

Taming the Soutpansberg

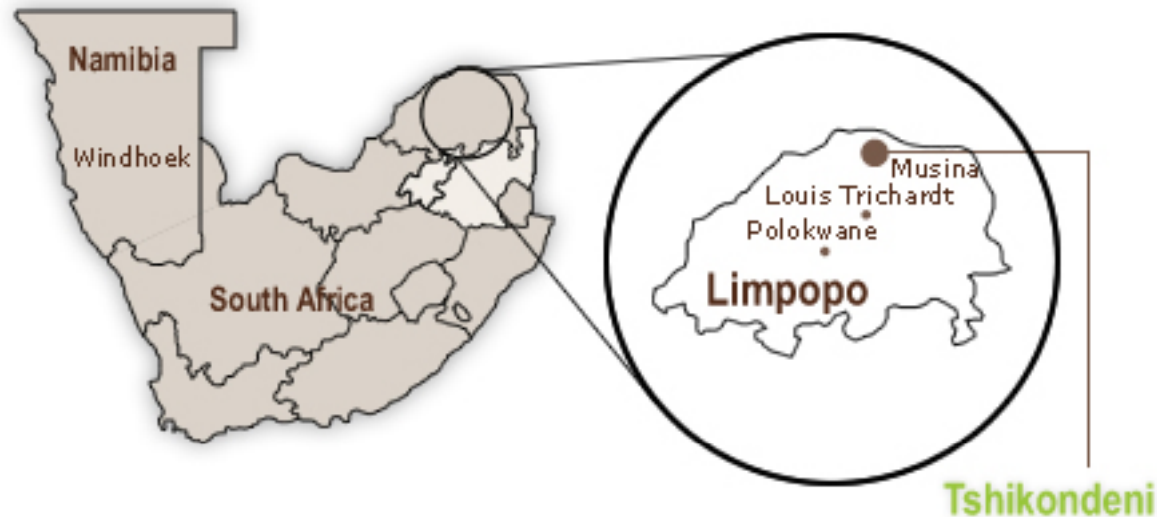
SACMA Presentation - Exxaro Tshikondeni Coal November 2011

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BRIEF OVERVIEW

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Located some 140 km east of Musina in Limpopo province, this underground mine employs 770 people and currently produces 414ktpa of premium hard coking coal. Conventional board and pillar extraction methods are used and coal is beneficiated using cyclones, spirals and froth flotation. The beneficiated product is trucked to Musina and railed to Mittal SA's works at Vanderbijlpark under a long-term agreement at the cost of production plus a management fee of 3%. The mine has coal reserves of 6Mt and a resource of 36Mt.



EXPLORATION & HISTORY

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- **Iscor** started with exploration in the area around **1961**.
- In **1975** exploration moved eastwards and permission was obtained to explore for coal in **Venda**.
- In **1978** Iscor applied for the mineral lease for an area of 1 500 ha on the farm **Tshikondeni**. It was granted in 1979 and the lease was extended in 1982.
- On 1 July **1983** the **Tshikondeni Mining Co (Pty) Ltd** was registered in the former Republic of Venda.
- The first coal was dispatched in January **1984**.

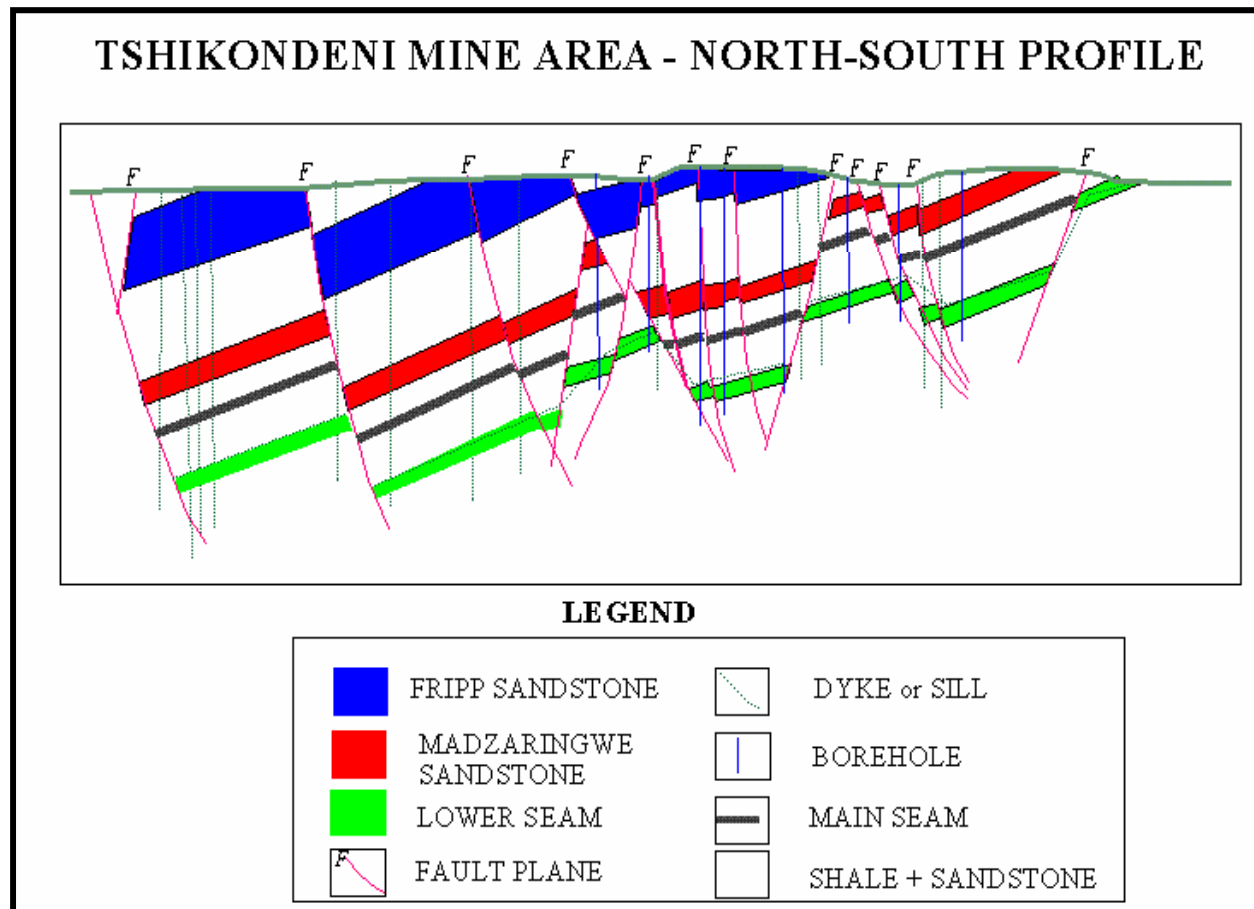


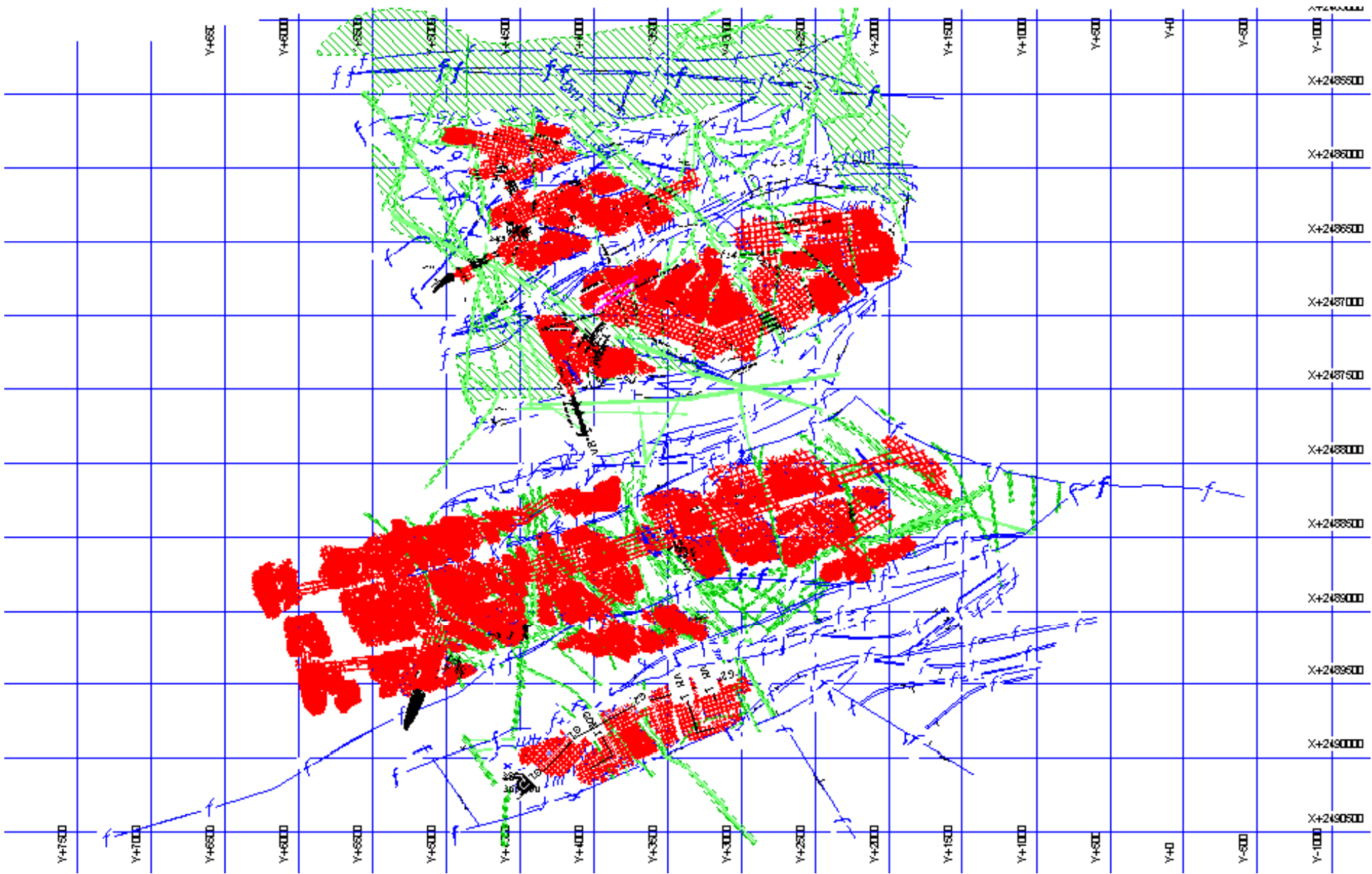
- **Tshikondeni Mine** forms part of the **Soutpansberg coalfield**.
- The area under consideration was tectonically active during various geological periods.
- The Karoo rocks in the Tshikondeni Mine Area unconformably overlie rocks of the Soutpansberg Group.
- The Soutpansberg Group is situated on the three-point coupling zone between the Limpopo mobile belt, the Sabi monocline and the Lebombo monocline.
- The northeastern margin of the Kaapvaal craton was down-faulted into a graben structure, in which this pre-Karoo Soutpansberg Group was deposited.
- This faulting, which controlled graben formation, continued during the deposition of the Karoo sediments and was reactivated in post-Karoo times, which resulted in a very complex structural setting
- The Madzaringwe formation, the formation in which the economical coal seam occurs, is composed of alternating shale, sandstone and carbonaceous layers.



Typical section of the Karoo Supergroup in the Tshikondeni Mine Area

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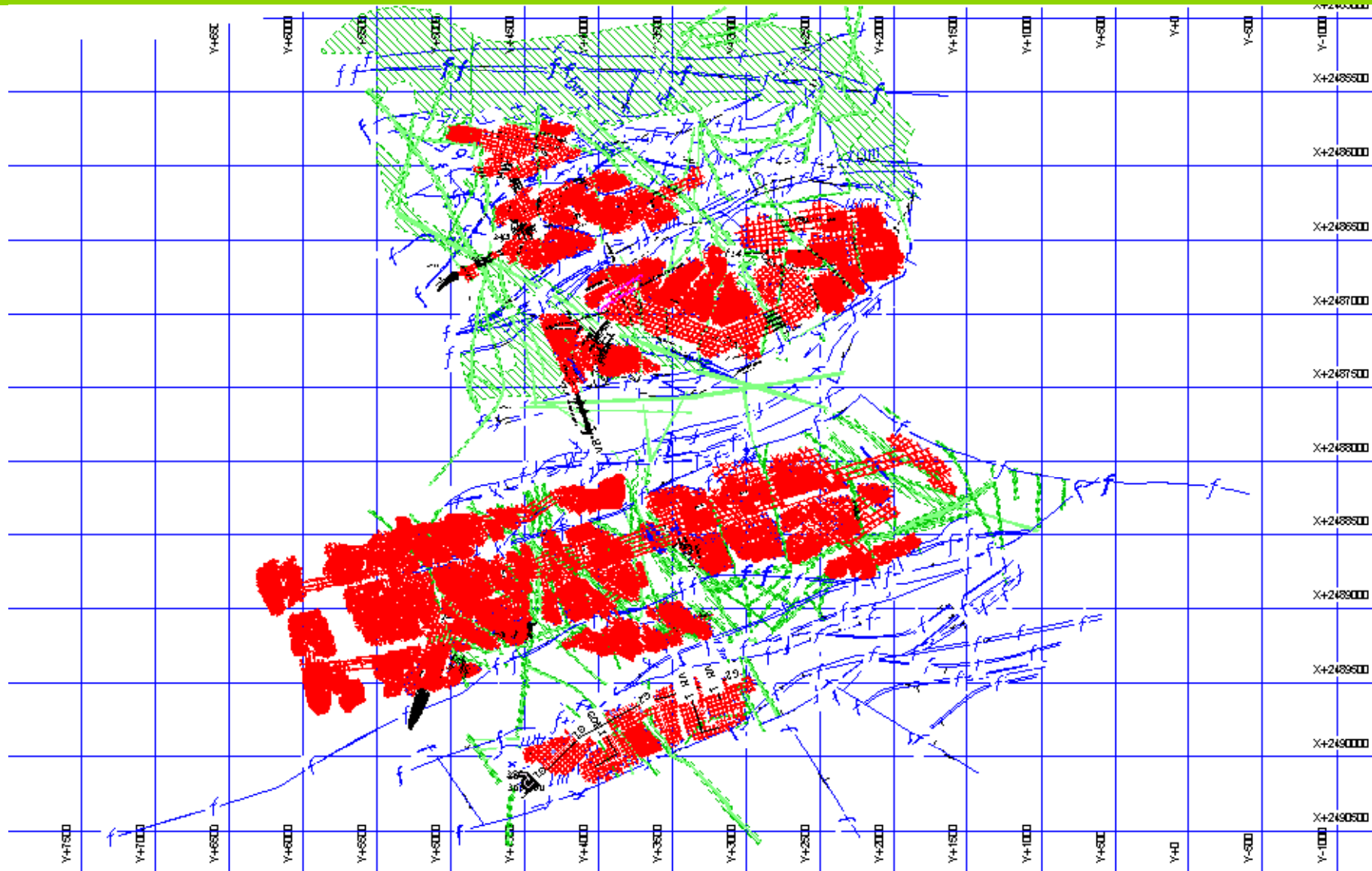




MAJOR FAULTS

NORTHEAST-SOUTHWEST

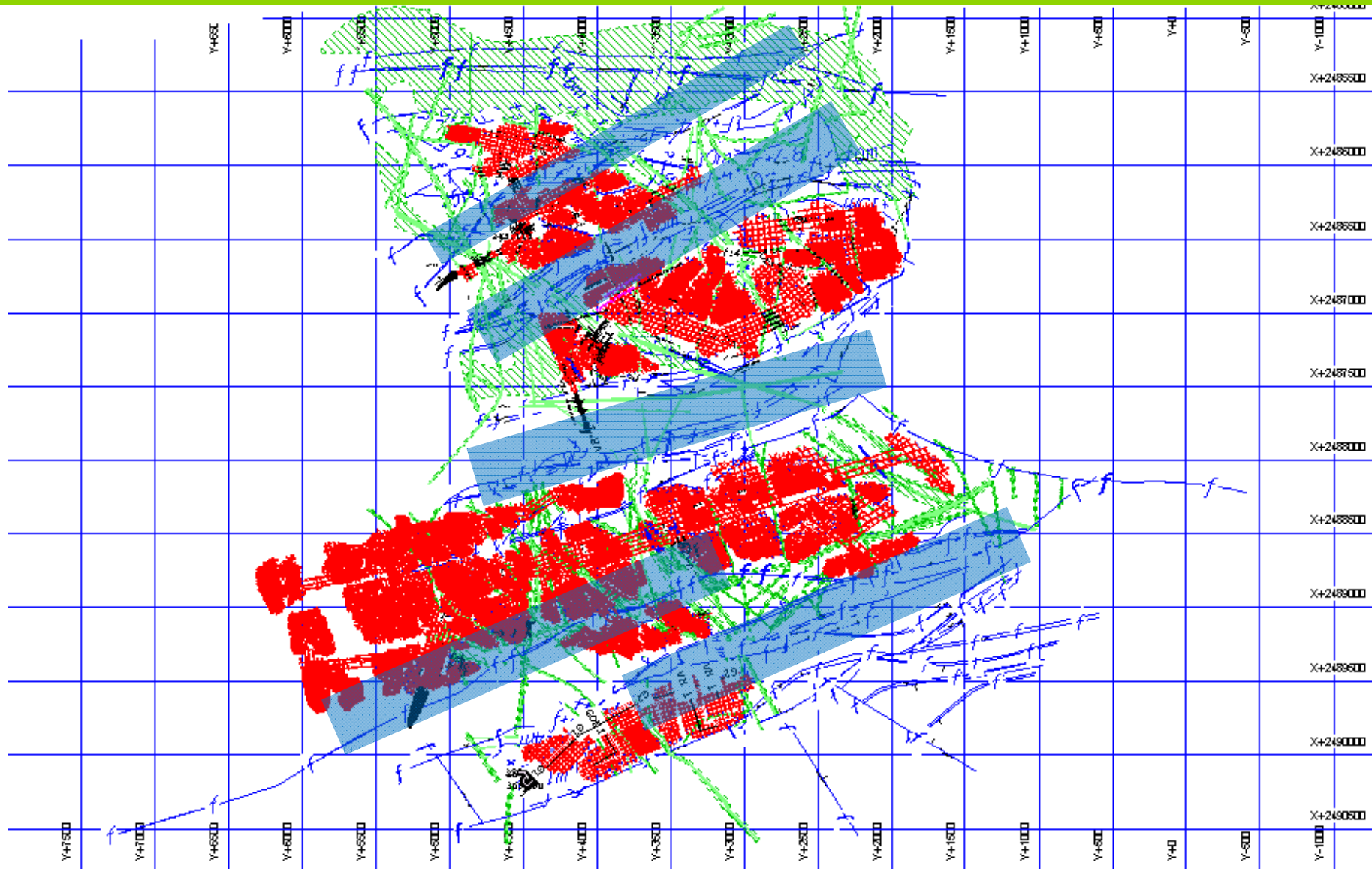
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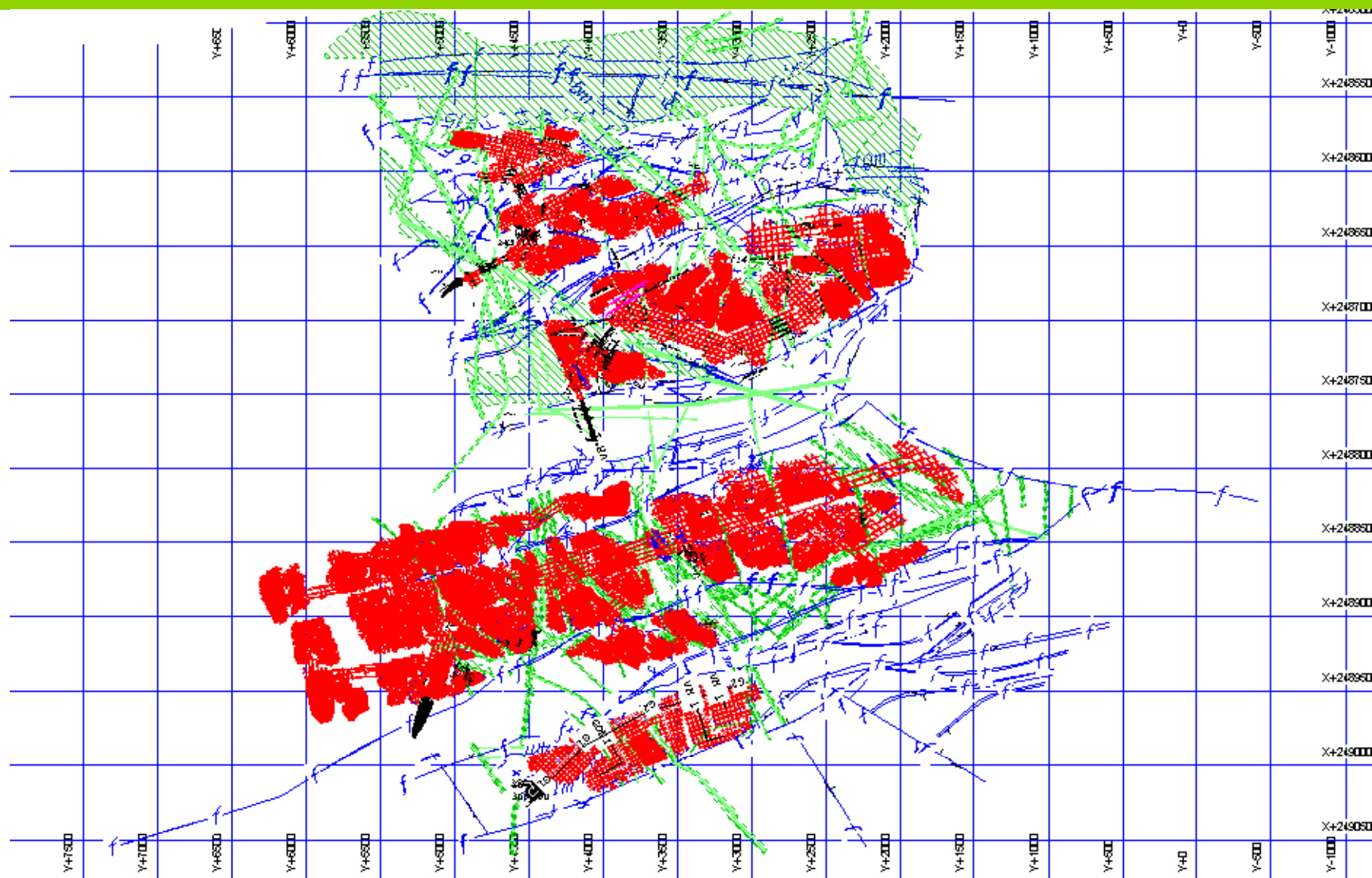
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MAJOR DYKES

NORTHWEST-SOUTHEAST

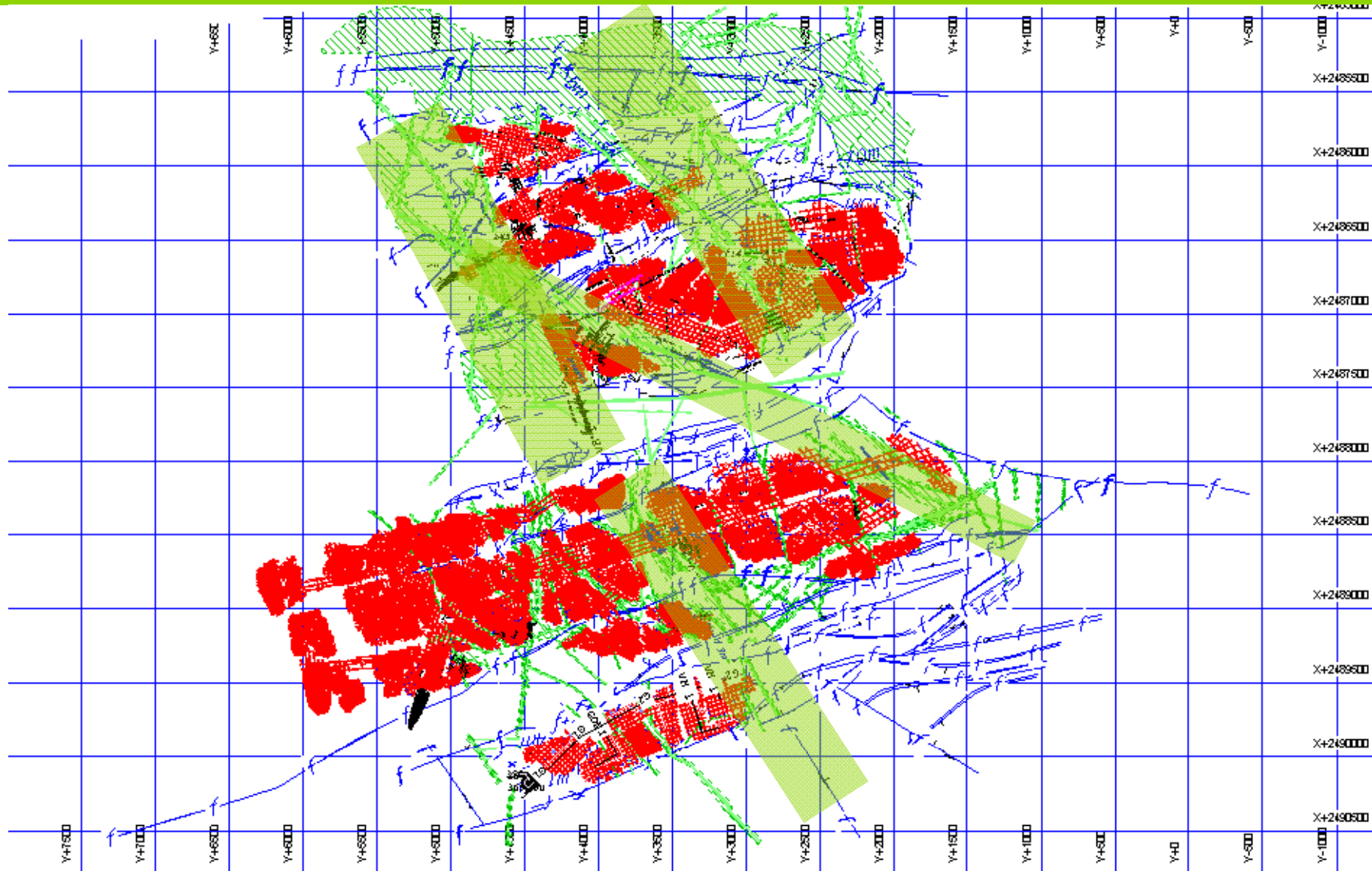
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NORTHWEST-SOUTHEAST

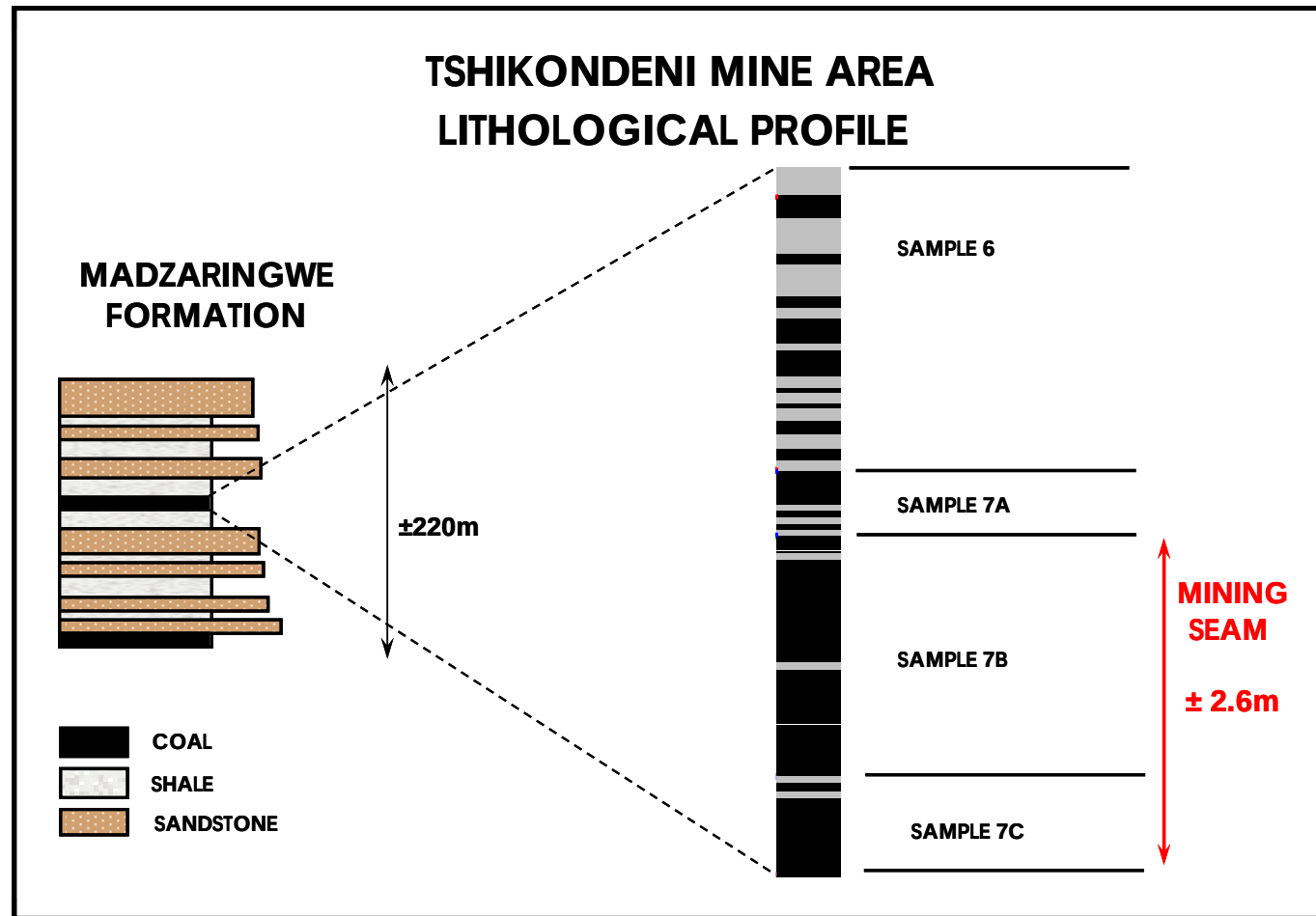
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Lithological Profile of Tshikondeni Mine

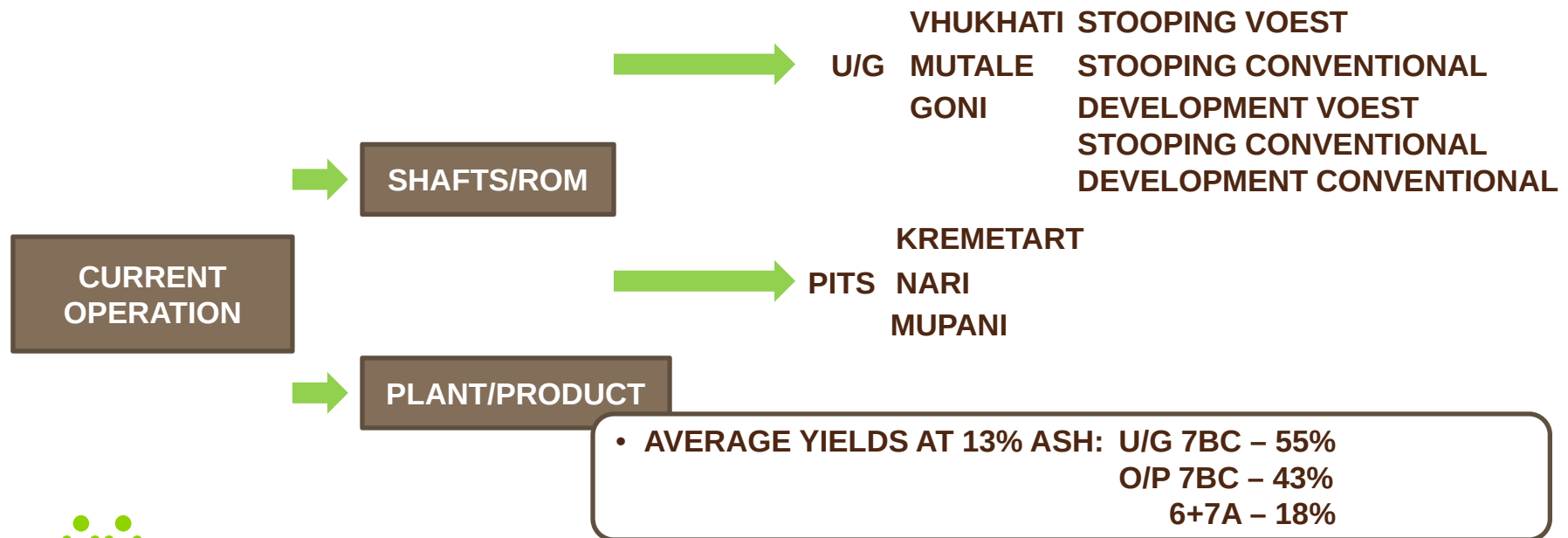
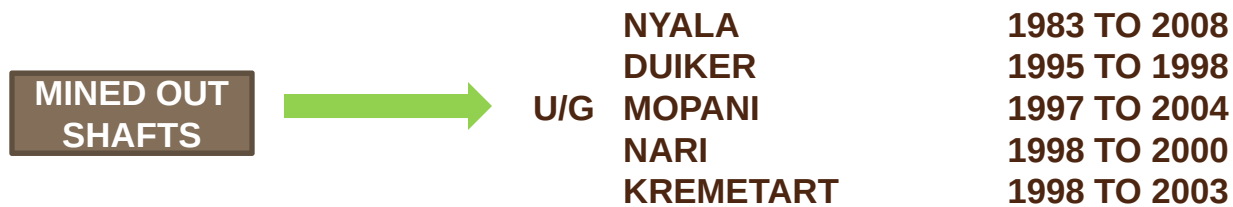
position of Mining Seam, Sample 7BC

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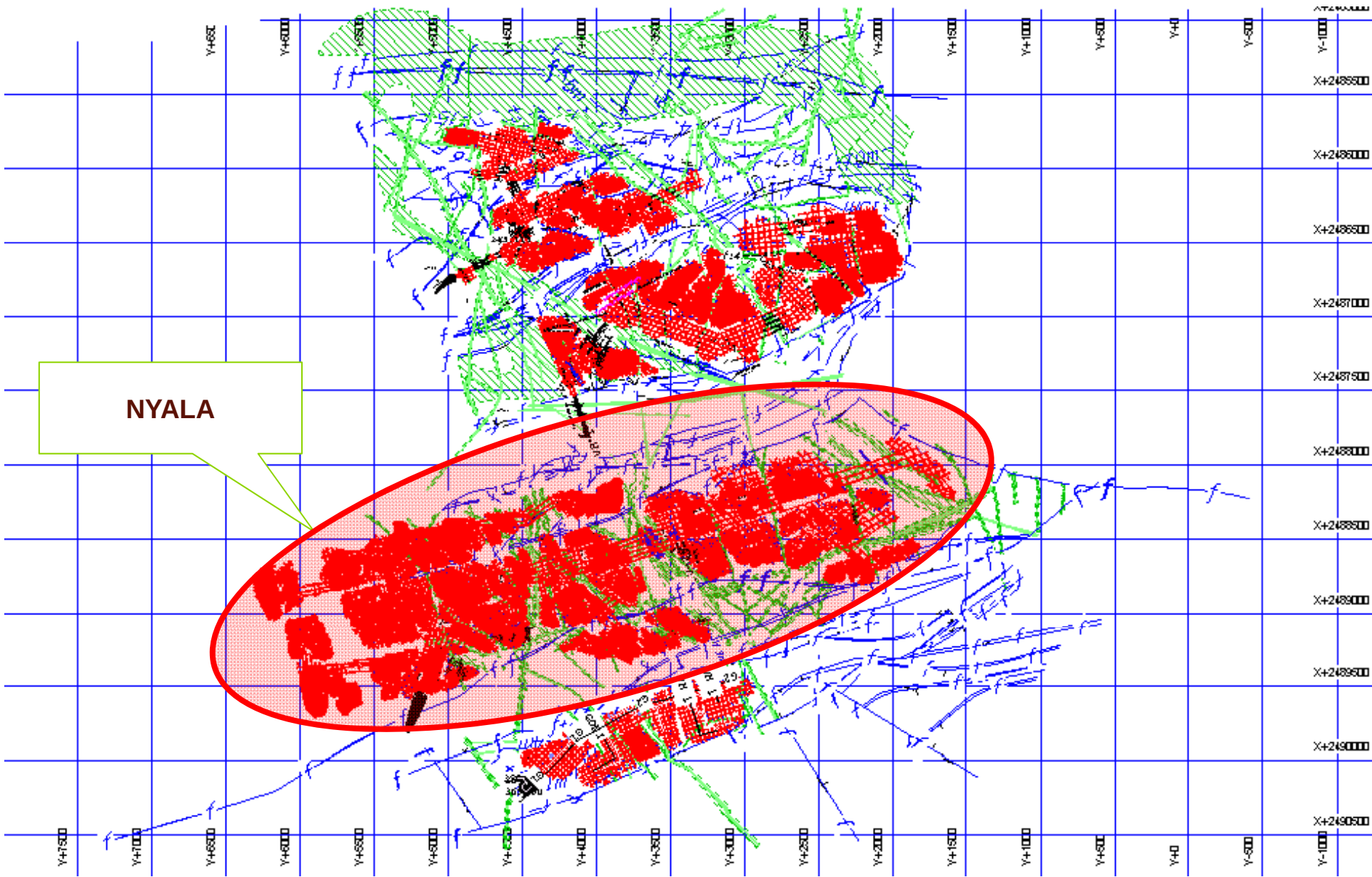
PAST & CURRENT OPERATIONS

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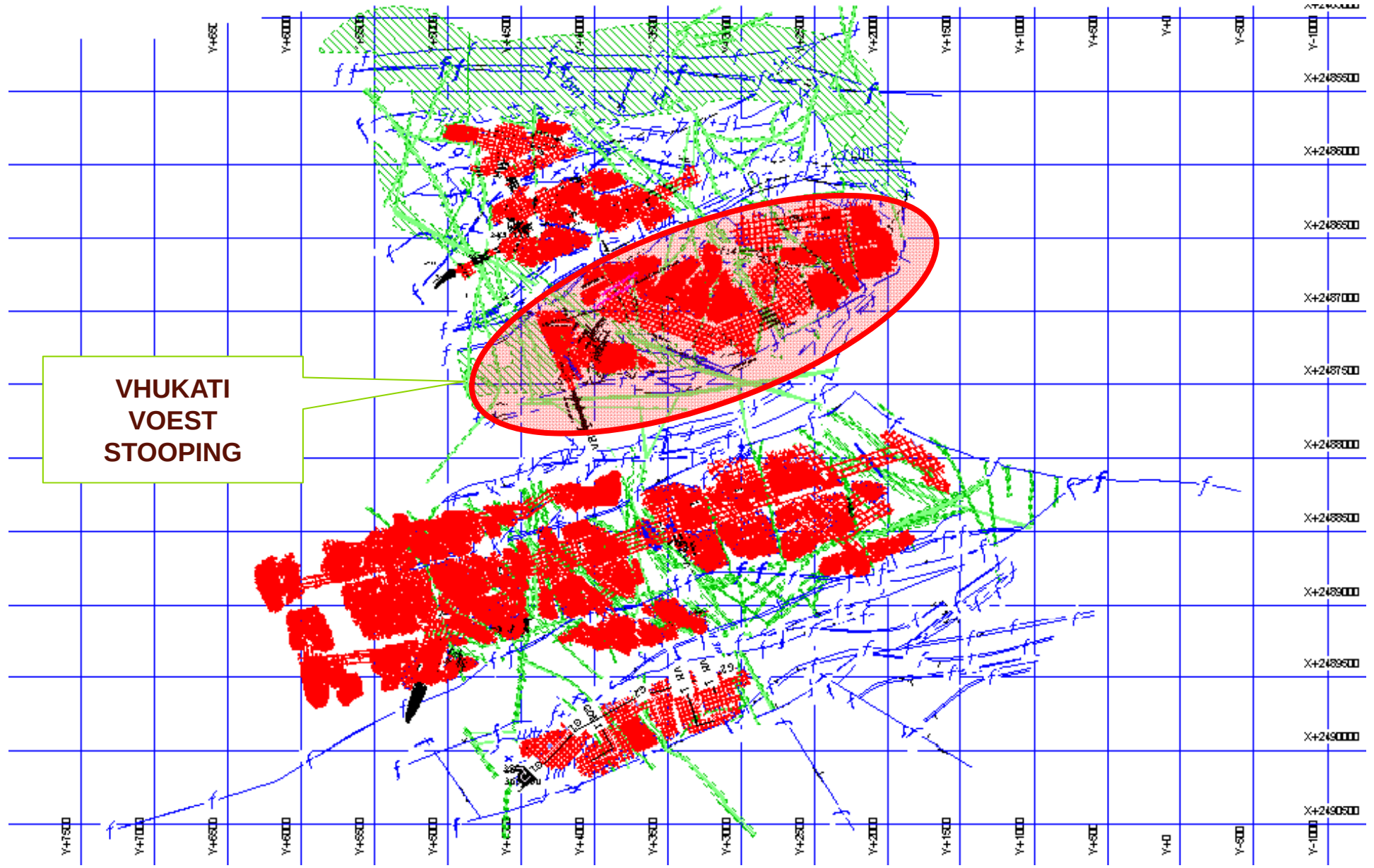


NYALA



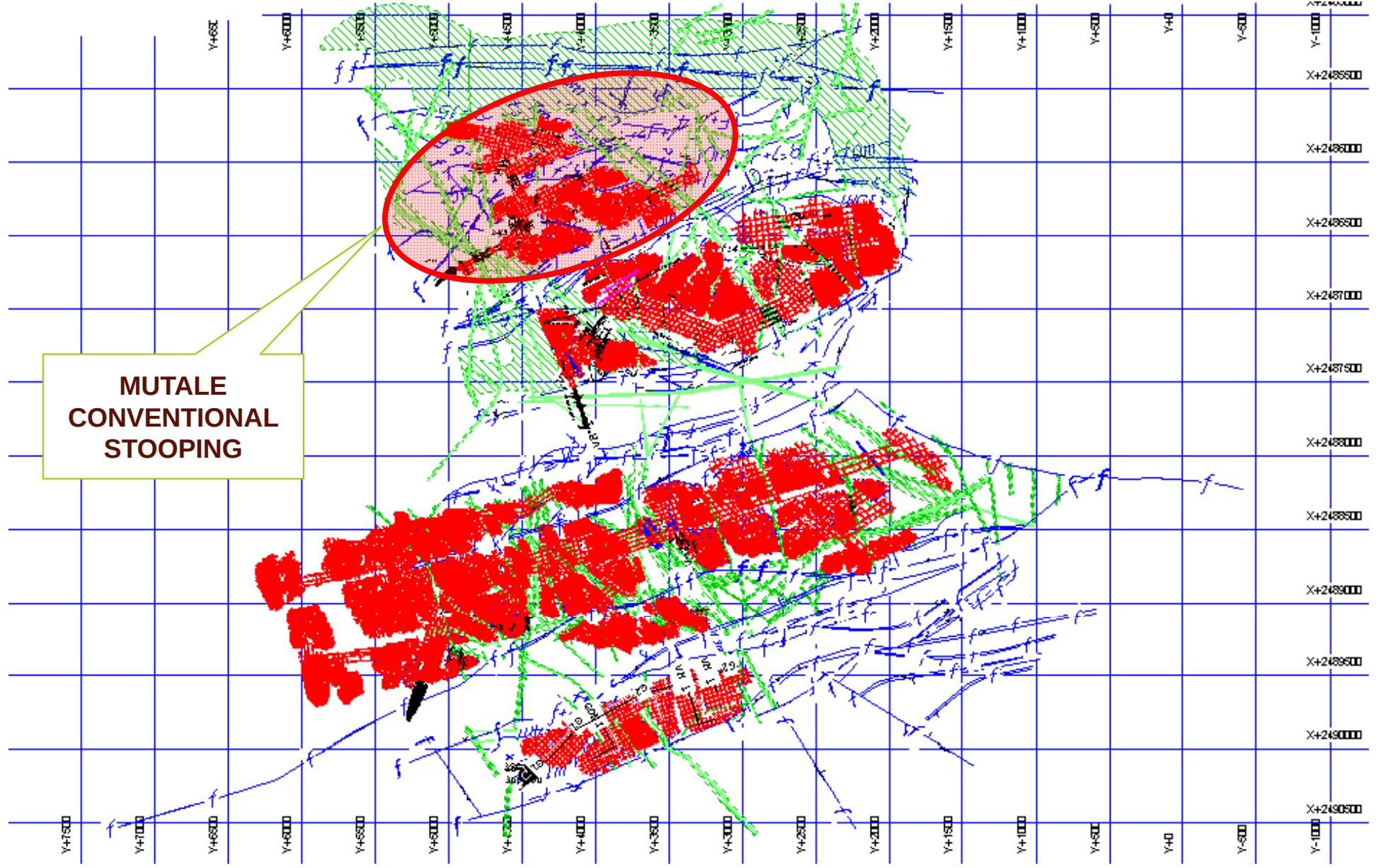


VHUKATI
VOEST
STOOPING





**MUTALE
CONVENTIONAL
STOOPING**



CURRENT OPERATIONS

PRODUCTION FIGURES

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		2011	2012	2013	2014	2015	2016
<u>Tons per Shaft</u>							
Vhukati coal	tons	150 226	153 120	157 962	188 364	188 399	63 819
Mutale coal	tons	58 068	78 535	99 604	43 587	0	0
Goni coal	tons	281 455	302 557	267 949	201 357	26 744	0
TOTAL COAL	tons	489 748	534 212	525 515	433 311	215 143	63 819



Mining Challenges

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Four major factors that influence our mining activity:

- **Faults and Joints** - All prominent faults strike northeast/southwest and tend to meander along strike
- **Prominent dolerite intrusions, such as dykes and sills** - Some of which are non magnetic, making their detection difficult. Sills are up to 30m thick, whereas dykes are up to 25m wide. Resultant “Burnt Coal” varies in width.
- **Dipping of the coal seam** - The average strike of the Main Seam is northwest-southeast. The dip of the coal seam varies between 2° and 18°, with an average dip of 11°. The coal seam dips from outcrop to depths of over 400m in a north-easterly direction
- **Occurrence of high horizontal stress** - The max horizontal stress is 26° West of North; of which the magnitude increases with depth

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PLANNING

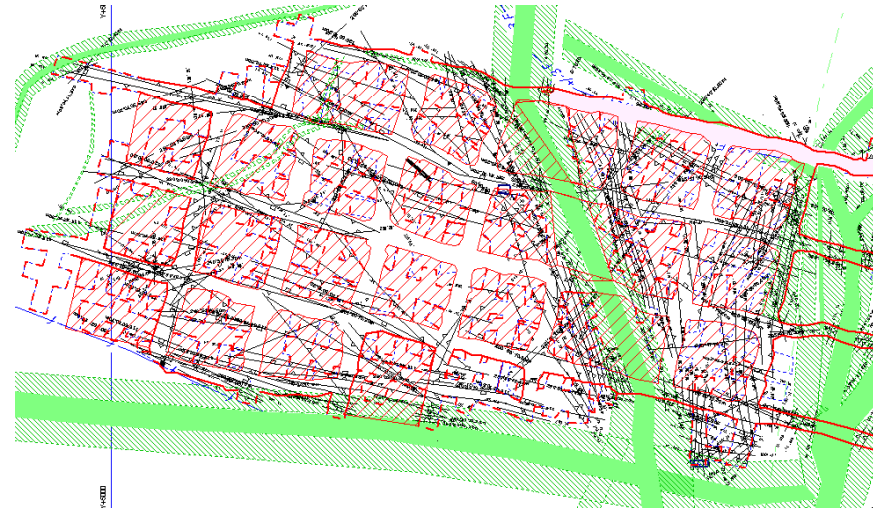
HOW DOES ONE PLAN FOR THIS?

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Mutale Shaft

Approx Depth:	220m
Dip:	9° - 17°
Intrusions:	Multiple dykes/sills
Discontinuities:	Multiple joint sets/wedges Multiple faults
Condition of joints:	Smooth/Polished/Water



ENTRENCHED BEST PRACTICES

PRO-ACTIVE SAFETY APPROACH

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- **Surface infill drilling:**

Additional surface holes drilled into 500m exploration grid; site specific and dependant on results from exploration grid

- **Horizontal confirmation:**

Continuous horizontal drilling confirms structures for at least 200m ahead of mining layout. No layout approved without horizontal confirmation

- **Daily structure mapping by Strata Officers:**

Strata Officers assigned to each shaft for daily structural mapping. Mapped structures are incorporated into working plans

- **Monthly Section Ratings by Rock Engineer:**

Section Risk Ratings performed on monthly basis.

- **Knowledge Transfer:**

Strata Book –Strata Risk “Trigger & Response” method



Individual Pillar Risk Assessments – Assessing Risk of each pillar & thus extracting each individual pillar on its own merit

WHAT NYALA TAUGHT US

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Stooping operations at Nyala Main Shaft showed that:

1. Many pillars were lost due to the fact that shaft development planning never considered stooping, i.e. exit roads, infrastructure
2. Dykes were the enemy of development, but the friend of pillar extraction
3. Stooping up-dip causes the roof to mobilize into the resultant cavity
4. Effective support during development enables higher pillar extraction ratios
5. Knowledge and experience must be transformed into effective tools that are readily available for use by employees at the face
6. Each pillar must be taken on it's own merit

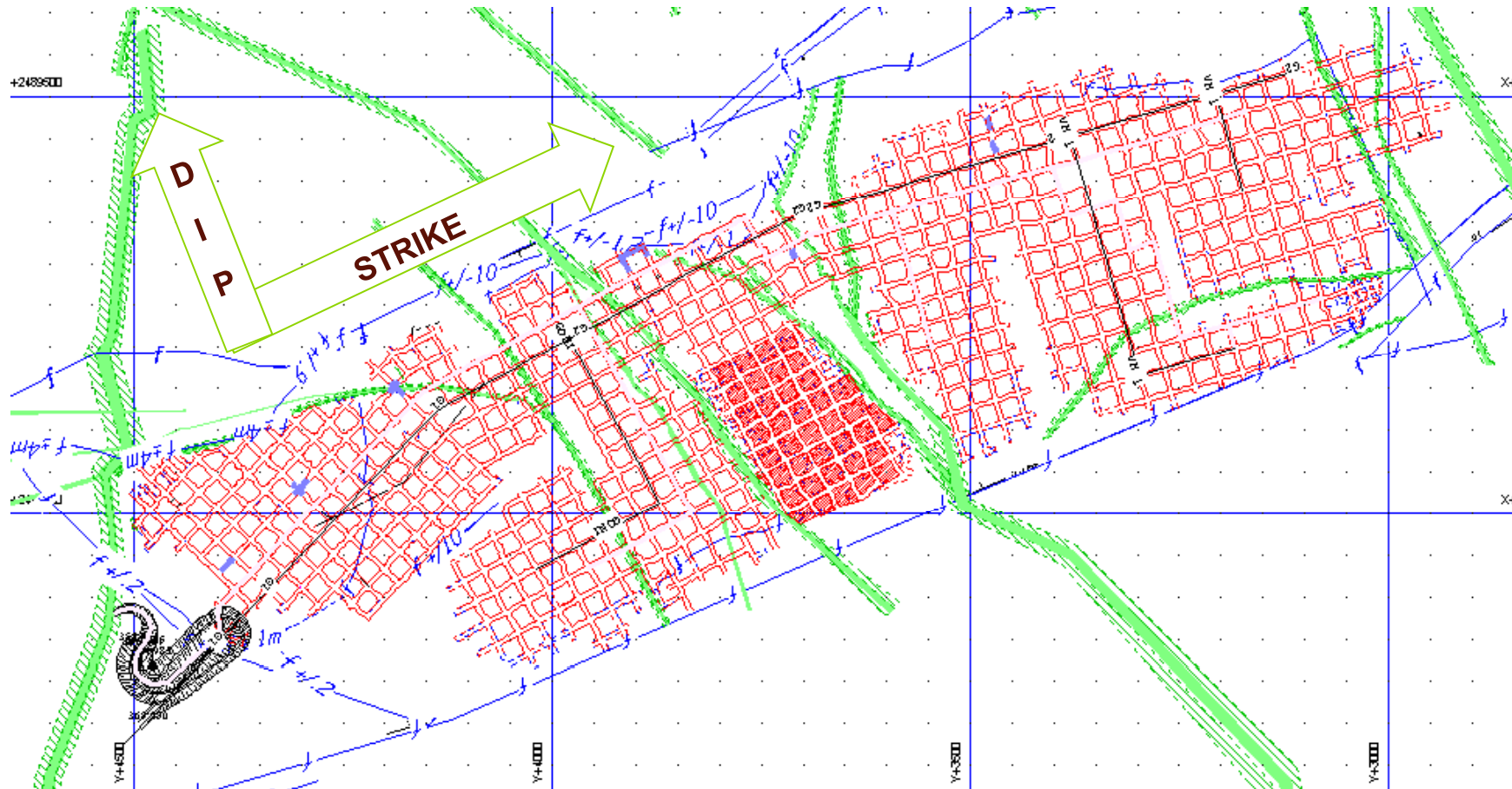
**IN OTHER WORDS – PLAN, DESIGN AND MINE FOR SAFE, OPTIMUM,
RESPONSIBLE EXTRACTION OF COAL RESERVES**



1-2-3 DESIGN DEVELOPMENT FOR STOOPING

GONI SHAFT DESIGNED FOR OPTIMUM RESERVE EXTRACTION

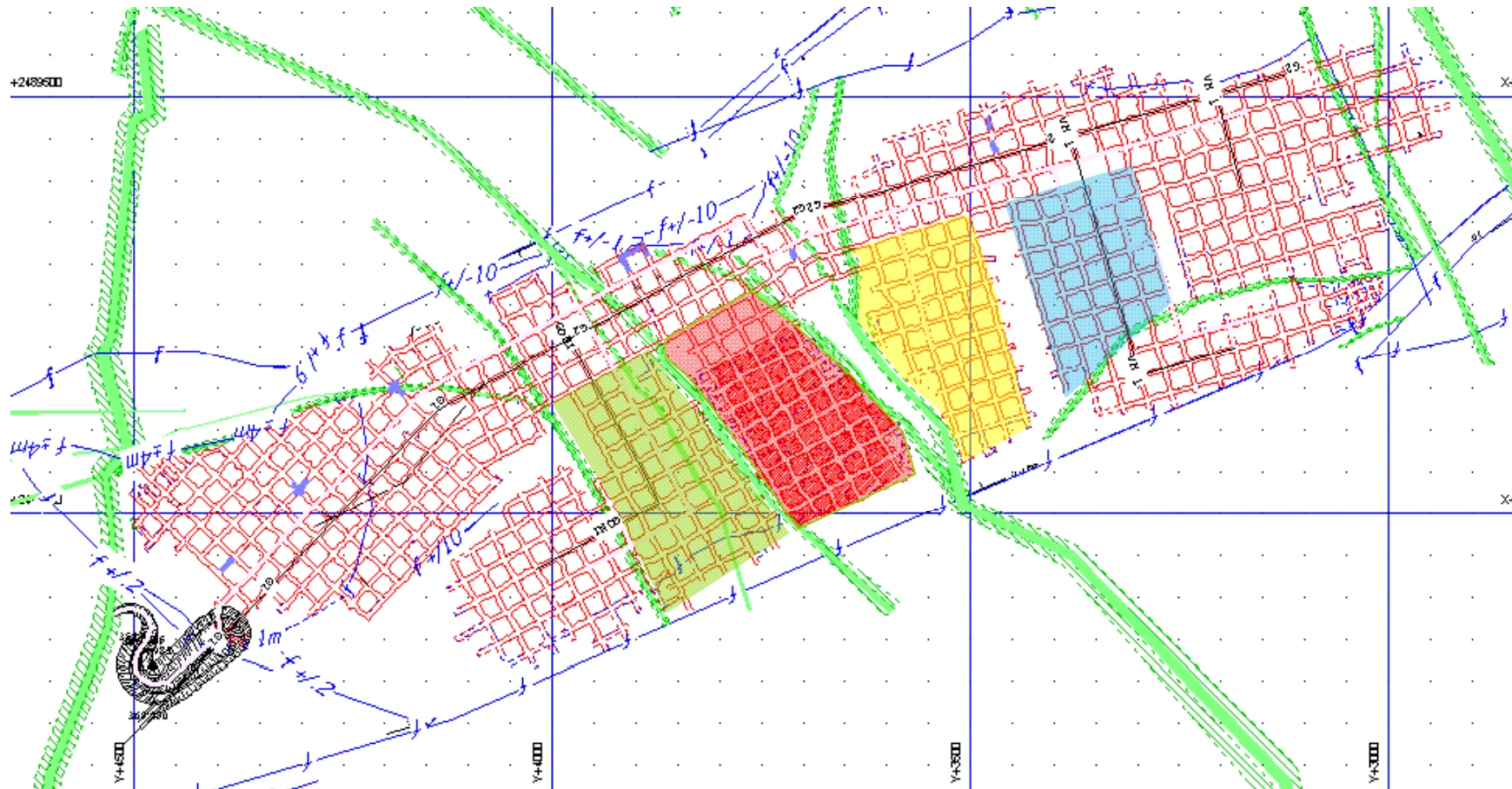
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1, 2, 3 DESIGN DEVELOPMENT FOR STOOPING

UTILIZE DYKES AS NATURAL BARRIERS

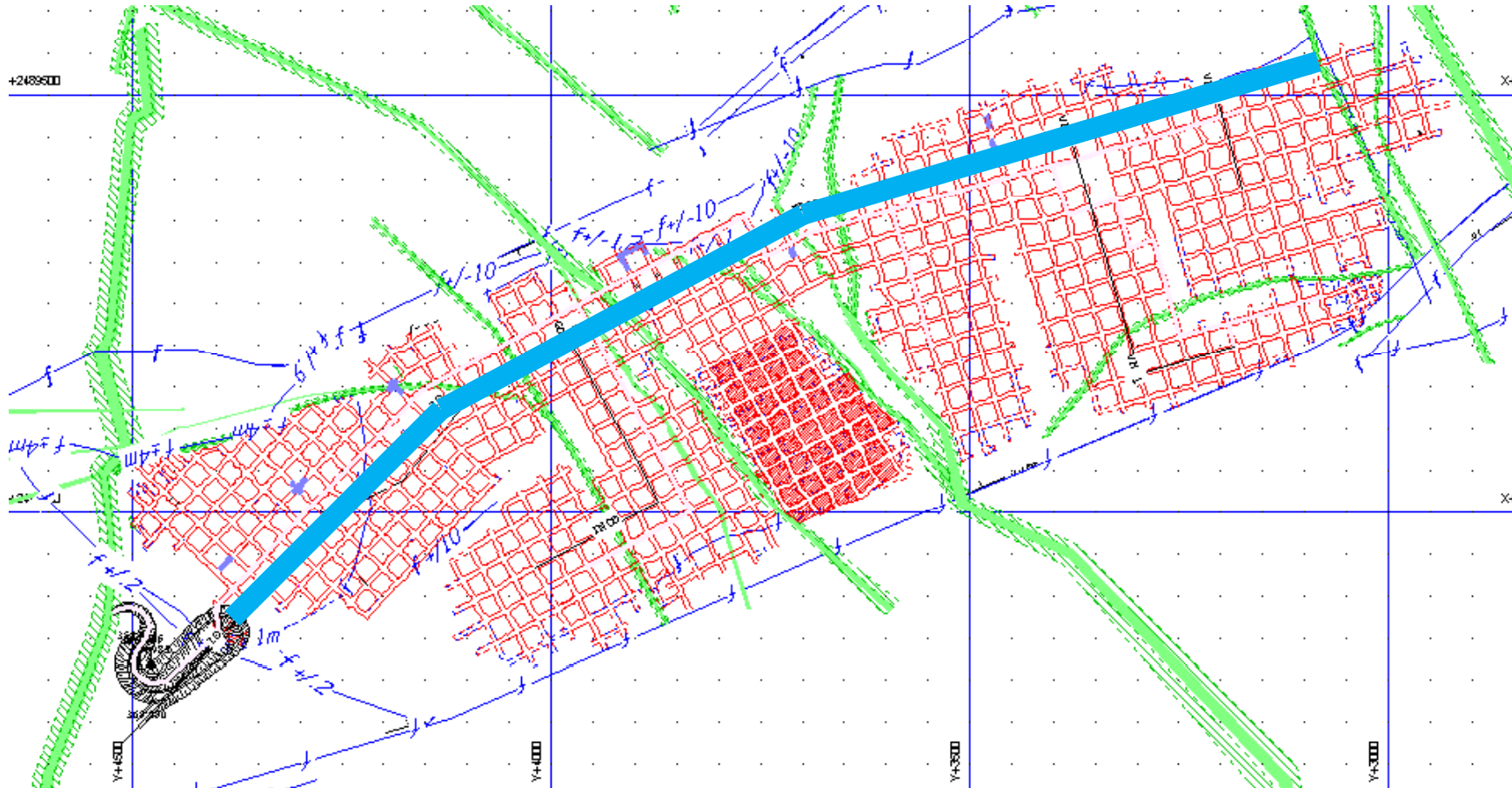
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1, 2, 3 DESIGN DEVELOPMENT FOR STOOPING

KEEP MAIN INFRASTRUCTURE DOWN-DIP

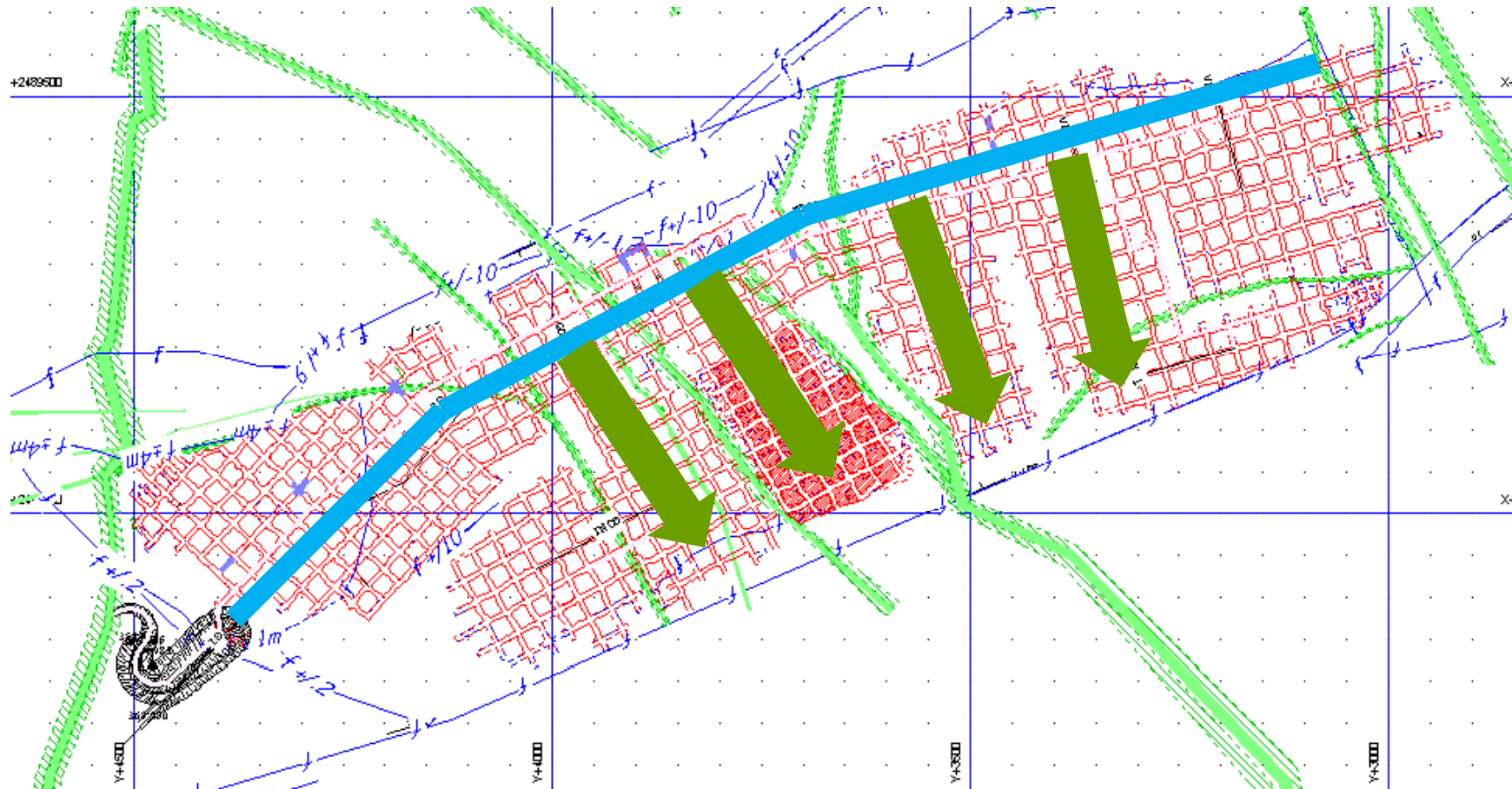
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1, 2, 3 DESIGN DEVELOPMENT FOR STOOPING

DEVELOP PANELS UP-DIP

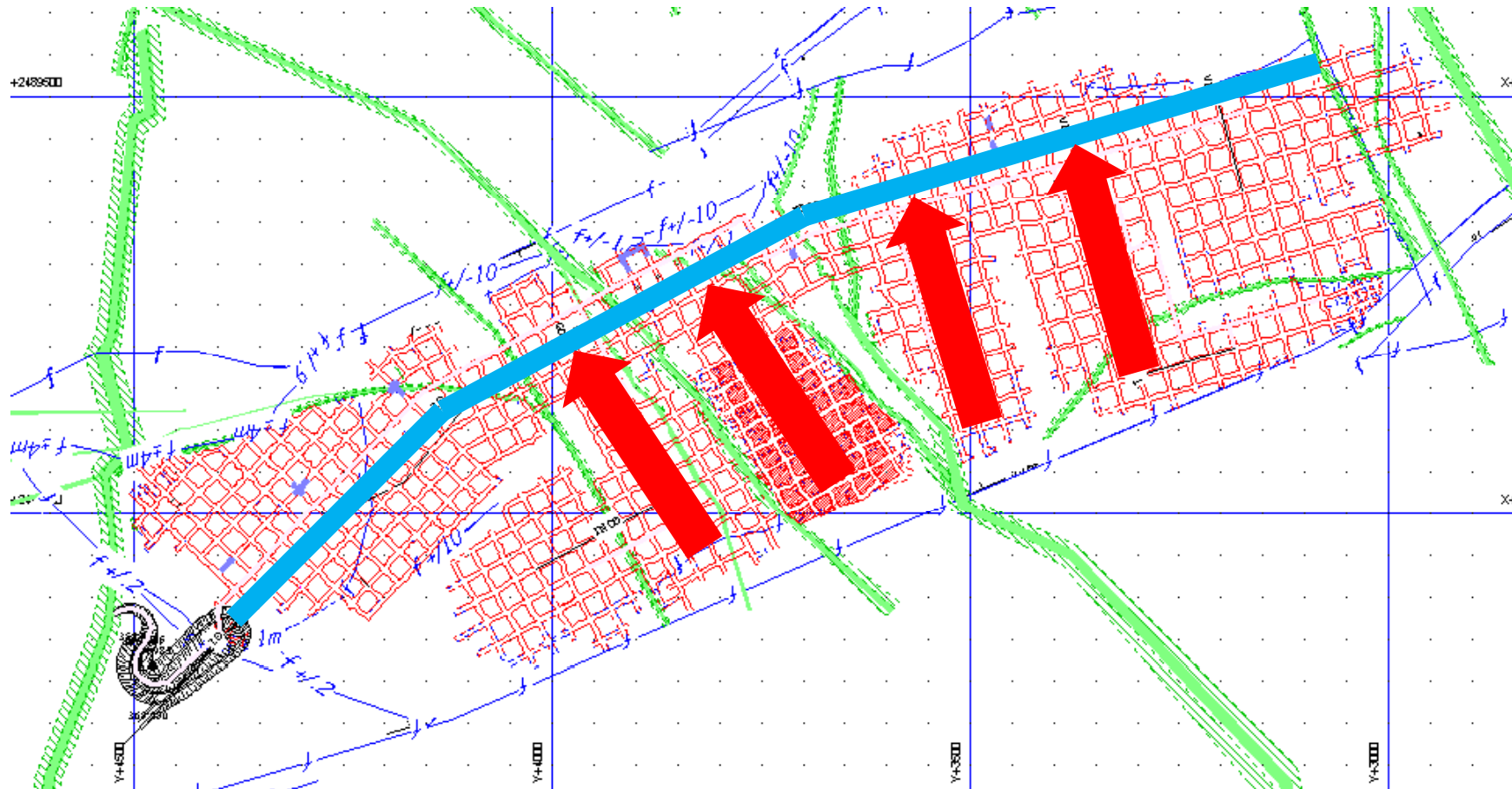
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1, 2, 3 DESIGN DEVELOPMENT FOR STOOPING

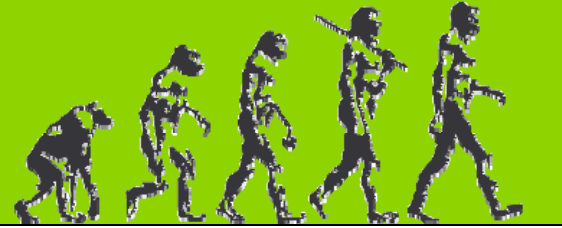
STOOP PANELS DOWN-DIP

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4 EFFECTIVE SUPPORT

EVOLUTION OF A STANDARD



26

- Effective beam-building can only be achieved with stiff active support
- The effect of horizontal stress on the beam can only be minimized with stiff active support
- Failure is time dependant; quick bolting must be achieved



5-6 KNOWLEDGE TRANSFER

EFFECTIVE USER-FRIENDLY TOOLS

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INDIVIDUAL PILLAR RISK ASSESSMENT																													
PHYSICAL VISUAL OBSERVATIONS																													
DATE		SECTION			PILLAR NR		PERFORMED BY																						
PILLAR GEOLOGY	Material	Friable/Burnt	Partially disturbed	Coal																									
	Dykes/Faults/Sandstone Rolls	Multiple	Single	None																									
	Pillar dip	>15°	between 8° and 15°	<8°																									
	JOINTS																												
	Documented vs actual	Incorrect		Correct																									
	Number	Multiple	Single	None																									
	Sets	Multiple	Single	None																									
	Joint Surface	Smooth		Rough																									
	Continuity	Continuous		Layer Bound																									
	Stability	Opening	Stable	Self Locking																									
Support	SUB STD		STD																										
DEVELOPED ROADS	Design Parameters vs Actual Mining																												
	Road width	>6m	6m	<6m																									
	Intersection Span	>21m	>21m Cable Anchors	<21m																									
	Intersection Support	Sub Std		Std																									
	Joints	Multiple	Single	None																									
	Telltales	None Present		Present																									
PILLAR ATTRIBUTES	Scaling	>0.3m	<.03m	Stable																									
	Joints in sidewalls	Multiple	Single	None																									
	Dimensions/Safety Factor	<1.6	1.6 to 1.8	>1.8																									
	W/H Ratio	<3	>3, <4	>4																									
	Visible Influence from stooping	Excessive scaling/Slide	Minor scaling	None																									
POSITIONING OF CUT	Pillar size	>30m 2 lifts		<30m 1 lift																									
	BISECTS IN PLACE TO ENSURE STRAIGHT/INTENDED MINING DIRECTION																												
	Fender size vs Cut out distance	>9m	9m	<9m																									
	JOINTS																												
	Orientation vs Cut	Parallel	Oblique	Perpendicular																									
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	Wedges vs Cut	Parallel	Oblique	Perpendicular																									
	Positioning of cable handler vs cut	Adjacent Goaf	Intersection	Developed Road																									
	Visible joints extended into pillar as to consider in pillar conditions	NO		YES																									
	Cut vs Retrievability	Extend joints into pillar		Consider cond in pillar																									
Risk Assessment outcomes	Pillar Safe for extraction	NO	YES																										
	If YES what method	CUTTING OF SINGLE CUT NOT EXCEEDING 9m																											
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		SPLITTING OF PILLAR, CUT EXCEEDING 9m																											
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	Est time to be spent on pillar	> 10 SHIFTS	6 - 10 SHIFTS	< 6 SHIFTS																									
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	Est Extraction Tons																												
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5-6 KNOWLEDGE TRANSFER

EFFECTIVE USER-FRIENDLY TOOLS

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PERFORMED BY									
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	Pillar dip	>15°	between 8° and 15°	<8°					
	JOINTS								
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	Number	Multiple	Single	None					
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	Joint Surface	Smooth		Rough					
	Continuity	Continuous		Layer Bound					
	Stability	Opening	Stable	Self Locking					
Support	SUB STD		STD						
DEVELOPED ROADS	Design Parameters vs Actual Mining								
	Road width	>6m	6m	<6m					
	Intersection Span	>21m	>21m Cable Anchors	<21m					
	Intersection Support	Sub Std		Std					
	Joints	Multiple	Single	None					
	Telltales	None Present		Present					
PILLAR ATTRIBUTES	Scaling	>0.3m	<.03m	Stable					
	Joints in sidewalls	Multiple	Single	None					
	Dimensions/Safety Factor	<1.6	1.6 to 1.8	>1.8					
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	Visible Influence from stooping	Excessive scaling/Slide	Minor scaling	None					
POSITIONING OF CUT	Pillar size	>30m 2 lifts		<30m 1 lift					
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	JOINTS								
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	Wedges vs Cut	Parallel	Oblique	Perpendicular					
	Positioning of cable handler vs cut	Adjacent Goaf	Intersection	Developed Road					
	Visible joints extended into pillar as to consider in pillar conditions	NO		YES					
	Cut vs Retrievability	Extend joints into pillar	Medium	Good					
Risk Assessment outcomes	Pillar Safe for extraction	NO	YES						
	If YES what method	CUTTING OF SINGLE CUT NOT EXCEEDING 9m							
		CUTTING OF MULTIPLE CUTS NOT EXCEEDING 9m							
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5-6 KNOWLEDGE TRANSFER

EFFECTIVE USER-FRIENDLY TOOLS

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DATE	SECTION			PILLAR NR	PERFORMED BY		
PILLAR GEOLOGY	Material	Exposed	Partially disturbed	Coal			
	Dykes/Faults/Sandstone Rolls	Multiple	Single	None			
	Pillar dip	>15°	between 6° and 15°	<6°			
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EFFECTIVE USER-FRIENDLY TOOLS

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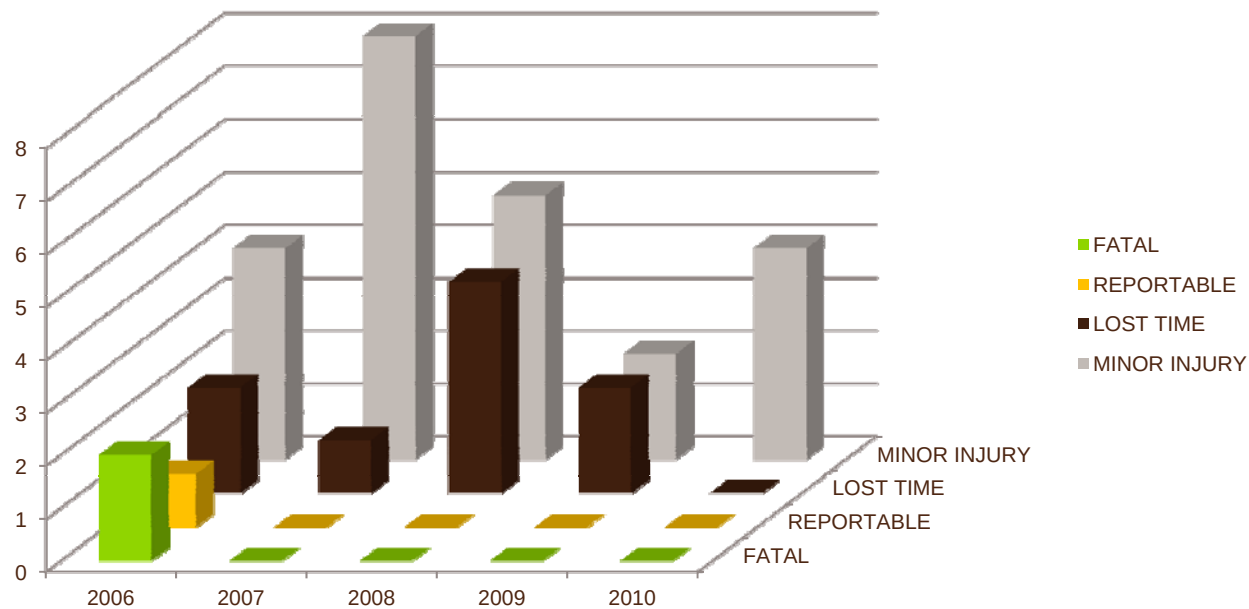


PROOF IN THE PUDDING

FOG SAFETY STATS LAST 5 YEARS

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YEAR	FATAL	REPORTABLE	LOST TIME	MINOR INJURY
2006	2	1	2	4
2007	0	0	1	8
2008	0	0	4	5
2009	0	0	2	2
2010	0	0	0	4

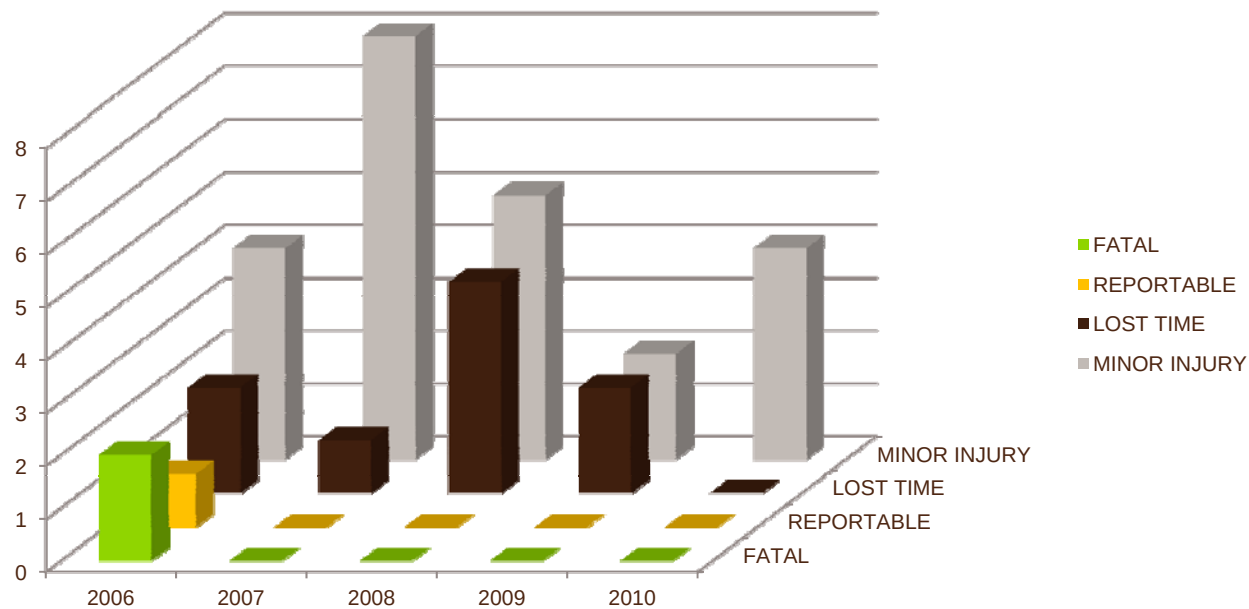


PROOF IN THE PUDDING

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2006	2	1	2	4
2007	0	0	1	8
2008	0	0	4	5
2009	0	0	2	2
2010	0	0	0	4

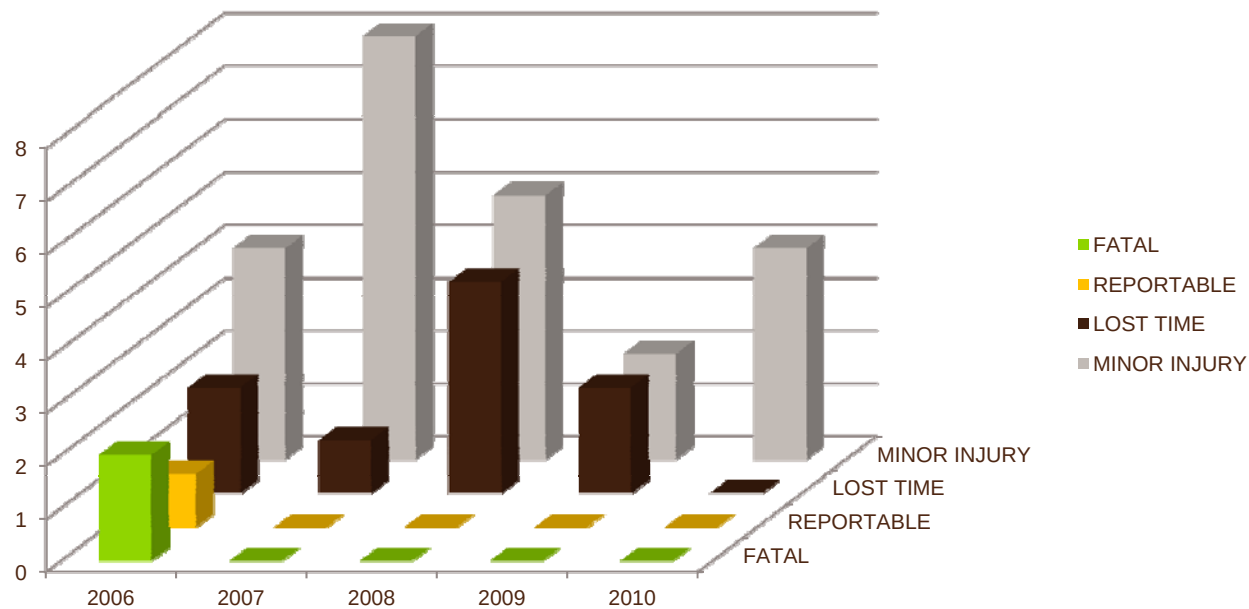


PROOF IN THE PUDDING

FOG SAFETY STATS LAST 5 YEARS

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YEAR	FATAL	REPORTABLE	LOST TIME	MINOR INJURY
2006	2	1	2	4
2007	0	0	1	8
2008	0	0	4	5
2009	0	0	2	2
2010	0	0	0	4



THANK YOU