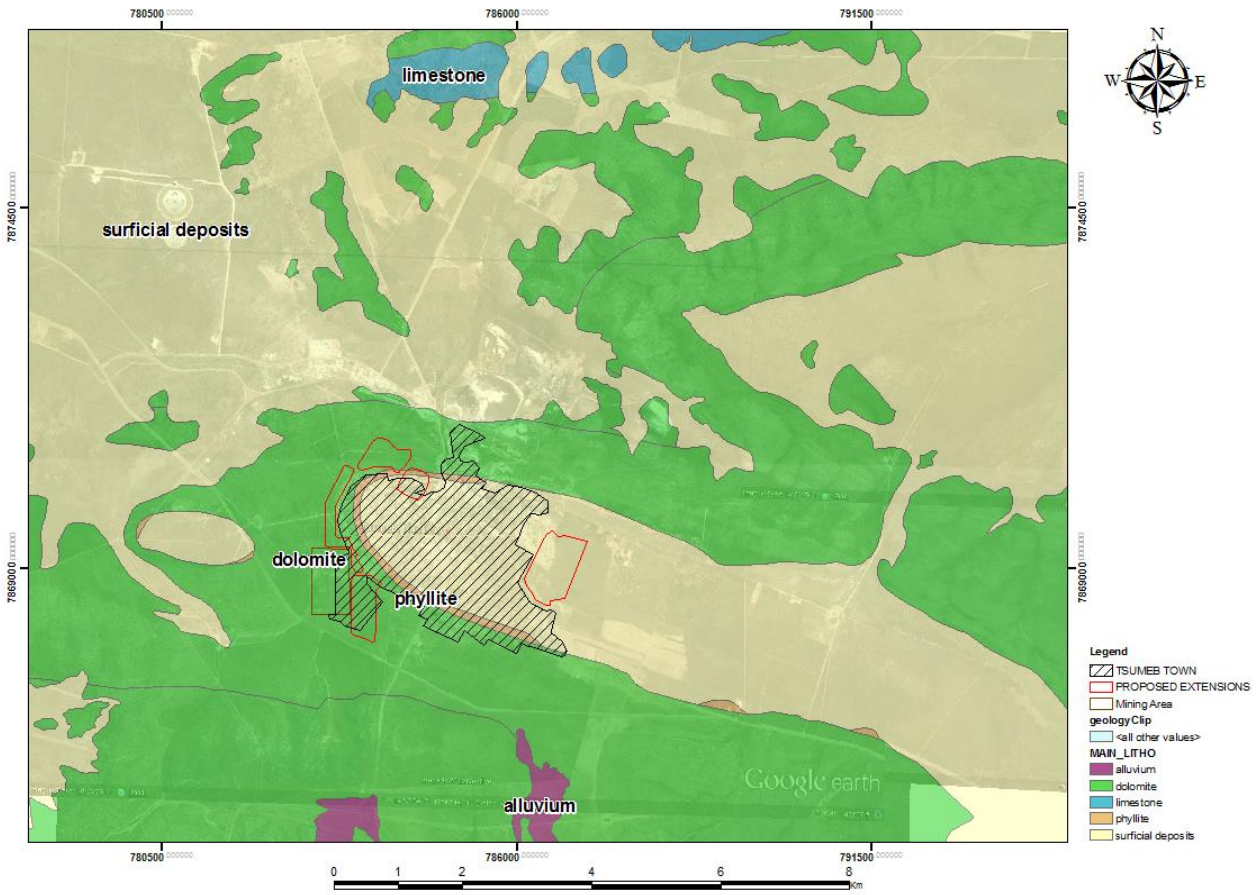


GEOLOGY

- Tsumeb is located on the edge of the Otavi Mountainland. The major part of the current urban area of Tsumeb is developed on deeply weathered arkosic sandstone and shale of the Tschudi Formation (Mulden Group) and carbonate rocks of Hüttenberg Formation (Tsumeb Subgroup).

- Carbonates of the Hüttenberg Formation are in some places heavily fractured due to faulting, which caused deep karstification.

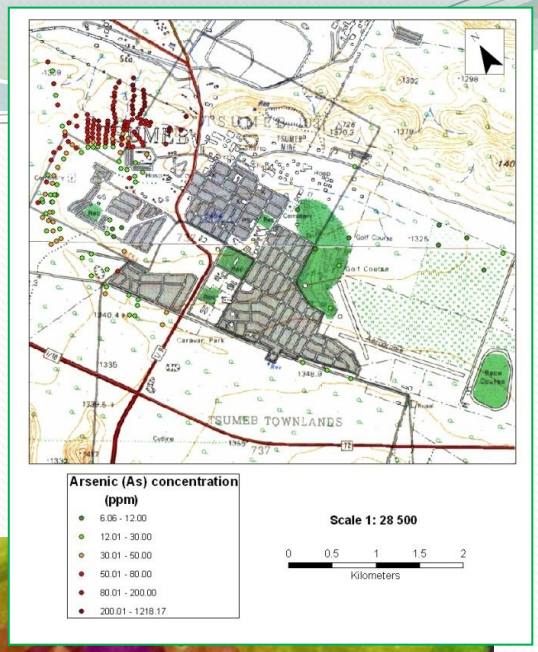
- Sedimentary rocks of Tschudi and Hüttenberg Formation are the hosts of copper mineralisation in the Tsumeb area

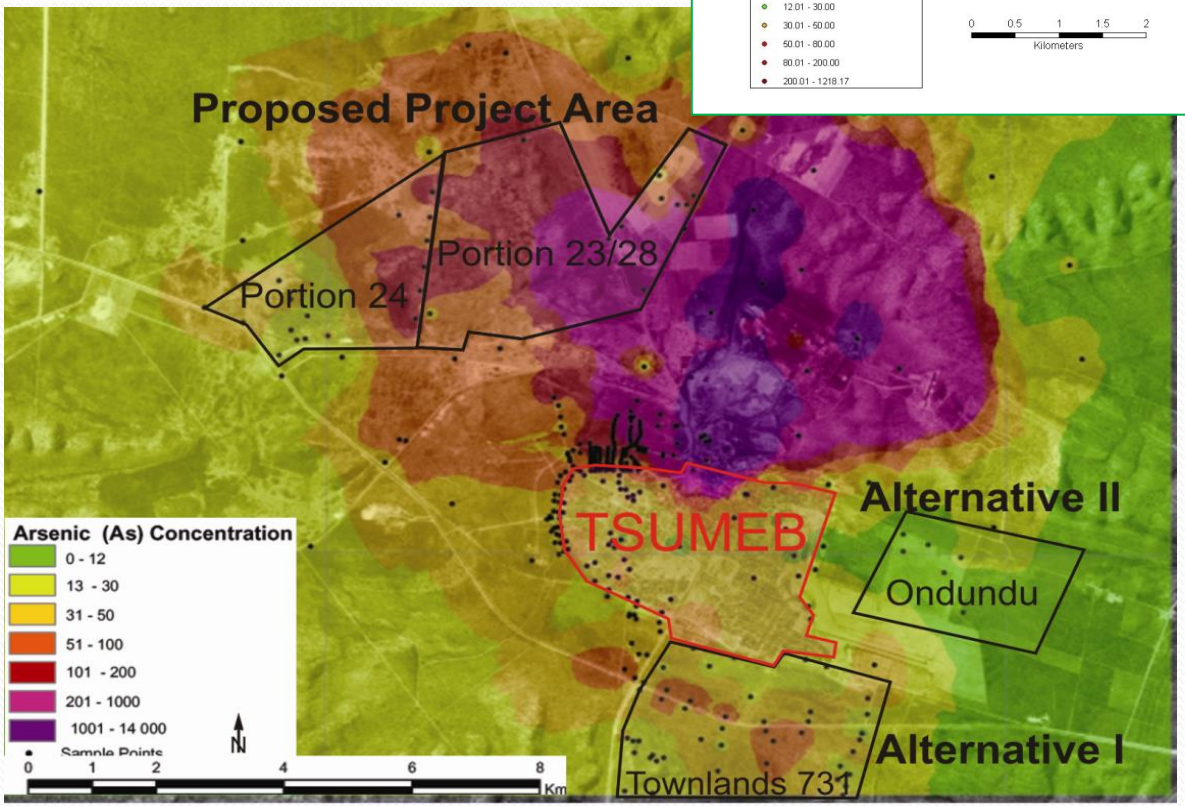


PREVIOUS SOIL STUDIES BY GSN:

(1) Geochemical soil Investigation in the Proposed Town Extensions Nomtsoub 6 and 7 (2006);

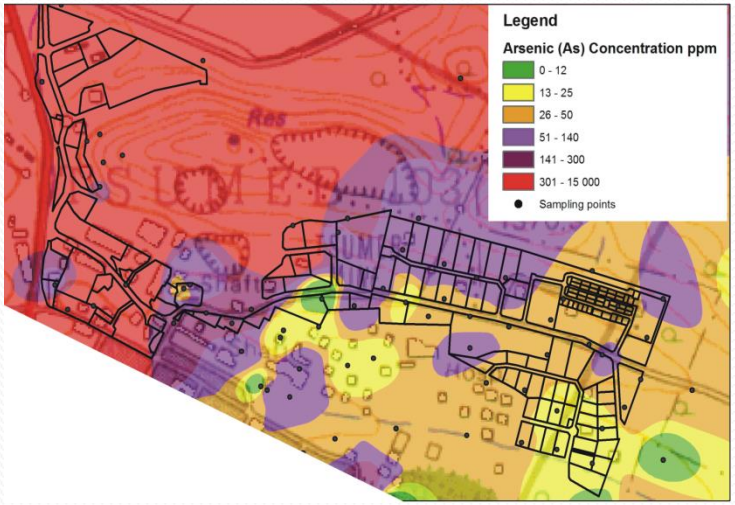
- **Finding:** varying but generally high concentrations of As, Cd, Cu and Pb exceeding by far international standards for soil in residential areas.
- Highest contaminations were found in the northern parts of Tsumeb
- **Recommendation:** a large portion of the proposed extension 7 is not suitable for residential use and should be excluded for residential purposes





2) Results of a geochemical soil survey for Extension 11 & 12 in Tsumeb (2008)

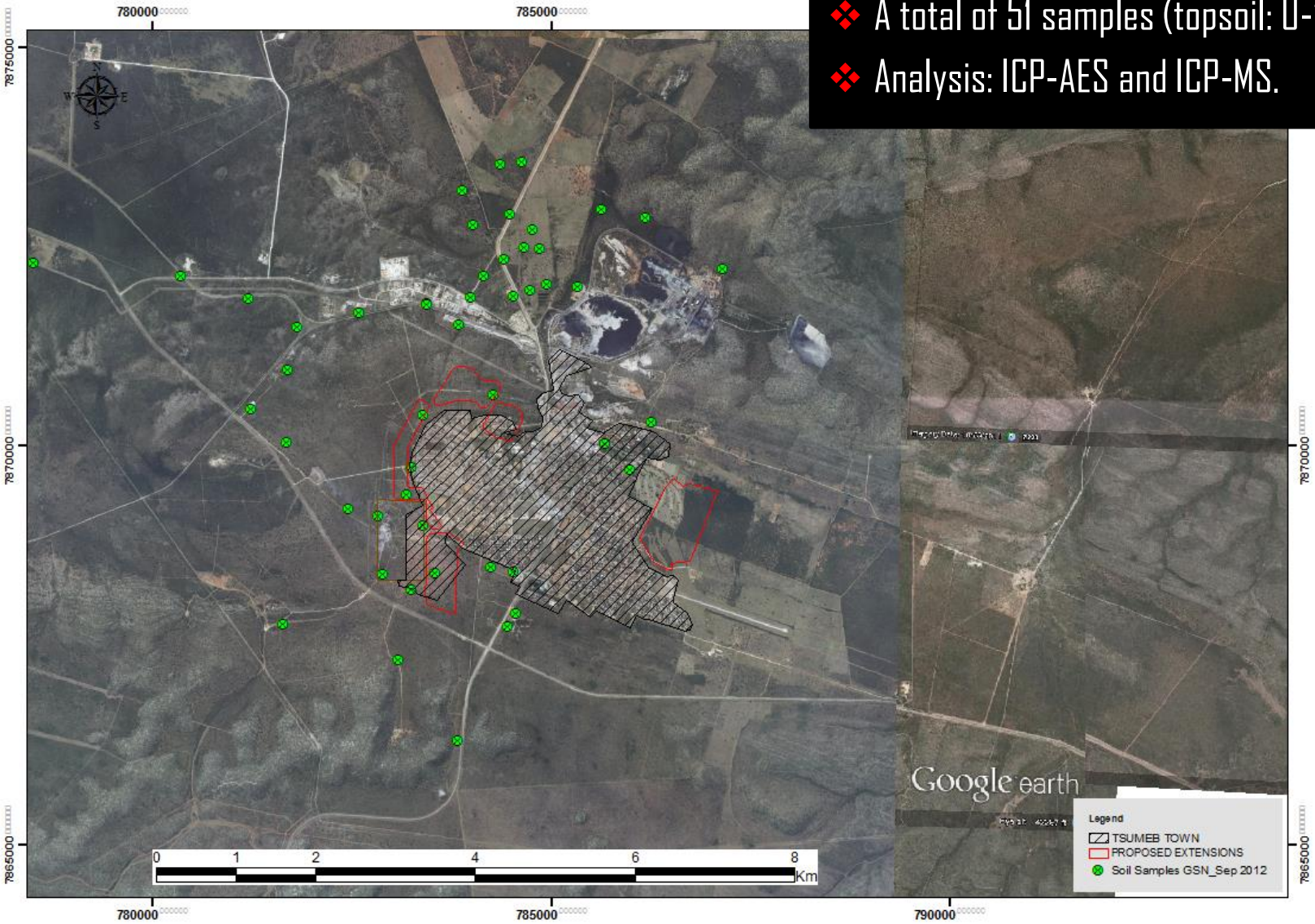
- Study was prompted by results of previous GSN studies that showed severe contamination of surface soil with heavy metals
- Additional developments in the northern part of Tsumeb must be limited.
- In general, industrial sites (i.e smelter) should be surrounded by buffer zones in which land use is restricted.



Distribution of arsenic in the topsoils of extension 11 and 12 in northern Tsumeb: Areas with purple or red colours (< 50 ppm As) are not suitable for residential land use.

SAMPLING AND ANALYSIS (2012)

- A total of 51 samples (topsoil: 0-10cm depth)
- Analysis: ICP-AES and ICP-MS.

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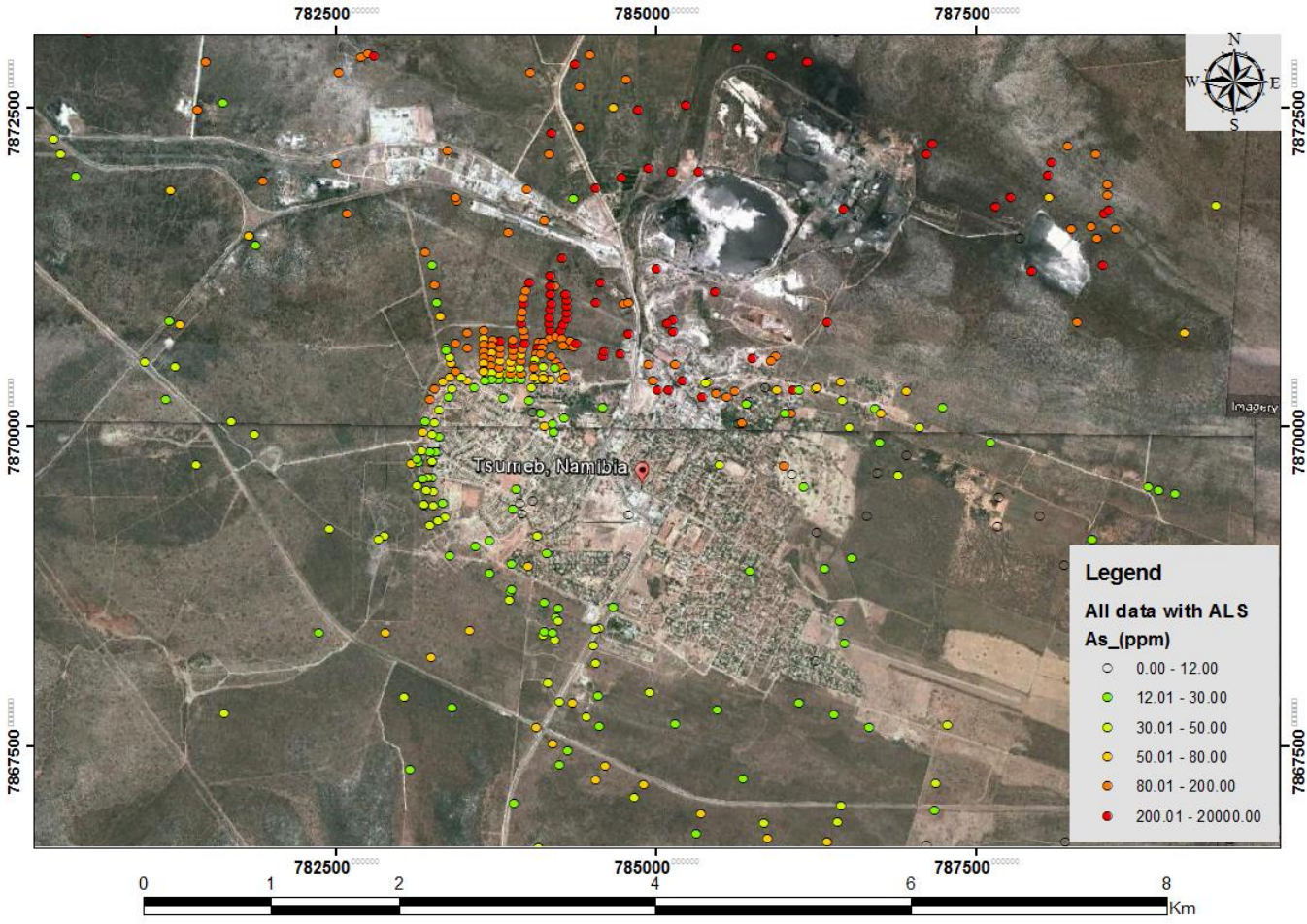
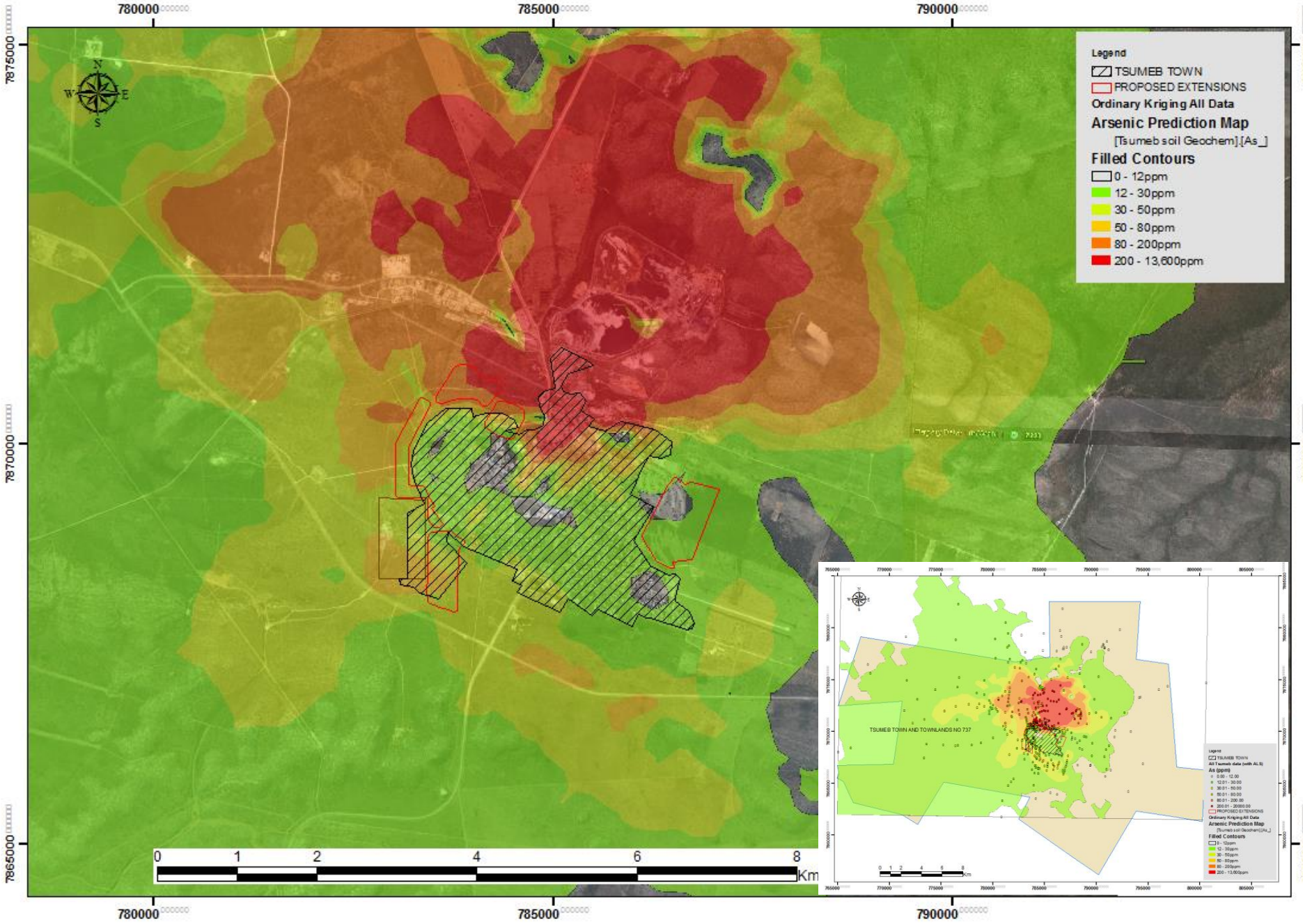
CONTAMINATION SITUATION (ARSENIC)

- Contamination impact of the smelter emissions extends to the north and northwest of Tsumeb
- Concentrations of As closer to the smelter reaches 13600ppm
- Toxic metals with similar contamination trends include Pb, Cu, Cd, and Zn



All sample plotted (>500 samples) symbolizing As levels


780000
785000
790000
7875000
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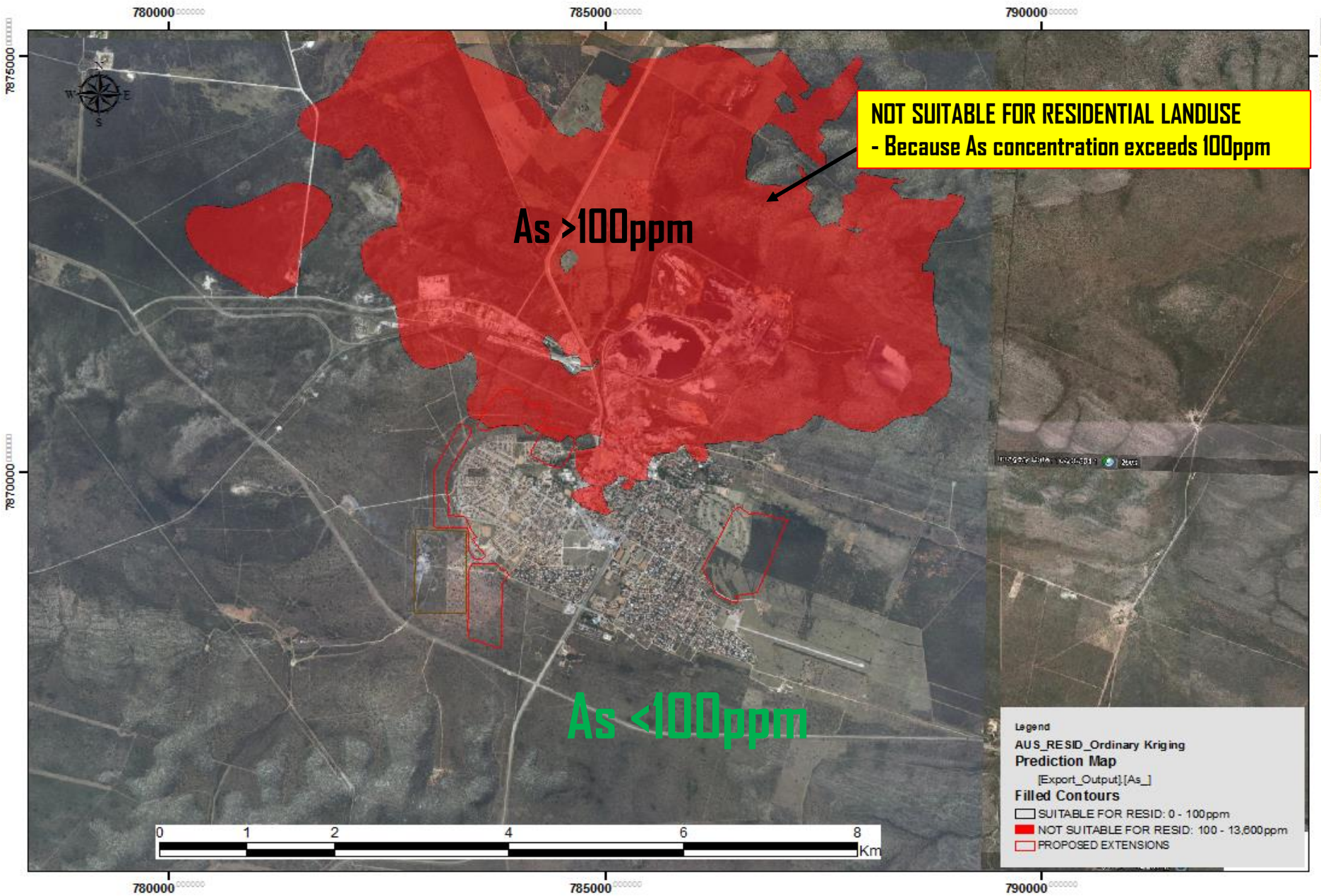
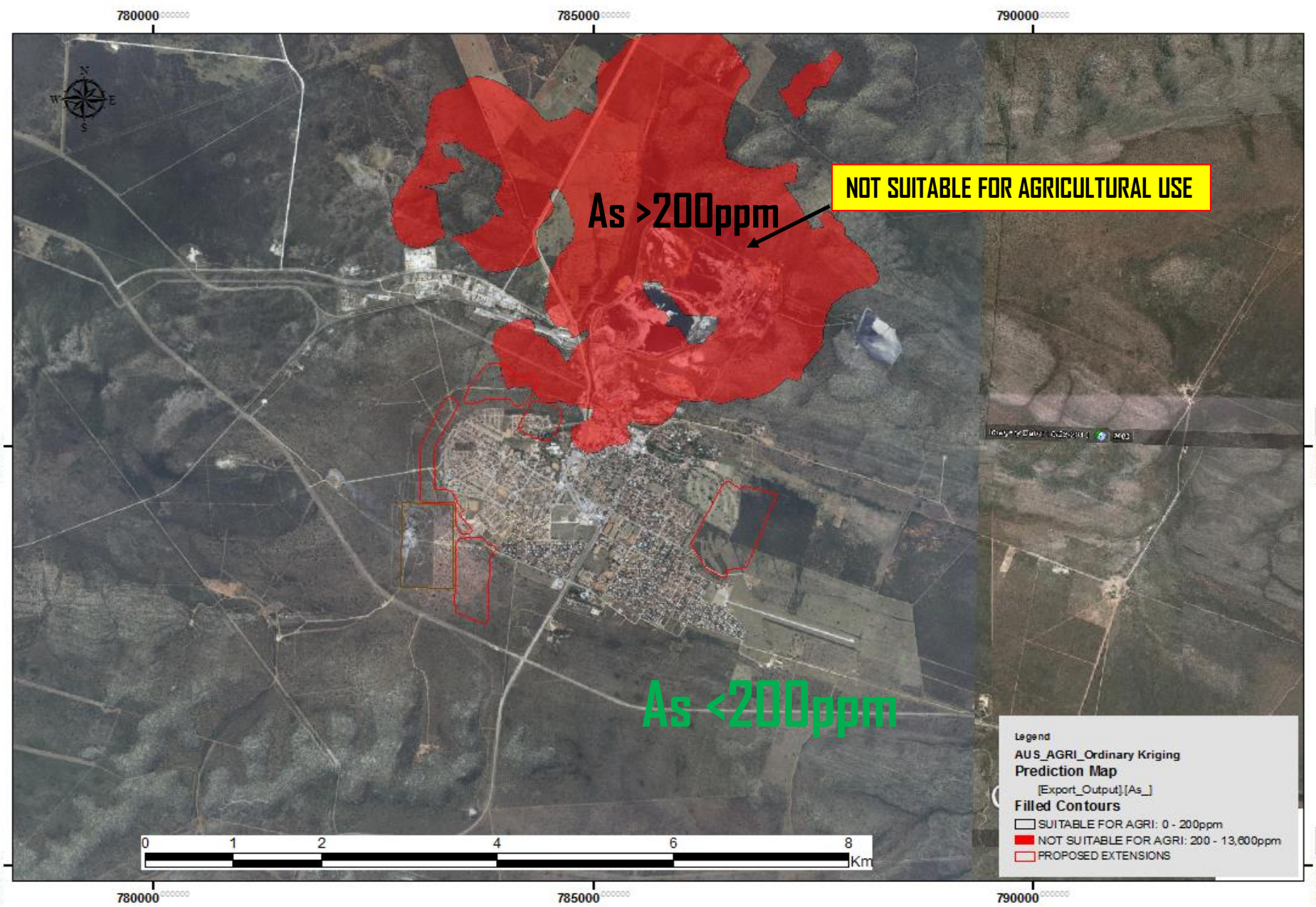
7865000
N
W
E
S
Legend
TSUMEB TOWN
PROPOSED EXTENSIONS
Ordinary Kriging All Data
Arsenic Prediction Map
[Tsumeb soil Geochem].[As_]
Filled Contours
0 - 12ppm
12 - 30ppm
30 - 50ppm
50 - 80ppm
80 - 200ppm
200 - 13,600ppm
0 1 2 4 6 8
Km
TSUMEB TOWN AND TOWNLANDS NO 737

LANDUSE CATEGORIZATION

In absence of our own (Namibian) soil guideline values, Australian and New Zealand soil guideline values for heavy metals were used in carrying out the landuse categorization exercise.

Landuse	Soil Guideline Values for heavy Metals (Australia and New Zealand) mg/Kg (NEPC,1999)									
	As	Be	Cd	Cr	Co	Cu	Pb	Mn	Ni	Zn
Residential	100	20	20	100	100	1000	300	1500	600	
Agri/Allotment	200	40	40	200	200	2000	600	3000	600	
Commercial	500	100	100	500	500	5000	1500	7500	3000	35000


780000
785000
790000
7875000
7870000
NOT SUITABLE FOR RESIDENTIAL LANDUSE
- Because As concentration exceeds 100ppm
As >100ppm
As <100ppm
Legend
AUS_RESID_Ordinary Kriging
Prediction Map
[Export_Output].[As_]
Filled Contours
SUITABLE FOR RESID: 0 - 100ppm
NOT SUITABLE FOR RESID: 100 - 13,600ppm
PROPOSED EXTENSIONS
0 1 2 4 6 8
Km


780000
785000
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7865000
NOT SUITABLE FOR AGRICULTURAL USE
As >200ppm
As <200ppm
0 1 2 4 6 8
Km
Legend
AUS_AGRI_Ordinary Kriging
Prediction Map
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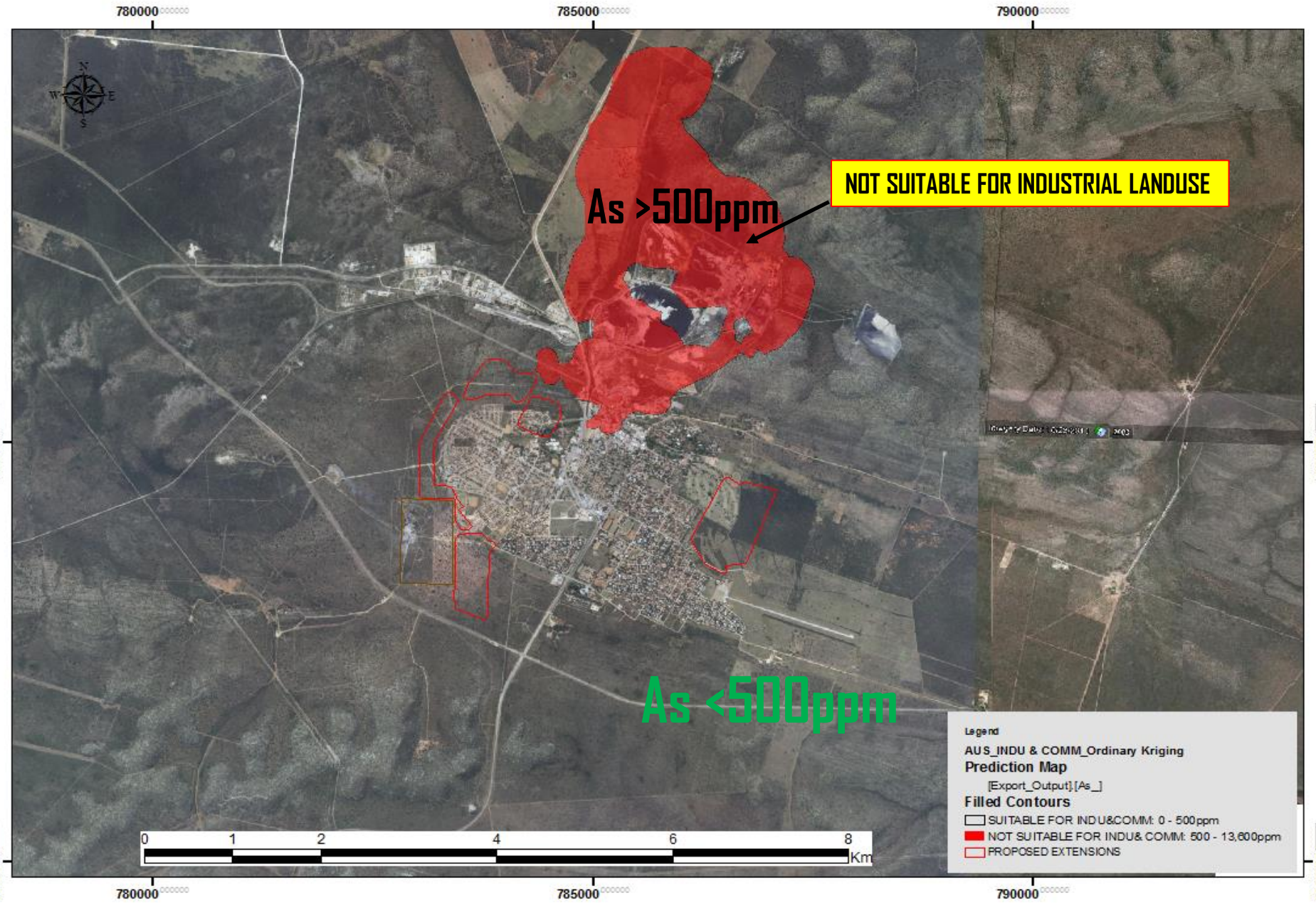
Filled Contours
SUITABLE FOR AGRI: 0 - 200ppm
NOT SUITABLE FOR AGRI: 200 - 13,600ppm
PROPOSED EXTENSIONS


780000
785000
790000
7870000
7865000
As >500ppm
NOT SUITABLE FOR INDUSTRIAL LANDUSE
As <500ppm
0 1 2 4 6 8
Km
Legend
AUS_INDU & COMM_Ordinary Kriging
Prediction Map
[Export_Output].[As_]
Filled Contours
SUITABLE FOR INDU&COMM: 0 - 500ppm
NOT SUITABLE FOR INDU& COMM: 500 - 13,600ppm
PROPOSED EXTENSIONS

POSSIBLE HEALTH EFFECTS OF CHRONIC ARSENIC EXPOSURE

- Skin lesions (e.g., hyperpigmentation, melanosis, keratosis)
- Respiratory system problems (e.g., chronic cough,shortness of breath, bronchitis),
- Nervous system effects (e.g., neuropathy, neurobehavioral, weakened memory, lower IQ, decreased attention),
- Cancers of different organs (e.g., skin, lung, bladder),
- Reproductive effects (e.g., pregnancy complications, fetus abnormalities, premature deliveries, reduced birth weight).

Cases from Bangladesh

Potential Receptors

- Human beings (inhaling or ingesting contaminated dust; kids at a higher risk as they play in the soils)
- Large scale crop and livestock farming activites
- Vegetable gardens/allotments
- Other economic activities

RECOMMEDATIONS

- Namibian Soil Guideline Values need to be developed
- At the moment contamination maps produced be used to guide town council in to avoid highly contaminated areas as identified
- Town council should take an approach that encourages remediation of land or other ways of removing the pathway (i.e. capping, replacing topsoil) rather than locking it off as unusable
- It is recommended to cease any agricultural land use activities near the smelter, especially in the areas towards the west and north.
- Based on the contamination trend, this survey recommends land on the south and eastern areas of the town to be used for Residential purpose as it is least contaminated


THANK YOU !!!
Questions?

REFERENCES

(1) Schneider, G.I.C., and Seeger, K.G. (1992) Copper, Mineral Resources of Namibia, Geological Survey of Namibia, pp. 2,3-1-2.3-118. (2) Kribek, B. and Kamona F. (eds., 2005): Assessment of the mining and processing of ores on the environment in mining districts of Namibia. Final Report. Czech Geological Survey, Prague, (3) Ettler,V., Johan, Z. Kříbek, B., Šebek, O., and Mihaljevič, M., 2009, Mineralogy and environmental stability of slags from the Tsumeb smelter, Namibia, Applied Geochemistry, v. 24, p.1-15., (4) Miller R. McG. (1983). The Pan-African Damara Orogen of South West Africa/Namibia, 431- 515. In: Miller R. McG. (Ed) Evolution of the Damara Orogen of South

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