APPENDIX Q: SUMMARY OF AMD ASSESSMENTS (STANTEC)

BEYOND 2018 – SUMMARY OF AMD ASSESSMENTS OF ST IVES GOLD MINE

PREPARED FOR GOLD FIELDS LTD

20 July 2018

Stantec

20 July 2018

Gold Fields Ltd
Durkin Road
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Attention: **Alex Langley**
Superintendent: Environment Approvals

Dear Alex,

RE: Beyond 2018 - Summary of AMD Assessments at St Ives Gold Mine

This letter documents a summary of the geochemical characterisation assessments completed by Stantec Australia Pty Ltd (Stantec) for Gold Fields St Ives Gold Mine (SIGM) following the 2015 Acid Metalliferous Drainage (AMD) Optimisation Study (MWH, 2016a). The intent of this summary is to inform the SIGM Beyond 2018 project.

As of 2015, over 3,000 samples collected from SIGM had been analysed for acid generation potential. Since 2015, six additional AMD assessments have been completed by Stantec, comprising a total of 165 mine waste samples from various lithologies across the SIGM operation.

The entire Project has previously been separated into three Project Areas, known as the: Northern, Central and Southern Project Areas. This structure has been followed for presentation of the sample locations and their classification within **Figure 1**; **Figure 2** and **Figure 3** (the number in brackets represents the total number of samples from the specified area).

Acid Base Accounting Classification Criteria

The acid base accounting (ABA) classification criteria used for the SIGM geochemical assessments is presented in **Table 1**. The criteria have been developed in accordance with the Global Acid Rock Drainage (GARD) Guide (INAP, 2009) and the AMIRA International Acid Rock Drainage (ARD) Test Handbook (AMIRA, 2002). The criteria also align with the *Leading Practice Sustainable Development Program for the Mining Industry Handbook on Preventing Acid and Metalliferous Drainage* (DIIS, 2016).

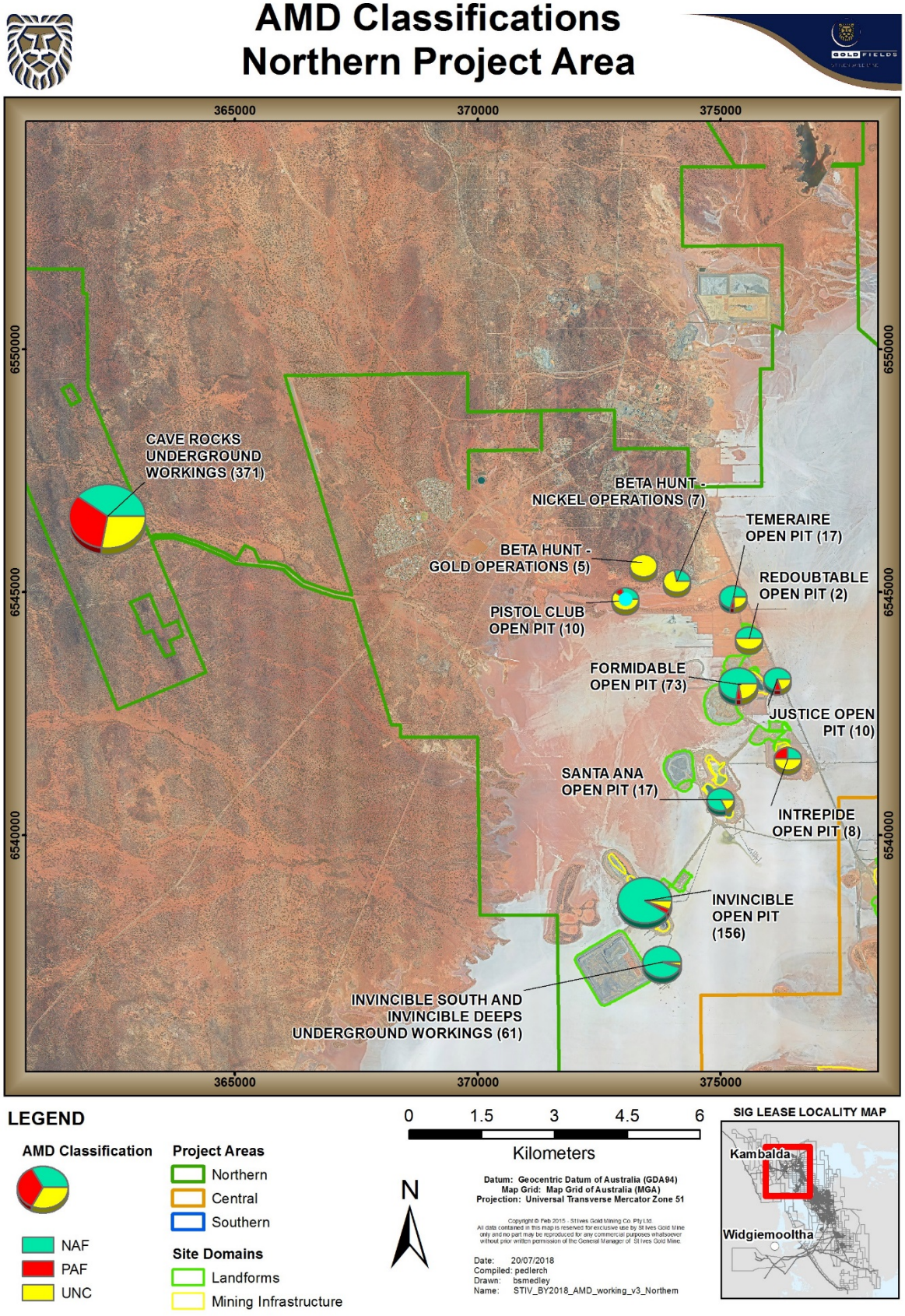

Figure 1: Northern Project Area AMD sample location and classification

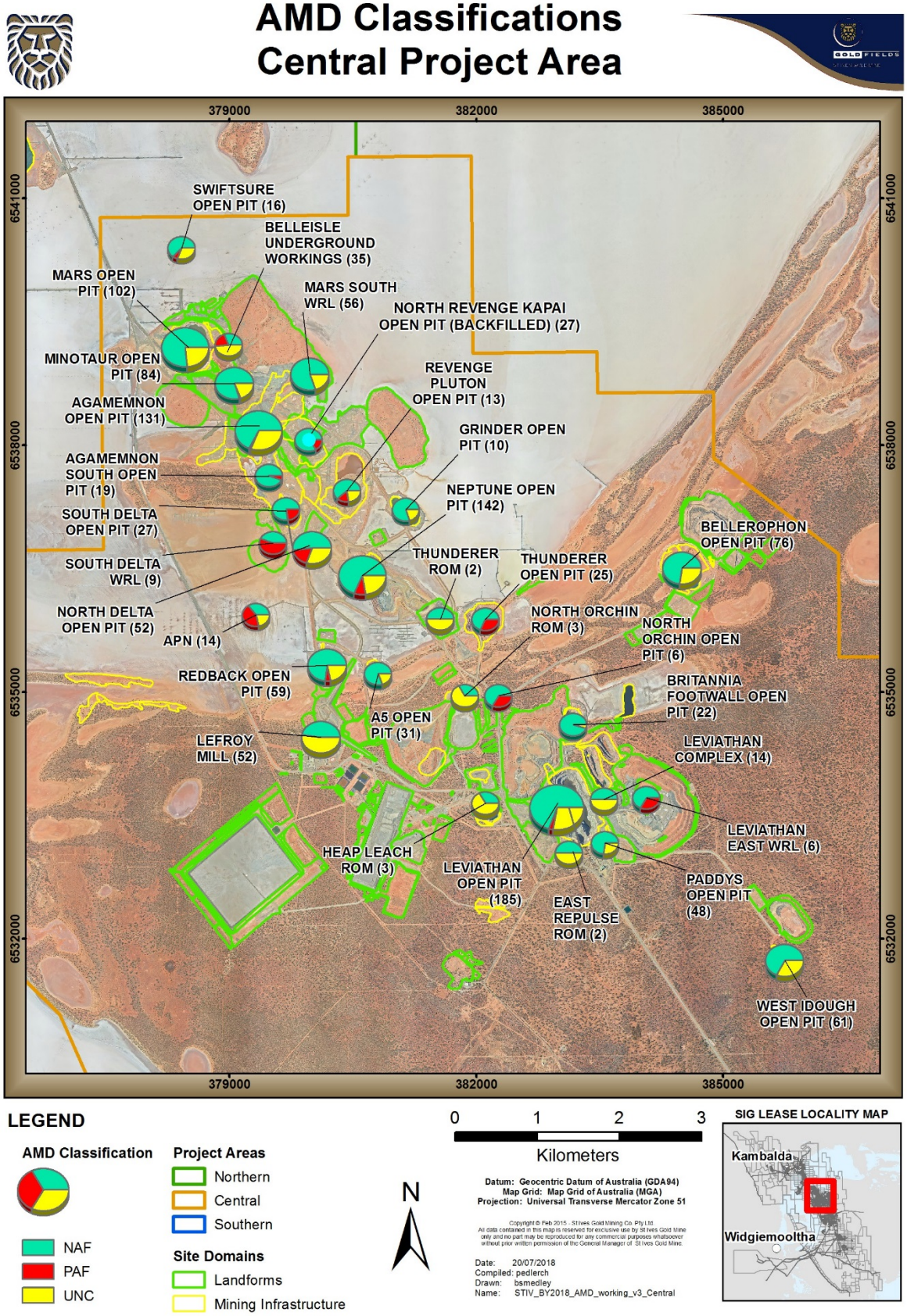

Figure 2: Central Project Area AMD sample location and classification

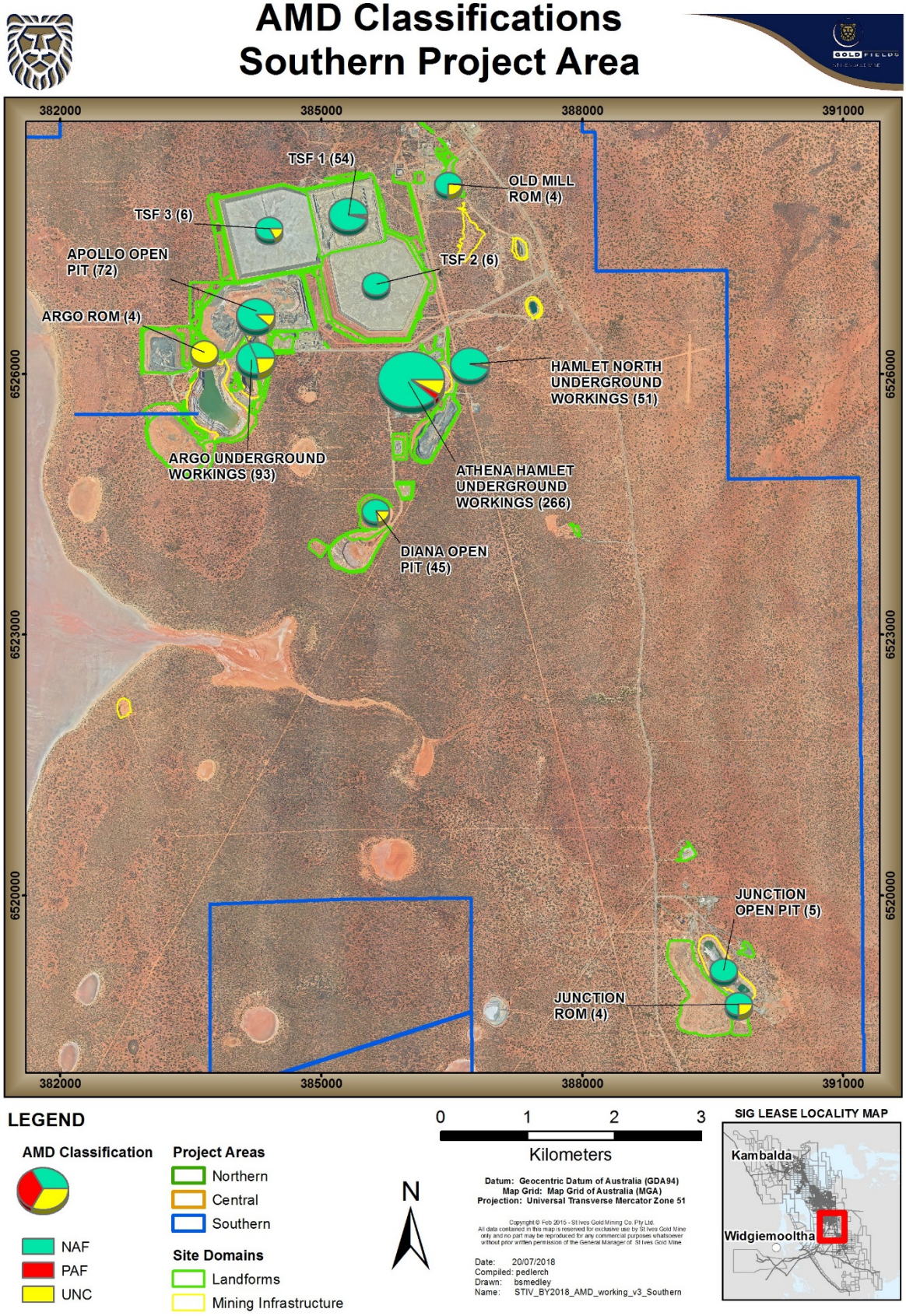

Figure 3: Southern Project Area AMD sample location and classification

Table 1: Classification criteria for static ABA (see Notes for glossary of terms)

Classification	NAPP	NAG_{pH}	ANC/MPA	%S [1]	Notes
Acid Consuming (AC)[2]	<-20 kg H_2SO_4/t	pH >4.5	≥2	<0.1	Must meet all criteria
Non-acid Forming (NAF)	<0 kg H_2SO_4/t	pH >4.5	>1	<0.3	
Uncertain (UNC)	<0 kg H_2SO_4/t	pH >4.5	>1 and <2	>1.0	May be related to insufficient sulfide oxidation
		pH ≤4.5	>1	>0.1	Conflicting results
	>0 kg H_2SO_4/t	pH ≤4.5	<1	<0.1	May be related to presence of other acids[3]
		pH >4.5	>1 and <2	>0.1	Conflicting results
Potentially Acid Forming (PAF)	>0 kg H_2SO_4/t	pH ≤4.5	<1	>0.3	Further classification of PAF material may be required for high %S

Notes:

1. Total %S values are a guideline only, as sulfur content can be in different mineralogical forms and may be highly variable in a sample. This classification criterion is less important than other criteria and is generally only related to classification of samples as AC, NAF or PAF.
2. AC classification incorporates a safety factor related to Total S% and ANC.
3. Generally related to samples with high organic carbon (TOC generally >5%).

Limitations

There are some limitations to the dataset as not all of the data was complete. The number of unknown samples in the database is 391; these samples were excluded from the analysis.

Where published ABA classifications were not provided in the database, the criteria presented in **Table 2** was used to classify samples.

Table 2: Classification criteria utilised in the absence of ABA classifications

Classification [1]	NAPP	NAG pH	Sulfide S [2]	NP/AP ratio
NAF	- NAPP	>4.5	S <0.3	>2
PAF	+NAPP	<4.5	S >0.3	<2
UNC	any sample that does not meet the above criteria			

Notes:
Some samples contained only NAGpH values. In these cases, NAF or PAF classification was based on this criterion.
Where sulfide sulfur values were not available, total S was used.

Previous AMD Assessments

The six AMD assessments undertaken for mine waste materials from various deposit at SIGM, since the 2015 AMD Optimisation Study (MWH, 2016a) are presented in **Table 3**. These assessments were undertaken to provide supporting information for the development of related Mining Proposals.

The 165 samples analysed comprised various lithological units typical of the SIGM mine area. The majority of samples were found to be non-problematic with respect to acid generation potential (i.e. classified as NAF, NAF-barren or AC). In general, samples from the Cainozoic, Tertiary sediment and Upper saprolite units had the potential to be acid generating and were considered unsuitable for use in rehabilitation, requiring selective management. Isolated samples within the Paringa Basalt, Merougil Creek Beds, Felsic Intrusion, Defiance Dolerite units were classified as either UNC or PAF.

Table 3: Summary of geochemical assessments completed by Stantec for SIGM projects (see key for glossary of terms)

Deposit	Reference	Number of Samples Analysed	Lithologies (Number of Samples)	ABA Classification	Elements of Potential Environmental Concern	Recommendations for Management
Pistol Club Open Cut Mine	MWH (2016b)	10	• Tertiary sediments (6) • Upper saprolite (2) • Lower saprolite (1) • Paringa Basalt (1)	All samples within the Tertiary sediments and Upper saprolite lithologies (8 samples) were classified as either UNC-PAF_{LC} or PAF_{LC}. The lower saprolite and Paringa Basalt samples were classified as NAF.	**GAI**: all lithologies enriched in sulfur (GAI between 7 and 8). **Total elements**: all samples were elevated in Ni relative to EIL and ISQG screening criteria. Minor exceedances in Cr and Cu observed in Tertiary sediments and Paringa Basalt lithologies. **Soluble elements**: elevated concentrations of soluble elements reported for Tertiary sediments (Zn and Cu) and Paringa Basalt (Ni).	**Tertiary sediments and Upper saprolite**: materials from these units (estimated volume of 1,805,893 BCM) should be selectively segregated and placed in below-water table disposal areas (e.g. open pit backfill), or by encapsulating materials in benign, non-acid producing and/or acid consuming materials. **Lower saprolite and Paringa Basalt**: materials from these units (estimated volume of 7,897 BCM) may be suitable for use in rehabilitation. Further assessment of physical properties and potential for bioavailable elements is required if used on outer batters of landforms.
Delta Island South Open Pit	MWH (2016c)	12	• Tertiary sediments (2) • Upper saprolite (3) • Paringa Basalt (5) • Defiance Dolerite (2)	Most samples (11 of 12 samples) were classified as NAF, of which three samples (from the Upper saprolite and Paringa Basalt lithologies) were considered NAF-barren. One Paringa Basalt sample was classified as PAF_{LC}.	**GAI**: all lithologies enriched in sulfur (GAI between 6 and 9). **Total elements**: all samples reported minor exceedances in Ni, with most samples also exceeding guideline criteria concentrations for Cr and Cu. **Soluble elements**: most samples had elevated concentrations of soluble Zn relative to the GIL Fresh Water screening criterion. Exceedances in soluble Co, Cu and Ni were also observed for Paringa Basalt samples to the GIL and ANZECC screening criteria.	**Tertiary sediments and Upper saprolite:** materials from these units (estimated volume of 426,100 BCM) are likely to be erodible and are unsuitable for use on the outer surfaces of landforms. It is recommended that the materials be backfilled into the open pit. **Paringa Basalt**: Material from this unit (estimated volume of 38,500 BCM) can be backfilled into the open pit. Further assessment of physical properties (relating to erosion) and potential for bioavailable elements is required if used on outer batters of landforms. **Defiance Dolerite**: Material from this unit (estimated volume of 12,400 BCM) is potentially suitable for use in rock armouring and rock sheeting.

Deposit	Reference	Number of Samples Analysed	Lithologies (Number of Samples)	ABA Classification	Elements of Potential Environmental Concern	Recommendations for Management
Invincible South Open Pit	MWH (2016d)	21	• Tertiary sediments (5) • Lower saprolite (1) • Merougil Creek Beds (5) • Black Flag Beds (10)	Most samples (16 of 21 samples) were classified as NAF, of which three samples were considered NAF-barren. One sample was classified as UNC (Merougil Creek Beds). Four samples were classified as PAF (Tertiary sediment – two samples, and one sample each of Lower saprolite and Merougil Creek Beds). All samples that were classified as UNC of PAF were collected from drill hole LD14645 which is located in the vicinity of one of the declines and may be located within the mineralised zone.	**GAI**: no element enrichment measured. **Total elements**: generally elevated concentrations of As, Cr, Ni and Zn relative to EIL and ISQG screening criteria. Isolated exceedances in Cu, Pb and Hg also observed in Tertiary sediments and Lower saprolite. **Soluble elements**: generally elevated concentrations of soluble Co, Ni and Zn relative to GIL and ANZECC screening criteria.	**Tertiary sediments / lake sediments:** materials from this unit (estimated volume of 1,099,000 BCM) are likely to be erodible and are unsuitable for use on the outer surfaces of landforms. It is recommended that the materials be backfilled into open pits. **Upper and Lower saprolite and oxidised Merougil Creek Beds and Black Flag Beds**: materials from these units (estimated volume of 997,000 BCM) are likely to be erodible and are unsuitable for use on the outer surfaces of landforms. It is recommended that the materials close to the ore zone and weathered zone be backfilled into open pits. **Merougil Creek Beds (predominantly transitional)**: recommended uses for this material (estimated volume of 169,000 BCM) included: • Backfill waste mined form close to ore zone and weathered zone waste to open pit; • Less competent transitional material is likely to be unstable and unsuitable for use on outer surfaces of the landform; and • Larger grain size, fresh rock mined outside of mineralised zone may be used on outer batters of waste rock landforms on lake-based mine areas (verification of absence of PAF required prior to use). **Black Flag Beds**: material from this unit (estimated volume of 527,000 BCM) is potentially suitable for use in rock armouring, rock sheeting (with sediment control bunding)

Deposit	Reference	Number of Samples Analysed	Lithologies (Number of Samples)	ABA Classification	Elements of Potential Environmental Concern	Recommendations for Management
						and in co-blending with PAF material due to higher neutralising capacity.
Justice Open Pit	Stantec (2018a)	10	• Cainozoic Units (3) • GIA Felsic Intrusion (2) • Tripod Hill Komatiite (4) • Unclassified Felsic Intrusion (1)	Most samples (7 of 10 samples) were classified as NAF or AC. Two samples from the Cainozoic Unit were classified as UNC-PAF_{HC}. One sample (Unclassified Felsic Intrusion) was classified as PAF_{LC}.	**GAI**: all lithologies enriched in sulfur (GAI between 8 and 12). **Total elements**: generally elevated concentrations of Cr and Ni relative to EIL and ISQG screening criteria. **Soluble elements**: Cainozoic Units and GIA lithologies generally had elevated concentrations of soluble Zn relative to GIL screening criteria.	**Cainozoic Units and Unclassified Felsic Intrusion:** materials from these units (unknown volume) should be either: • backfilled into Intrepide Open Pit below water-table to prevent oxidisation of sulfide minerals in the material; or • encapsulated in benign, non-acid producing and/or acid consuming materials. **GIA Felsic Intrusion and Tripod Hill Komatiite**: materials from these units (unknown volume) can be backfilled into Intrepide Open Pit. Materials may also be suitable for encapsulation of PAF materials encountered during mining operations. Further investigation into the availability of ANC (e.g. ABCC testing, sequential NAG testing) is recommended to determine suitability as an encapsulation material.
Hamlet North Underground Mine	Stantec (2018b)	51	• Defiance Dolerite (36) • Medium-grained Feldspar (1) • Paringa Basalt (9) • Unclassified Intermediate Intrusive (5)	Most samples (49 of 51 samples) were classified as NAF or AC. One Defiance Dolerite sample was classified as UNC, and one Paringa Basalt sample was classified as PAF_{HC}.	**GAI**: all lithologies enriched in sulfur (GAI between 5 and 10). **Total elements**: generally elevated in Ni relative to EIL and ISQG screening criteria, with majority of samples from Paringa Basalt also elevated in Cu and Cr. Samples from Unclassified Intermediate Intrusive unit elevated in Cr. **Soluble elements**: all lithologies (excluding Medium-grained	**Defiance Dolerite, Medium-grained Feldspar and Unclassified Intermediate Intrusion:** materials from these unit (estimated volume of 47,000 m^3) can be placed on Athena-Hamlet WRL or backfilled into Hamlet North Underground mine. If materials are placed on the Athena-Hamlet WRL, confirmation of material properties (i.e. competency and physical properties) is required prior to placement on landform. Further investigation into ANC availability (e.g. ABCC and/or sequential NAG testing) may be

Deposit	Reference	Number of Samples Analysed	Lithologies (Number of Samples)	ABA Classification	Elements of Potential Environmental Concern	Recommendations for Management
					Feldspar) reported isolated exceedances in soluble Zn and/or Cu relative to GIL screening criteria.	required for UNC samples (Defiance Dolerite unit) to determine suitability for use. **Paringa Basalt**: material from this unit (estimated volume of 254,000 m^3) can be placed on Athena-Hamlet WRL or backfilled into Hamlet North Underground mine. PAF waste material should be selectively managed by: • placing material below water-table to prevent oxidisation of sulfide minerals; or • encapsulating material with benign, non-acid producing or acid consuming materials.
Invincible South Underground Mine	Stantec (2018c)	31	• BFM - Black Flag Beds (Speedway) Mudstones (8) • BFA - Black Flag Beds Andesite (10) • BLF - Black Flag Beds Unclassified (3) • MER - Merougil Creek Beds (10)	Most samples (29 of 31 samples) were classified as NAF or AC. One MER sample was classified as UNC, and another MER sample was classified as PAF_{LC}.	**GAI**: all lithologies enriched in sulfur (GAI between 5 and 10). **Total elements**: all samples elevated in Ni relative to EIL and ISQG screening criteria. Samples from BFM elevated in As, Cr and Zn. Samples from MER elevated in Cr. **Soluble elements**: some minor exceedances in soluble elements (As, B, Cd and Zn) relative to GIL Fresh Water screening criterion.	**BFM, BFA and BLF:** materials from these units (estimated volume of 600,000 m^3) can be backfilled into the Invincible Underground or Invincible Open Pit. If material is placed on the Invincible WRL, confirmation of material properties (i.e. competency and physical properties) prior is required to placement on landform. **MER:** material from this unit (estimated volume of 26,000 m^3) backfilled into the Invincible Underground or Invincible Open Pit. PAF waste material should be selectively managed by: • placing material below water-table to prevent oxidisation of sulfide minerals; or • encapsulating material with benign, non-acid producing or acid consuming materials.
Invincible Deeps Underground Mine	Stantec (2018c)	30	• BFM - Black Flag Beds (Speedway) Mudstones (10)	Predominantly NAF (29 of 30 samples). One MER samples was classified as UNC.	**GAI**: all lithologies enriched in sulfur (GAI between 5 and 10). **Total elements**: samples generally elevated in Cr and Ni, with	**BFM and BFA:** materials from these units (estimated volume of 471,000 m^3) can be backfilled into Invincible Open Pit. If material is placed on the Invincible WRL, confirmation of material properties (i.e. competency and

Deposit	Reference	Number of Samples Analysed	Lithologies (Number of Samples)	ABA Classification	Elements of Potential Environmental Concern	Recommendations for Management
			• BFA - Black Flag Beds Andesite (10) • MER - Merougil Creek Beds (10)		isolated exceedances in As and Zn within BFM and MER, relative to the EIL and ISQG screening criteria. **Soluble elements**: samples from BFM had elevated concentrations of soluble As relative to GIL Fresh Water screening criterion. All lithologies had isolated exceedances in soluble Zn relative to GIL Fresh Water screening criterion.	physical properties) is required prior to placement on landform. **MER**: materials from this unit (estimated volume of 21,000 m^3) can be backfilled into Invincible Open Pit. If material is placed on the Invincible WRL, confirmation of material properties (i.e. competency and physical properties) is required prior to placement on landform. Further investigation into ANC availability (e.g. ABCC and/or sequential NAG testing) may be required for UNC samples to determine suitability for use.

Key:

ABCC	Acid Buffering Characteristic Curve
AC	Acid consuming
BCM	Billion cubic metres
EIL	Environmental Investigation Level (NEPM, 2013)
GAI	Geochemical abundance index
GIL	Groundwater Investigation Level (NEPM, 2013)
ISQG	Interim Sediment Quality Guideline (ANZECC, 2000)
NAF	Non-acid forming
NAG	Net acid generating
PAF	Potentially acid forming
PAF_{LC}	Potentially acid forming (low capacity)
PAF_{HC}	Potentially acid forming (high capacity)
WRL	Waste Rock Landform

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