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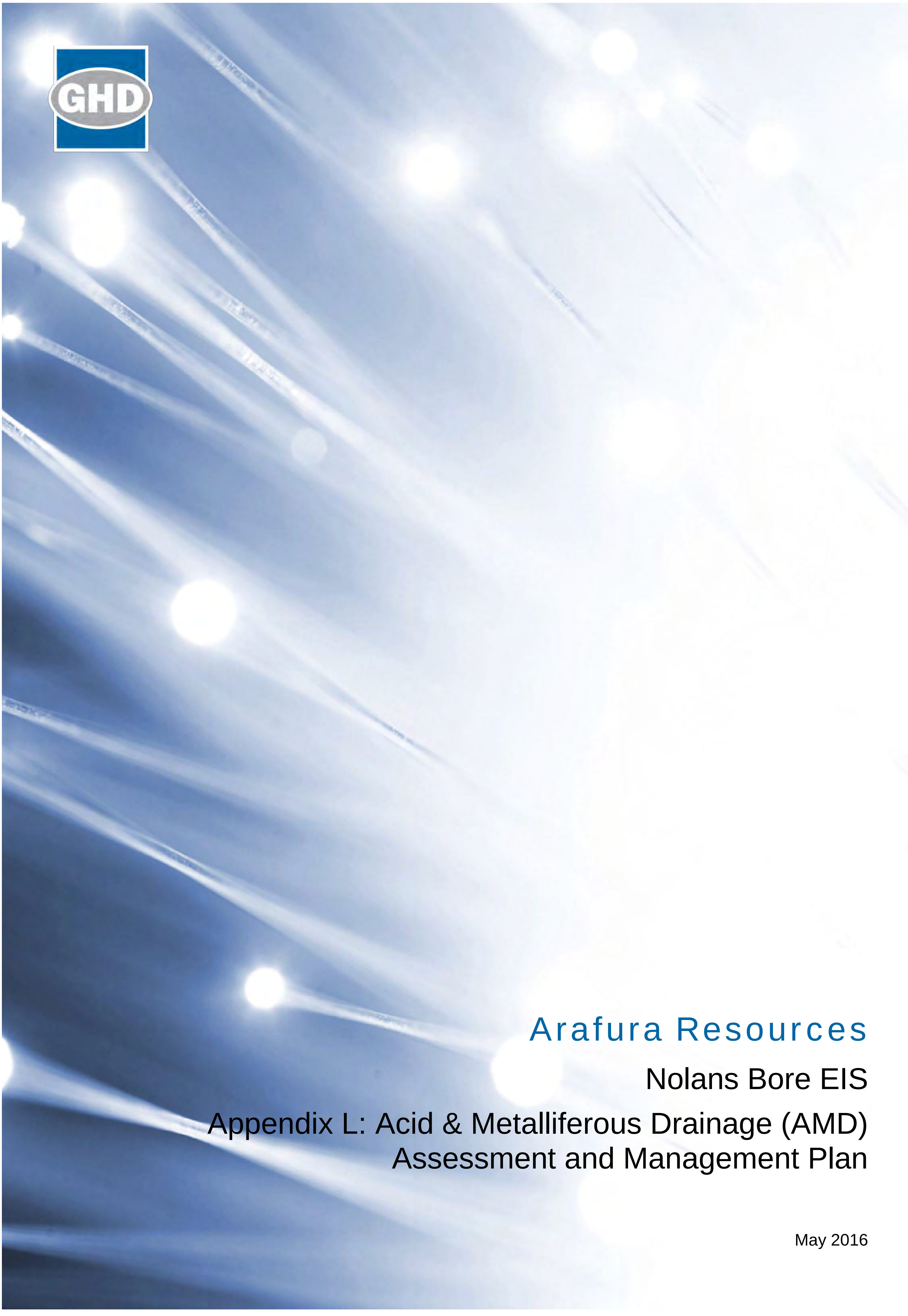
Acid, Metalliferous Drainage Report



Arafura Resources

Nolans Bore EIS

Appendix L: Acid & Metalliferous Drainage (AMD) Assessment and Management Plan

May 2016

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1. Introduction

1.1 Purpose of this Document

This document presents the findings of a desktop review of historical geochemical data, detailed geochemical analysis of potential for Acid, Metalliferous of Saline Drainage (AMD) assessment of mine development information relating to the risk of development of AMD at the Nolans Bore Rare Earth Mine, for Arafura Resources (Arafura). Based on this data review, the level of risk of AMD generation has been identified and an AMD management Plan (AMDMP) is provided, to inform Arafura of the various waste rock types and ore, according to their risk of AMD generation.

The report and AMDMP is based on interpretation and a detailed review of the available geochemical data, noted in Section 1.3. It is noted that additional geochemical analyses of tailings and process residue are currently being undertaken and not available for inclusion at the time of this report although the implications of likely results are discussed.

1.2 Scope and Limitations

The scope of works for this study included:

- Identify the total amount of waste rock to be produced
- Characterise the waste rock in terms of hazardous material and potential to develop acid, metalliferous or saline drainage (AMD)
- Develop a Waste Rock Management Plan.

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1.3 Data Sources

The following key data sources were used in this assessment.

- Site-specific climate and hydrological data.
- Assay data for metals: Al, Ba, Be, Bi, Cd, Ce, Co, Cs, Cu, Fe, Ga, Ge ,Hf, In, K ,La, Li, Mg, Mn, Mo, Na, Nb, Ni, Pb, Rb, Re, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Ti, Tl, U, W, Y, Zn and Zr
- Stage 1 Static AMD testing of potential ore and waste rock material for Total Metals by ICPMS; NAPP; NAG; and 1:5 EC and pH
- Stage 2 Waste rock static NAG, NAPP and total metals; kinetic NAG and ABCC; and ASLP leachate analyses
- Life of mine (LOM) plan and potential options relative to the above features
- Hydrogeological (including geological and geotechnical) documents, reports and borehole logs.

1.4 Project Summary

The Nolans Bore Mine Site is located 135 kilometres to the north-west of Alice Springs and 13 kilometres north west of Aileron community (latitude 22° 34' 54" longitude 133° 14' 24" or 7501720 N 319070 E).

The project is currently being designed to produce 20,000 tonnes per annum (tpa) of rare earths (RE) products and phosphoric acid over an operational period of 41 years. The host rock also contains anomalous levels of uranium and thorium.

The open pit is currently designed to a depth of 225 m below ground level and is expected to require dewatering to on-site water storage dams. Overburden and waste material will be deposited in purpose-constructed Waste Rock Dumps (WRD). Mining operations will deliver broken rock to a Run-of-Mine pad ("ROM pad") from which a front-end loader will feed the crushing circuit. Beneficiation comprises three stage crushing and concentration using a combination of heavy media separation and froth flotation. Ore will be processed through single stage crushing followed by a SAG mill. This was made to reduce dust emissions. Flotation tails will be stored in a Tailings Storage Facility (TSF) within the mine site. The concentrate will be pumped to a processing site located to the south of the mining operation. The process plant operation will produce four waste streams, all of which will be confined to the site, and stored in separate facilities (water leach residue, neutralisation residue, phosphate residue, excess process liquor).

The layout of the proposed Nolans site is shown in Figure 2, which shows the principle areas comprising the mine pit, tailings storage facility, and waste rock dumps, RE Intermediate Plant in addition to the water supply bore field. The proposed project key infrastructure includes:

- Site access roads, comprising:
  - Access road from Stuart Highway
  - Access road and service corridor between the RE Intermediate plant and concentrator
  - Access road and service corridor to the accommodation camp
  - Access track and service corridor to the bore fields.
- Site Buildings
- Potable water supply and sewerage treatment
- Accommodation camp and associated power, water supply and sewerage treatment

- Concentrate and filtrate return pipelines and pumps between concentrator and RE Intermediate plant
- Overhead power line, including HV switch breakers and step down transformers from the RE Intermediate plant to the concentrator, camp and bore fields
- Bore field and raw water supply pipeline to the RE Intermediate plant and concentrator
- Flotation tailings storage facility (FTSF) at the concentrator site
- Tailings storage facilities at the RE Intermediate Plant site, which includes separate facilities for:
  – Water Leach Residue (WLR)
  – Impurity Removal Residue (IRR)
  – Phosphate Removal Residue (PRR)
  – Evaporation Ponds.

1.5 Waste Rock Dumps

This report addresses the characterisation of the waste material to be stockpiled and the management of the waste rock.

A combined LOM waste quantity of 158 million loose cubic metres (mlcm) will be accommodated in six Waste rock dumps (Table 1). Waste rock dumps will extend over a combined maximum footprint of 586 ha (Figure 2) and constructed to a height of about 50 m above land surface built in 10 m lifts interspersed with 5 m wide berms.

The overall footprint of topsoil storage requirements has been estimated at 95 ha and areas identified as potential storage locations are located towards the south west of the mine site (Figure 2).

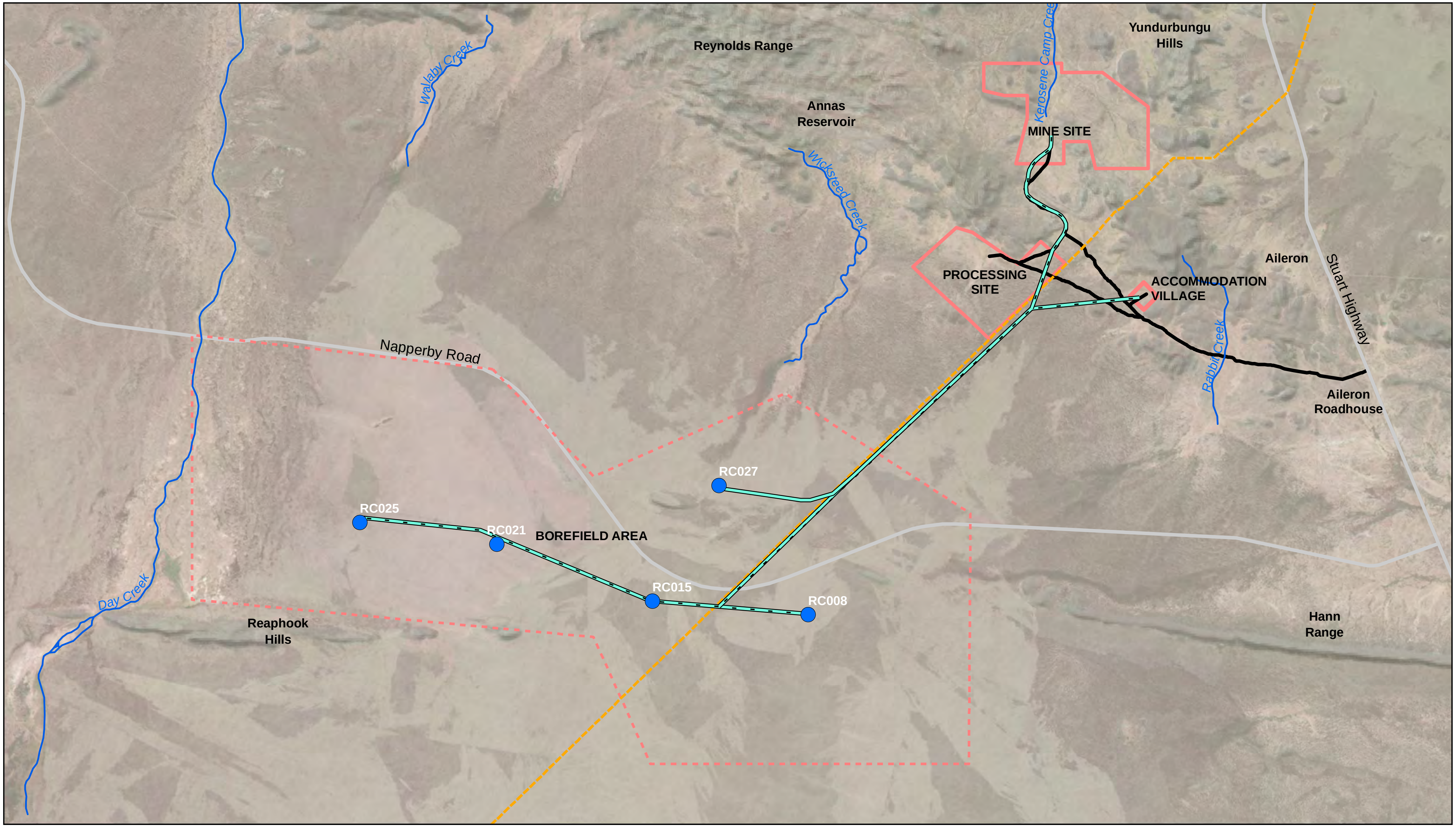
Table 1 Waste Rock Dumps

Name	Waste Volume (Mlcm)	Area (ha)
Waste Dump 1	77.14	212.62
Waste Dump 2	26.87	101.64
Waste Dump 3	14.30	68.22
Waste Dump 4	22.60	99.21
Waste Dump 5	14.57	70.36
Waste Dump 6	4.11	38.04
Top Soil Storage	Not yet known	56.01
Top Soil Storage	Not yet known	22.31
Top Soil Storage	Not yet known	7.61
Top Soil Storage	Not yet known	9.10

The material to be stored has broadly been classified into four waste rock types, mineralisation, pegmatite, schist and gneiss. The anticipated volume and tonnage of material is shown below in Table 2).

Table 2 Summary of Waste Rock

Waste Type	Volume (m^3)	Volume (Mm^3)	% of Total	Tonnage (Vol. x 2.7)
Mineralisation	17200516	17.20	12.44	46441393
Pegmatite	20891576	20.89	15.11	56407255
Schist	18496030	18.50	13.38	49939281
Gneiss	81675970	81.68	59.07	220525119
TOTAL	138264092	138.26	100.00	373313048



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0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Water Bores
- Proposed Powerline
- Proposed Pipelines and Easement
- Existing Gas Pipeline and Easement
- Waterways
- Existing Roads
- Existing Access Track
- Borefield Area
- Site Boundaries

Arafura Resources Limited
Nolans Project

Job Number	4322301
Revision	0
Date	05 May 2016

Nolans site

Figure 1

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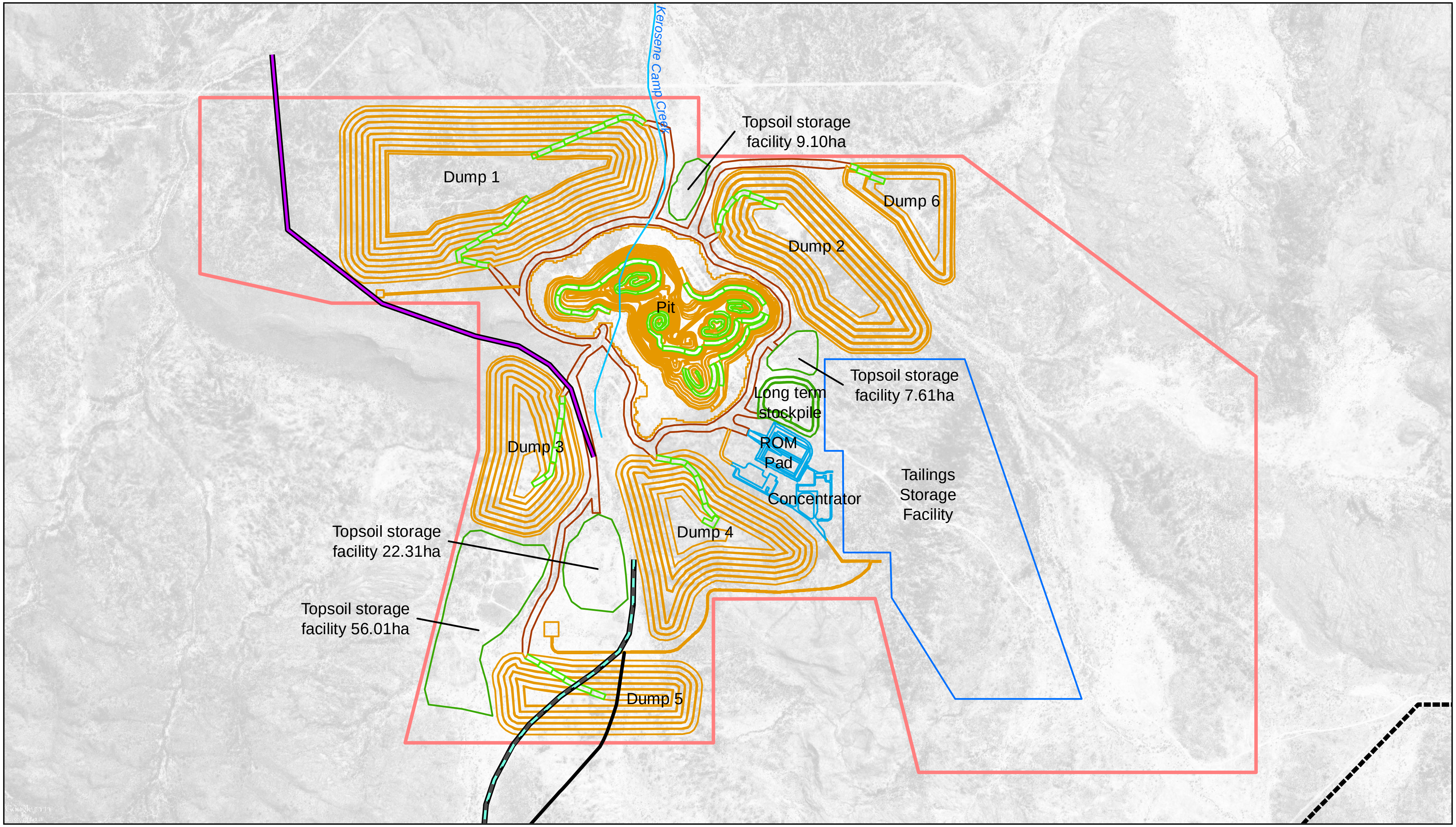
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM



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0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Powerline
- Potable Water Pipeline
- Diversion Channel
- Water Supply Pipeline
- Waterways
- Access Road
- Existing Gas Pipeline
- Mine Site Boundary

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Nolans Project

Mine site

Job Number	4322301
Revision	0
Date	18 Mar 2016

Figure 2

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Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). Created by: CM

2. Project Setting

2.1 Topography and Land Use

The proposed mine site lies within the valley of the Kerosene Camp Creek catchment on the north facing slopes of an east–west trending ridge of the Reynolds Range. Topographic elevation is 886 m above sea level (mASL) at Mt Boothby to the east of the mine site, and 1006°mASL at Mt Freeling to the west. Most of the valley floors are typically between 650 and 700°mASL, and longitudinal gradients along local creeks to the north and south of the ridgeline are typically less than 0.5 percent with steeper gradients of about 10 percent on isolated hills.

The mine lease area lies within the south-western fringe of the Ti Tree Water Allocation Area. The Woodforde River passes through the western margins of the Ti Tree Basin aquifer, which is about 20 km down gradient of the mine lease area. The aquifer at this location along the Woodforde River is about 60 m below ground level (~550°m AHD).

The mine lease area is also located within Aileron Station, which is currently operating rangeland cattle grazing. The project area is characterised by plains and low rocky ridges with extensive areas of mulga and other acacia woodlands.

2.2 Climate

The Study area experiences hot and arid conditions. The hottest months are November to March, with the monthly mean of daily maximum temperatures above 35°C, and monthly mean of daily minimum temperatures not dropping below 18°C (Table 1). The coolest months are May to August, with the monthly mean of daily maximum temperatures remaining at or below 25.5°C, and monthly mean of daily minimum temperatures not rising above 9.5°C.

The mean annual rainfall is approximately 319.1 mm, with a seasonal pattern of more summer rainfall than winter rainfall. Average monthly rainfall totals range from 4.7 mm in August to 65.8 mm in February (Table 1). Average three-monthly rainfall totals range from 18.3 mm in June/July/August to 178.7 mm in December/January/February. However, any month can receive relatively large rainfall totals, or little or no rain at all.

Table 3 Rainfall and Temperature Statistics (BoM 2015; Territory Grape Farm NT 1987-2014

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)												
Highest	280.4	342.2	109.2	151.7	136.3	53.8	34.2	39.4	96.6	56.8	119.2	119.2
95th %ile	159.0	244.2	96.9	89.9	100.1	48.7	21.3	26.9	41.7	51.3	81.4	109.9
Mean	62.4	65.8	21.9	18.0	23.3	8.7	4.9	4.7	10.3	15.3	30.9	50.5
5th %ile	3.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	8.9
Lowest	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
Temp (°C)												
Maximum[1]	37.3	36.2	34.3	30.5	25.5	22.2	22.5	25.3	30.5	33.3	35.6	36.3
Minimum[2]	21.9	21.6	19.5	14.6	9.5	6.2	5.2	7.1	12.1	15.6	18.8	21.1

2.3 Basement Geology and Hydrogeology

The basement geology of the study area is complex but for the purposes of this AMD assessment is simplified to the following:

- Proterozoic Arunta Region granites and gneiss outcrop forming the bulk of the hills and ranges adjacent to the mine area (including Reynolds Range and Yalyirimbi Range) and basement rocks beneath the basins
- Ngalia Basin sedimentary rocks are also present, but comprise relatively little outcrop in the study area and form the basement to the majority of the Witchery Basin section of the Southern Basins
- Proterozoic Vaughan Springs Quartzite and Treuer Member are members of the Ngalia Basin sedimentary sequence and outcrop as the Hann Range and Reaphook Hills as a distinct, almost linear feature across the southern plain, as isolated hills outcropping from the plain at the southern fringe of the Yalyirimbi Range and as basement rocks beneath only a minor section of the Southern Basins.

It is recognised that the Arunta Region also contains multiple units other than granites and gneiss (i.e. schist, quartzite etc.) which may contain higher fracture permeability, but all Arunta Region rocks are collectively grouped as the hydrogeological unit ‘basement’ for the purpose of this assessment.

Only the mineralised areas of the ore deposit that contain primary porosity are considered in isolation as distinct aquifer. The rocks of the Vaughan Springs Quartzite and Treuer Member, are part of the Ngalia Basin and, like the units of the Arunta Region, collectively included in the hydrogeological unit ‘basement’.

3. Acid and Metalliferous Drainage (AMD) - Theoretical Considerations

A brief overview of the AMD process is provided below as a frame of reference to ascertain any potential for AMD issues for the project. The discussion, therefore, is restricted to key issues of likely relevance and application at the project site, including:

- Pyrite oxidation
- Oxidation kinetics – grain size and morphology
- Hydrolysis reactions and latent acidity
- Metals
- Erodibility and salinity.

3.1 Pyrite Oxidation

Pyrite oxidation by atmospheric and/or aqueous oxygen occurs through a complicated sequence of biologically mediated reactions. The overall process however, may be summarised as shown in Equation 1.

Equation 1

$$FeS_2 + 3.75\ O_2 + 3.5\ H_2O \rightarrow 2SO_4^{2-} + Fe(OH)_3 + 4H^+$$

(pyrite) +(oxygen) + (water) → (sulfate) + (iron hydroxide) + (hydrogen ions)

The important factor to note in Equation 1 is that for each mole of pyrite oxidised, there are four hydrogen ions liberated. It is the hydrogen ions that reduce aqueous pH values (i.e. create acidity).

The atmospheric or aqueous oxidation of pyrite is more significant if ferric iron becomes the primary oxidant. This typically accelerates below pH values of 3.5 to 4 (Nordstrom & Alpers, 1998). Equation 2 is a summary reaction for the ferric iron pyrite oxidation process, and shows that sixteen hydrogen ions are released per mole of pyrite oxidised.

Equation 2

$$FeS_2 + 14Fe^{3+} + 8H_20 \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$$

(pyrite) + (ferric iron) + (water)→ (ferrous iron) + (sulfate) + (hydrogen ions)

Depending on local geological conditions, acidic drainage may be buffered by (amongst other things) the presence of naturally occurring carbonate minerals such as calcite and/or dolomite for example. Equation 3 shows such a reaction with calcite acting as the neutraliser.

Equation 3

$$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$$

(sulfuric acid) + (calcite) → (gypsum) + (water) + (carbon dioxide)

Other locally relevant minerals, including feldspars and aluminosilicates for example, can also buffer acid drainage, although reaction kinetics and acid neutralising potentials vary widely, with implications on site management.

Seemingly small concentrations of sulfide, as low as 0.3 %S, can release enough acid to cause significant impacts in the absence of natural buffering capacity.

3.2 Grain size and Morphology

The grain size and morphology of sulfides varies according to the environment and geochemistry of its formation, amongst other factors. The smaller the grain size, the larger the total pyritic surface area exposed for environmental and microbial degradation and therefore, the faster the rate of reactivity when compared to crystals of massive pyrite. As grain size and morphology considerations have implications for the rate of oxidation, they will influence the management controls.

3.3 Acidity

Latent acidity is an unreleased stock of potential acid generation, based on a range of factors including local environmental geochemical conditions, surface drainage and the metal content of waste rock for example. It is a potential source of acidity in the form of metal and metalloid ions (e.g. iron, manganese, aluminium) stored in minerals that may mobilise and form free hydrogen ions following precipitation of metal hydroxides downstream by oxidation, dilution or neutralisation reactions. Quite often, the impacts of acidity only reveal themselves kilometres downstream from a mine site, and therefore, are often not factored into AMD potential when traditional geochemical static tests are conducted.

For example, ferric iron may be liberated in oxidising conditions on site following pyrite oxidation and subsequent ferrous to ferric iron oxidation. It may then become less soluble; possibly due to increasing solution pH resulting from downstream dilution of localised acid mine drainage water for example by water sourced from a neutral or alkaline catchment. Depending on local conditions, the ferric iron ion may undergo hydrolysis to form ferric hydroxide as shown in Equation 4 thereby liberating hydrogen ions.

Equation 4

$$Fe^{3+} \quad + \quad 3H_2O \quad \rightarrow Fe(OH)_3 \quad + \quad 3H^+$$

(ferric iron) + (water) → (ferric hydroxide) + (hydrogen ions)

Whilst the hydrolysis reaction shown in Equation 4 was in fact an inclusion in Equation 1; that may not always be the case, depending on local surface water pH conditions. Ferric hydroxide is an insoluble compound at pH values greater than approximately 3.5 and is commonly seen in acid mine drainage water as a browny-red or yellow stain on bottom sediments.

Acidity also measures the acid potential from ions that release acid in hydrolysis reactions similar to that shown in Equation 4, including for example; Al^{3+} and Mn^{2+}. Put more simply, pH measures H^+ ions, while acidity includes other dissolved species capable of producing H^+ ions following certain reactions; thus the term ‘latent acidity’.

Estimates of acidity can either be measured directly in a laboratory or estimated using key metals from existing water quality data with a formula such as that shown in Equation 5, for example (DITR, 2007).

Equation 5

$$\text{Acidity (mg/L } CaCO_3) = 50 * \{3 * [\text{Total Soluble Fe}] / 56 + 3 * [Al^{3+}] / 27 + 2 * [Mn^{2+}] / 55 + 1000 * 10^{-(pH)}\},$$

where [ ] denotes concentration, mg/L.

The acidity load refers to the total acidity (i.e. acid potential from pyrite + latent acidity) multiplied by the flow rate (or volume), and is expressed as mass of $CaCO_3$ equivalent per unit time (or mass $CaCO_3$ equivalent for a given volume of water) (DITR, 2007). It is, therefore, important to consider both acid potential from stored pyrite in addition to latent acidity when assessing the overall acid potential of a mine site.

3.4 Acidity Classifications

3.4.1 Net Acid Generation (NAG)

Net acid generation (NAG) testing provides an indication of the behaviour of a material when subject to a powerful oxidising environment. The test is performed by oxidising the pulped rock sample with a hydrogen peroxide solution. It is a relatively aggressive reaction (required to oxidise the sulfides in the sample in a short period) and provides an indication of the potential pH of leachate generated from the complete oxidation of the material. The leachate is then titrated to measure the acidity of the solution, to an endpoint of 4.5 indicative of typical pyrite oxidation acidity and to a pH of 7, to assess remaining acidity from other mineral species.

3.4.2 Net Acid Producing Potential (NAPP)

Assessment of net acid producing potential (NAPP) is performed by combining two key parameters, total sulfur and acid neutralising capacity (ANC). The sulfur content of the sample is used to derive the maximum potential acidity (MPA), the theoretical amount of sulfuric acid produced, expressed as kg H_2SO_4/t, if all sulfur in the sample is in the form of pyrite and is fully oxidised. Caution must be used when assessing the MPA of organic-rich material, or polymetallic deposits, as a significant proportion of the sulfur may not be in the form of pyrite or other acid-generating sulfides, in which case chromium-reducible sulfur (S_{CR}) may be used. Barite (barium sulfate) is present in the mineralisation and Schoneveld (2013) reported an average of 0.33% SO_3 in apatite (80 apatites from 7 different thin sections), indicating a significant proportion of the already low sulfur content may be in the form on non-acid generating sulfate. The acid neutralising capacity (ANC), also expressed as kg H_2SO_4/t, is calculated by titrating an un-oxidised sample, to determine its ability to neutralise an acid solution. The NAPP is derived by subtracting the ANC from the MPA, with a positive value indicating the sample may produce acid and a negative value indicating it is non-acid-forming (NAF).

The following provides a guide to NAPP results:

- A NAPP of less than -100 kg H_2SO_4/t indicates it is likely to be acid consuming material (ACM) and has potential to neutralise some acid produced by other material on the site if blended together
- A NAPP of between -100 kg H_2SO_4/t and 0 kg H_2SO_4/t is classed as non-acid forming (NAF)
- Material with a NAPP of between 0 kg H_2SO_4/t and 10 kg/t H_2SO_4 (0.3%S) is generally classed as potentially acid forming - low capacity (PAF-LC)
- A NAPP value greater than 10 kg H_2SO_4/t is considered to be potentially acid forming (PAF) with a NAPP value greater than 100 kg H_2SO_4/t considered high risk material (DITR 2007).

3.4.3 Combined NAG and NAPP Classification

To classify AMD material, the NAGpH is plotted against NAPP, with the following classifications:

- Potentially acid-forming - low capacity (PAF-LC) (NAPP between 0 and 10 kg/t H_2SO_4 and NAGpH less than 4.5)
- Potentially acid-forming (PAF) (NAPP greater than 10 kg/t H_2SO4 and NAGpH less than 4.5)
- Non-acid–forming (NAF) (negative NAPP and NAGpH greater than 4.5)
- Acid-consuming material (ACM) NAPP less than -100 kg/t H_2SO4 and pH greater than 4.5

- Uncertain (UC) (contradictory NAG and NAPP results such as negative NAPP with NAG less than 4.5 or positive NAPP with NAGpH greater than 4.5).

3.5 Metals

The ‘M’ in AMD is now commonly referred to as ‘metalliferous’ rather than ‘mine’. As discussed above, pyrite oxidation and / or hydrolysis reactions can lead to a lowering of solution pH values. Typically, pH values are the most important control of metals partitioning in aqueous systems (Smith, 1999). Therefore, pyrite oxidation reactions and subsequent pH changes can control metal solubility in mine waters (Figure 3).

An important aspect of Figure 3 is it indicates that some metals, such as zinc, if mobilised from oxidised sulfides, can remain relatively soluble even if the resultant leachate is neutralised. Although not indicated on Figure 3 aluminium is often the key metal toxicant in acid leachate, as it is present in almost all rock and soil and can become mobilised under acid conditions below pH 6.

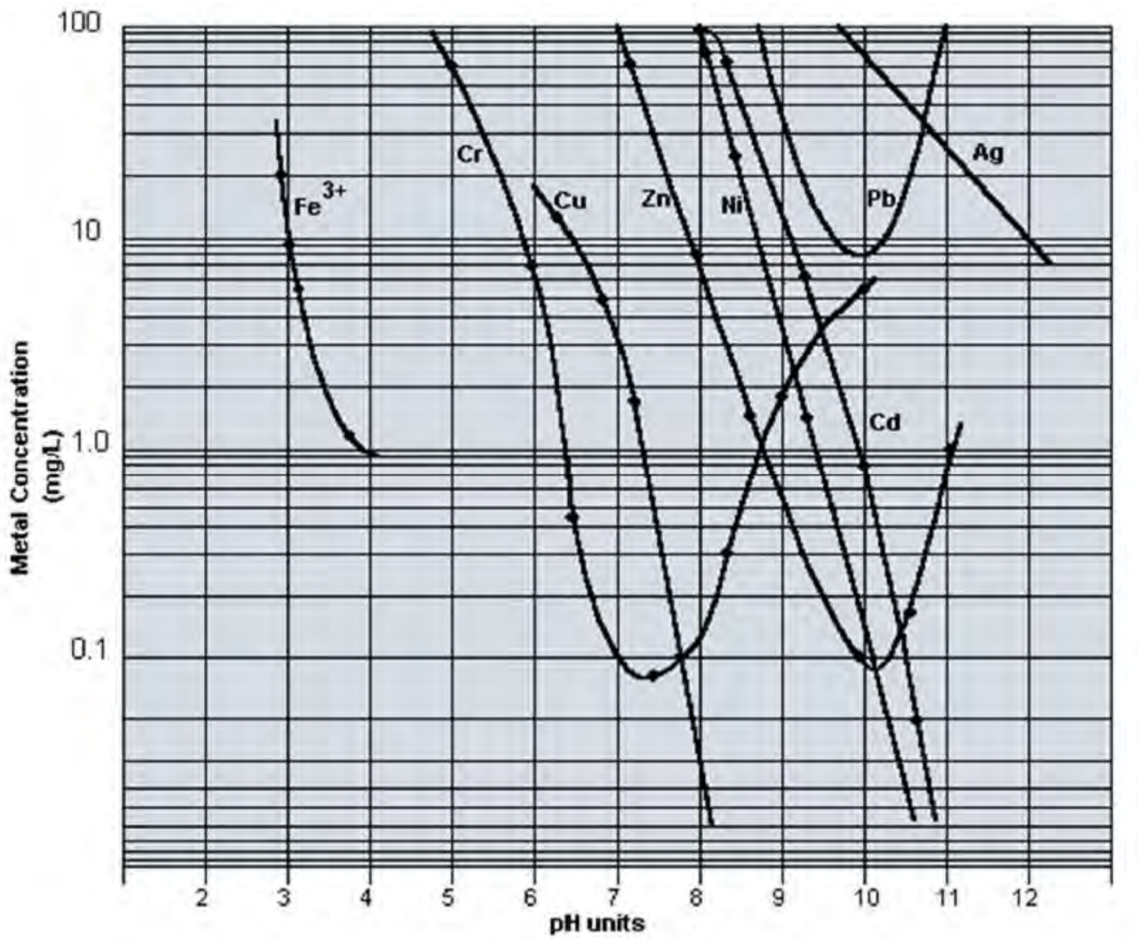


Figure 3 Theoretical Solubilities for Common Metals

It is important to note that elevated metal concentrations may occur in neutral and/or alkaline mine drainage at mine sites. Generally, though, increasing pH values lead to lower metal concentrations; with the exception of a few amphoteric species. For example, the International Network for Acid Prevention (INAP, 2011) define Neutral Mine Drainage (NMD) and Saline Drainage (SD) as having pH values of >6; with SD further differentiated as having sulfate concentrations exceeding 1,000 mg/L (or parts per million) and low metals relative to AMD.

To gain an early understanding of the risk a particular metal may pose to the environment, a comparison between the metal concentrations and their average crustal abundance can be presented as a *Geochemical Abundance Index* (GAI). This is only a simple, preliminary method of assessment, as it does not take in to account the solubility and mobility of the metals nor their relative toxicity to the receiving environment. A GAI of less than 0 indicates that the content of the element is less than the average crustal abundance. A GAI of 3 corresponds to a 12-fold enrichment above the average-crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average-crustal abundances. A GAI of 3 or greater is considered significantly elevated (DITR, 2007). A GAI of 3 for sulfur equates to 0.43%S or 13.2 kg/t H_2SO_4 which is slightly above the lower limit for PAF-LC (3.4) assuming there is no neutralising capacity.

The GAI is defined as:

$$GAI = \log_2 [Cn/(1.5 \times Bn)]$$

Where:

Cn = measured content of n-th element in the sample.

Bn = "background" content of the n-th element in the sample.

Where the GAI is greater than 3, more detailed geochemical analyses are usually carried out. The results of the GAI assessment for the Nolans project are discussed in Section 4.3.1.

3.6 Soil Stability and Salinity

Given the nature of the environment at the site, with runoff having naturally high turbidity and sediment loads, soil erodibility of cover material and potential turbidity produced from ore and waste rock runoff will be managed in a manner that will not exacerbate the natural environment.

A range of soil salinity and stability indicators are commonly assessed against the criteria developed below by QLD DME (1995).

Table 4 Indicative Mine Waste Salinity Classification Parameters

Test	Units	Very Low	Low	Medium	High	Very High
pH (1:5)	pH units	<4.5	4.5-5.5	5.5-7.0	7.0-9.0	>9.0
Electrical Conductivity (1:5)[1]	µS/cm	<150	150-450	450-900	900-2,000	>2,000
Exchangeable Sodium Percentage (ESP)	%	<2	2-6	6-12	12-20	>20
Ca/Mg	ratio	<1	1-2	2-5	>5	-

1: Values become approx. 200, 200-400, 400-800, 800-1,600 and <1,600 if analysis undertaken by saturated extract/paste.

As noted above, the information presented in Table 4 is indicative and acts as a guideline only. A soil may be considered sodic when sodium concentrations begin to affect soil structure. This is generally recognised in Australia when ESP >6 %; while strongly sodic soils have ESPs of >15 (Isbell, 1996). When sodic soils become wet; as sodium is a monovalent cation as compared with the bivalent cations magnesium and calcium; the bonds weaken and the soils can become dispersive or slake. Therefore, a high level of exchangeable sodium is not desirable in soils for mine rehabilitation, as it can lead to dispersion, tunnel erosion and surface crusting; with individual clay particles going into suspension potentially leading to decreased surface water quality (Charman & Murphy, 2000).

Secondary consequences include surface hard-setting as soil structure breaks down, with decreased infiltration leading to difficulties in establishing vegetation and therefore, ongoing erosion from bare surfaces.

Another indicator of dispersion potential in soils is the Ca:Mg ratio. Where waste rock is generated from relatively impermeable rock, the fracturing can expose soluble salts such as chlorides and sulfates, as well as fluorides, leading to saline or fluoride-rich leachate from otherwise benign material.

Soils that are high in sodium and magnesium tend to show more dispersion than soils that are high in sodium and calcium (Hazelton & Murphy, 2007). The potential for dispersion may be increased in soils with Ca:Mg ratios of below approximately 1-2. This is because Ca^{2+} ions flocculate or open soils, while Mg^{2+} ions tend to coagulate or close soils. Low Ca:Mg ratio soils are sometimes known as high magnesium soils. A Ca:Mg ratio of approximately 4-6 is generally considered ideal; although ultimately it becomes a function of the crop/vegetation's tolerance.

At a broader level, low cation exchange capacity (CEC) of, nominally, <5 meq/100g, indicates that the soils have a low ability to hold nutrients.

4. Geochemical Assessment

4.1 Available Data

4.1.1 Assay Data

Depending on the analyte, between 101 and 3156 analysis for 42 elements (Al, As, Ba, Cd, Ce, Cr Co, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ho, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pr, Pb, S, Sb, Sc, Se, Sm, Sr, Ta, Tb, Te, Th, Ti, Tm, Tl, U, V, Y, Yb, Hg, Zn and Zr) were available from Arafura's exploration and resource definition database. There were no sulfur data in the historical assay dataset.

4.1.2 Stage 1 Static AMD Tests

Arafura carried out static AMD testing on 154 samples of potential waste rock, with the tests including:

- Total metals by ICPMS
- NAPP
- NAG
- 1:5 leachate EC and pH.

4.1.3 Stage 2 Kinetic AMD Tests

Splits from 25 of the Stage 1 samples were selected from each of the major rock types and from samples showing the highest indication of AMD risk as well as generally representative samples. To gain an understanding of the relative rate of acid production and neutralisation over time as well as the mobility of metals in leachate testing included:

- Kinetic NAG (KNAG)
- Acid buffering characteristic curves (ABCC)
- Australian Standard Leaching Procedure (ASLP), using distilled water and analysis for:
  - ICPMS 26 metal scan and mercury by FIMS
  - Major ions (Na, Ca, K, Mg, SO_4, Cl, CO_3, HCO_3)
  - Fluoride
  - pH

4.2 Sample Density, Numbers and Locations

4.2.1 Sample Density

Geochemical sample density is a critical parameter to ensure that a statistically significant data set has been captured, such that the AMD risk assessment is based on sound mineral waste characterisation.

There is arguably no 'right' number of samples that should be collected for geochemical characterisation, rather, demonstrating a level of confidence for the stated purpose statistically is the preferred method. In that regard, several publications provide guidance toward obtaining a representative sampling density. For example Price (1997), Miller (1997) and the (then) Queensland Department of Mines and Energy (DME) (1995) have provided guidance on geochemical sampling numbers / density. The correct number, however, relates to a level of statistical significance for which the AMD risk becomes acceptable based on the proposed development.

The above sources provide the following recommended sample number by major lithological unit:

$n = 25 \times \sqrt{x}$. (Where x = Million tonnes (MT) of material per major lithological unit)

Therefore, and based on the above formula, a rule of thumb to be quasi-representative is around 250 samples per 100 MT of waste material, per major geological unit.

At Nolans bore, the waste rock comprises multiple lithologies as previously discussed.

With regard to sampling densities, DITR (2007) recommend that at pre-feasibility stage, "Several hundred representative samples of high and low grade ore, waste rock and tailings should be collected for geochemical test work. i.e. Sufficient samples to populate a block model with a reliable distribution of net acid production potential (NAPP) data on ore, waste and wall rock".

This has been completed at Nolans bore in the form of Arafura's laboratory Inductively Coupled Plasma Mass Spectrometry/Optical Emission Spectrometry (ICPMS/OES) dataset and supplemented by selected representative datasets of in-house portable XRF analysis.

Further, DITR (2007) recommend that at feasibility stage, the proponent should, 'Improve density of NAPP data for block model if necessary, and conduct sufficient NAG test work to cross check NAPP data for key lithologies. If there are still insufficient data to assess AMD potential and provide a convincing management plan for approval, additional sampling, test work and refinement of block models will be required".

Arafura has included the NAG testing herein in addition to having populated the block model using their XRF/Gamma spectroscopy dataset. Further testing is included in the AMD MP.

4.2.2 Sample Numbers

The number of analyses from the Nolans bore are shown in Table 5.

Table 5 Size of Geochemical Data Sets by Type

Data Type	Approximate Number of samples
XRF assay (various metals including REE and U +Th)	30,000
In house XRF (various metals including sulfur)	679
Laboratory analyses (Total S, Ca, Mg and other metals)	154
ABA/NAG	154
ALSP Leachate, Kinetic NAG and ABCC tests	24

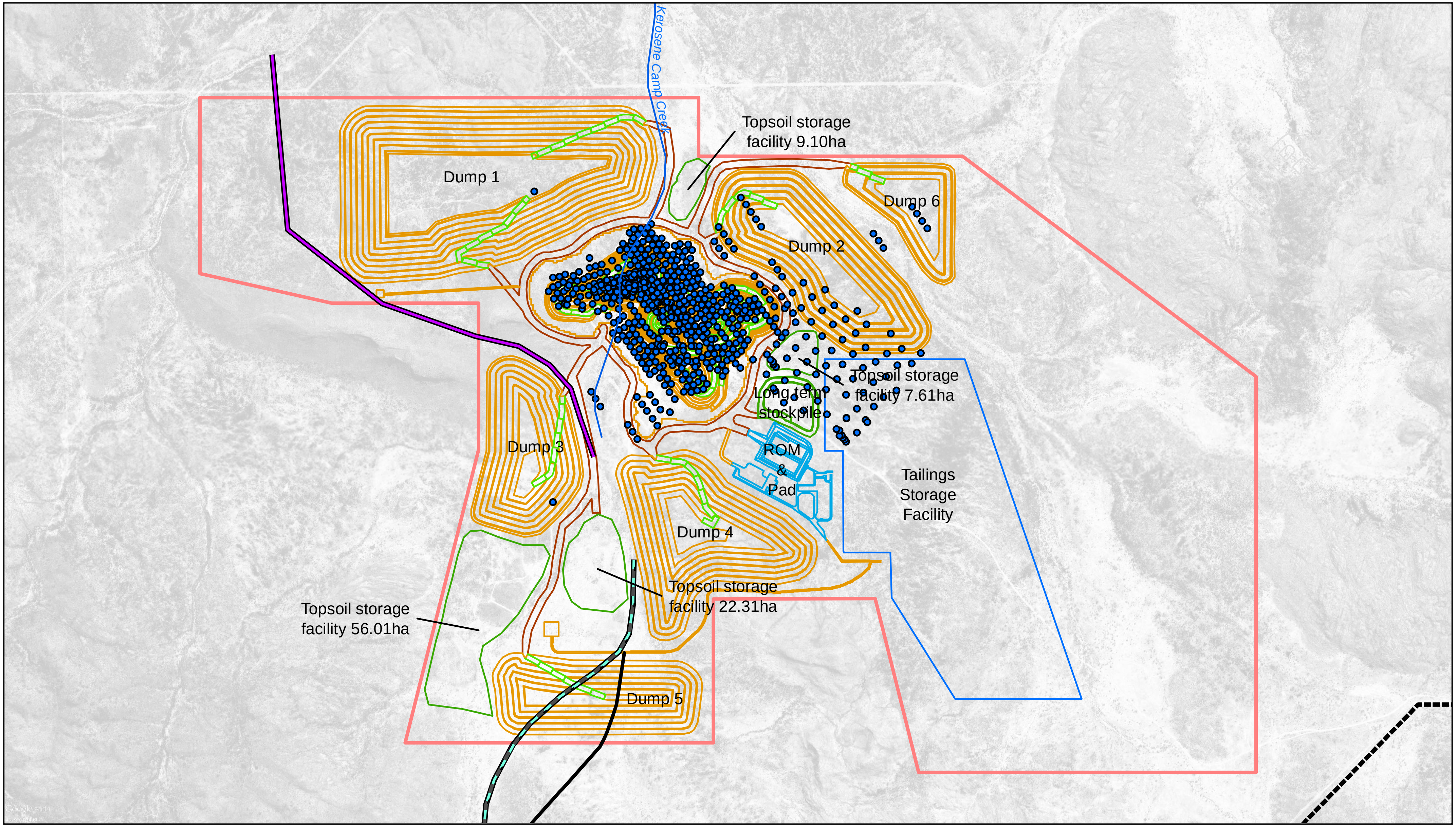
The samples outlined above are well in excess of the minimum numbers recommended for metals, especially considering the low-risk presented by a low sulfur deposit. The number of samples analysed for leachable metals and ABA is consistent with the low overall risk and the stage of the project.

4.2.3 Sample locations

Figure 4 shows the location of the ICPMS/OES dataset drillholes, while Figure 5 shows the collar locations of the drill holes from where the ABA / NAG samples were selected. Samples were selected from various depths across the deposit.

4.2.4 Summary

Based on the low geological risk and available analytical parameters, the number and density of analyses available are adequate for the current stage of the project.



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0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- ICPMS/OES Database Sample Locations
- Powerline
- Potable Water Pipeline
- Diversion Channel
- Water Supply Pipeline
- Waterways
- Access Road
- Mine Site Boundary

Arafura Resources Limited
Nolans Project

ICPMS/OES database sample locations

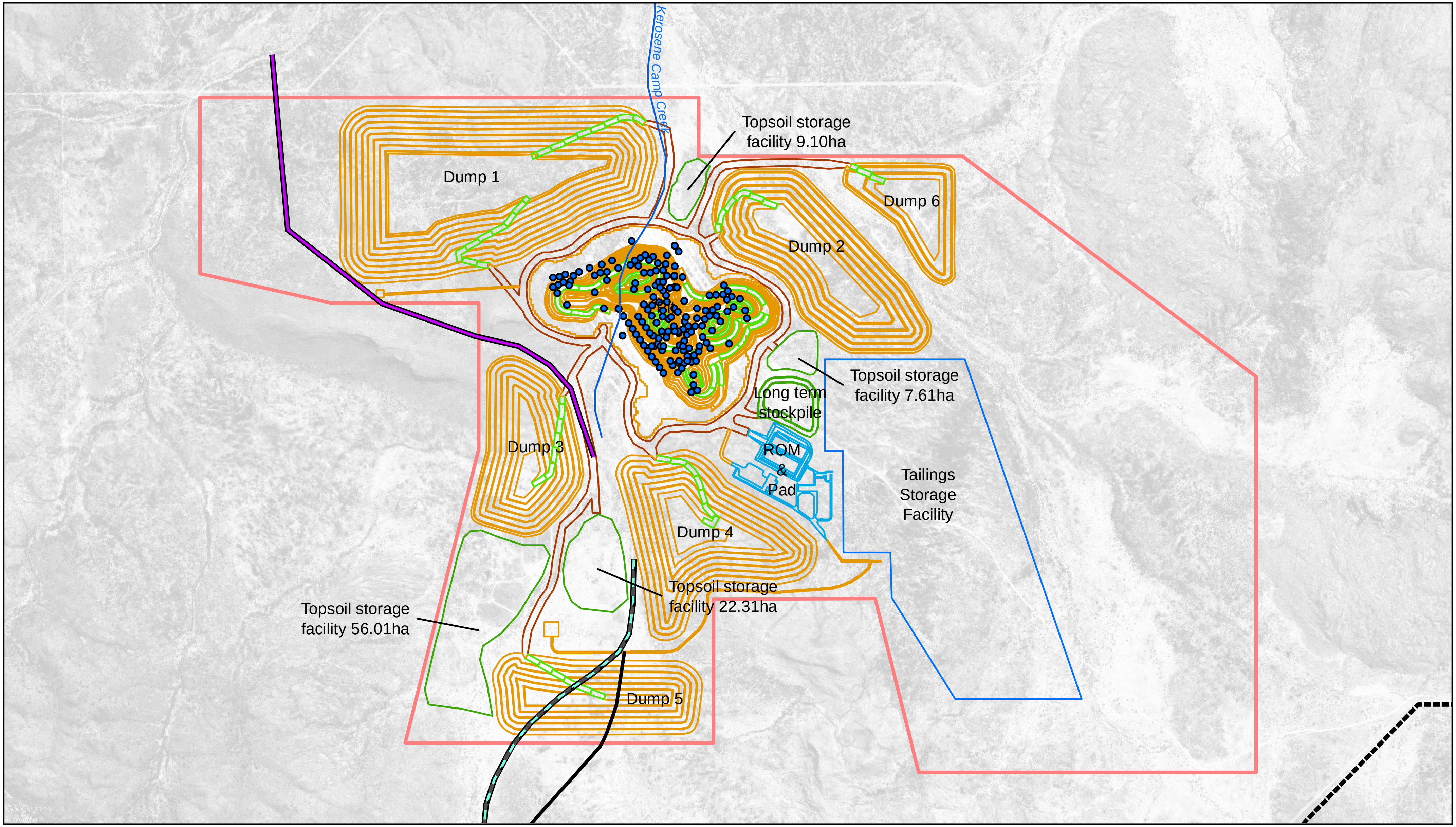
Job Number	4322301
Revision	0
Date	18 Mar 2016

Figure 4

G:\43\22301\GIS\Maps\4322301_104_XRF-SampleLocations.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). GHD - Sample Locations (2016). Created by: CM



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0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- ABA Database Sample Locations
- Powerline
- Potable Water Pipeline
- Diversion Channel
- Water Supply Pipeline
- Waterways
- Access Road
- Proposed Mine Site Boundary

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Nolans Project

Job Number	4322301
Revision	0
Date	18 Mar 2016

ABA (NAG/NAPP) Sample Locations Figure 5

G:\43\22301\GIS\Maps\4322301_105_ABA-SampleLocations.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Pipelines, Proposed Mine Site, Proposed Diversion Channel Options, Tailings Storage Facility (2015). GHD - Sample Locations (2016). Created by: CM

4.3 Assay-based AMD Assessment

4.3.1 Relative Elemental Concentrations

A Geochemical Abundance Index (GAI) of 3, the level above which concentrations are considered elevated (Section 3.5), was exceeded in at least one sample for 27 elements. Of these, 15 elements (in decreasing order of median GAI Pr, Se, Ta, Mo, Tl, Th, Ti, Be, Sb, Ce, La, Eu, Nd, Sm,) had a mean or median GAI of greater than 3 (Table 6), ranging from 3.0 to 6.6. It should be noted that Arafura exploration data set indicates that Ta and Mo are naturally elevated throughout the region. The 99% upper confidence limit (UCL) for these elements ranged from 3.1 to 7.1 suggesting that overall they were moderately elevated. Mercury's exceedance is an artefact of its high level of reporting relative to the average crustal abundance and the elements with the highest UCL also had the fewest results.

The elevated rare earth and thorium concentrations are, as would be expected, associated with the ore/pegmatite material. Based on the above assessment, the 15 elements noted as exceeding a GAI of 3 should be considered in any groundwater or leachability testing.

When broken down by lithology (Figure 6 - Figure 9), it is clear that individual lithological units had much higher GAIs than the entire dataset would suggest. Possibly of most importance, based on a combination of relative toxicity and overall concentration is the U and Th content in Allanitic, Apatite, and Cheralite material, with GAI in the order of 8 to 9.5 and 6 to 7.5 for uranium and thorium respectively.

Table 6 GAI Exceedance Summary

Element	Be	Ce	Eu	La	Mo	Nd	Pr	Sb	Se	Sm	Ta	Th	Ti	Tl	Hg
Number of samples	174	29,082	842	29,077	174	29,077	29,225	32	32	29,149	148	29,103	172	26	26
Min	-4.6	-9.9	-2.8	-5.4	-3.6	-10.0	-1.7	-0.7	1.3	-5.6	0.7	-9.3	0.2	1.5	**3.0**
Median	**4.0**	**3.8**	**3.4**	**3.7**	**5.4**	**3.3**	**6.6**	**4.0**	**6.0**	2.8	**5.5**	**4.3**	**4.2**	**5.3**	**6.9**
mean	**3.5**	**4.1**	**3.1**	**3.9**	**4.5**	**3.6**	**6.8**	**3.6**	**5.6**	**3.1**	**5.9**	**4.4**	**4.5**	**4.7**	**6.4**
Max	**7.9**	**11.1**	**8.7**	**10.9**	**8.6**	**10.6**	**13.8**	**8.4**	**10.4**	**10.0**	**11.2**	**11.4**	**9.1**	**6.7**	**8.1**
99%UCL (assume norm. dist.)	**4.1**	**4.1**	**3.4**	**4.0**	**5.1**	**3.7**	**6.9**	**4.6**	**6.6**	**3.1**	**6.5**	**4.4**	**4.8**	**5.4**	**7.1**

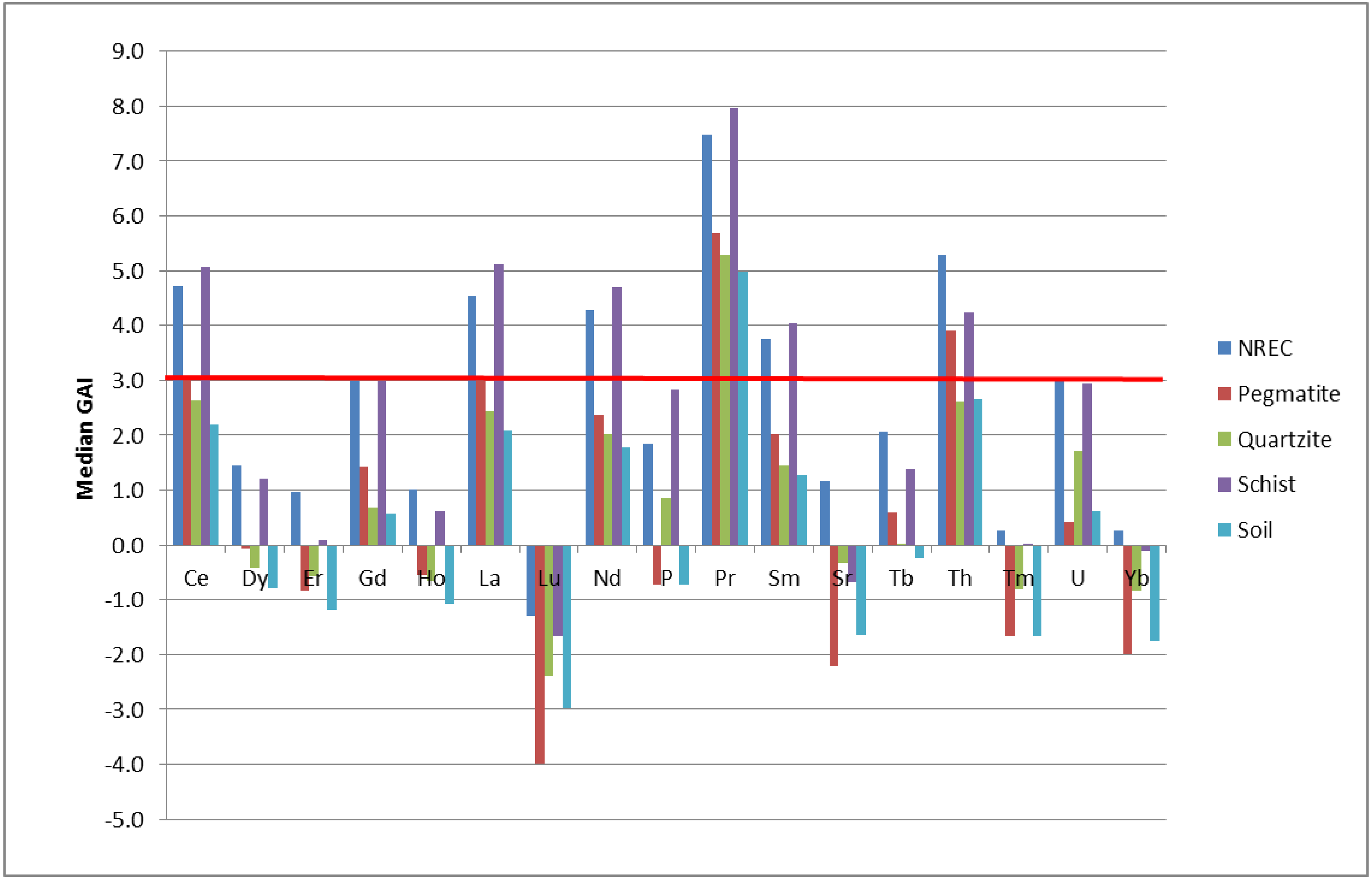

Figure 6 Median GAI NREC, Pegmatite, Quartzite, Schist and Soil

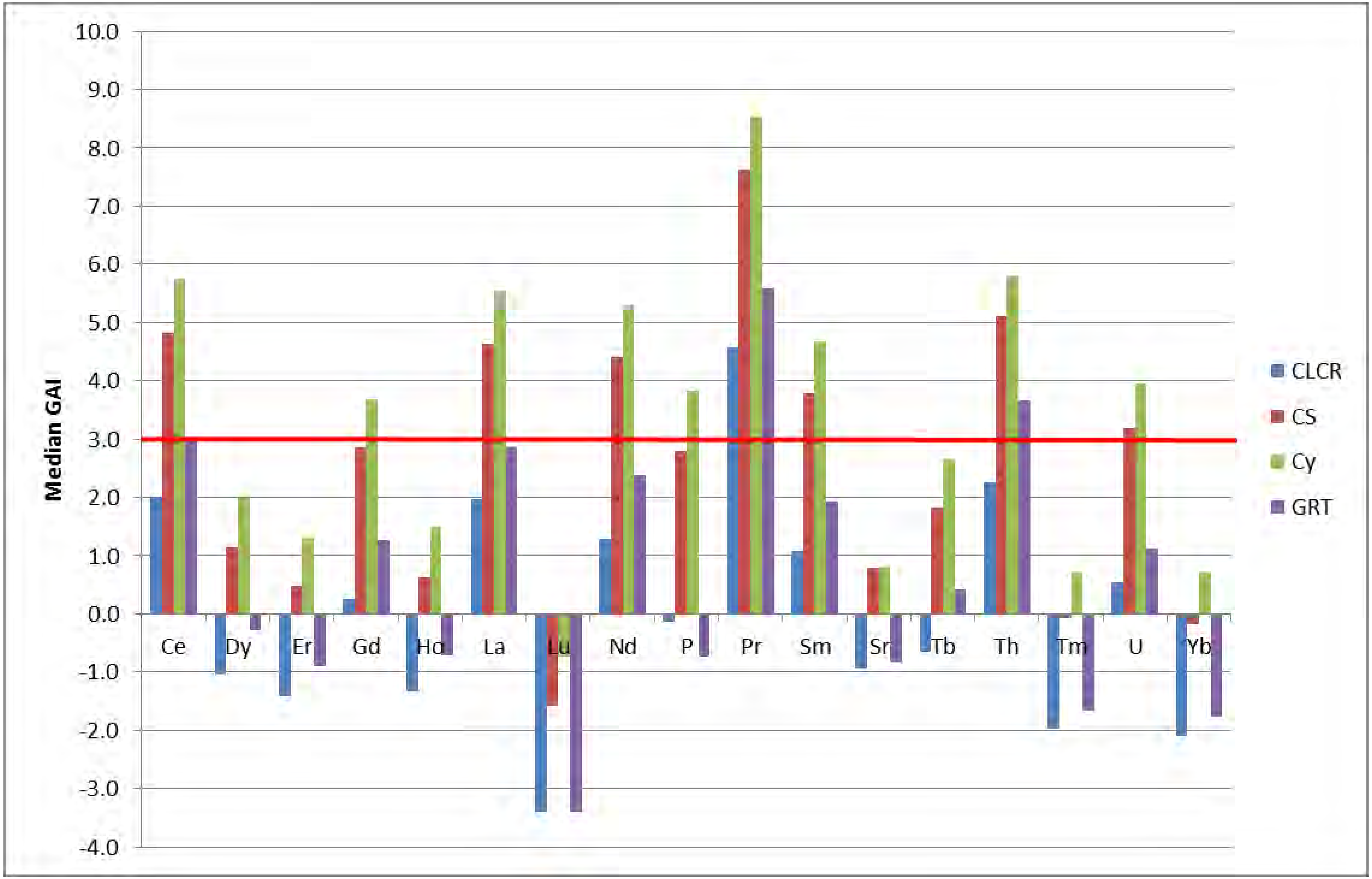

Figure 7 Median GAI CCLR, CS, GRT

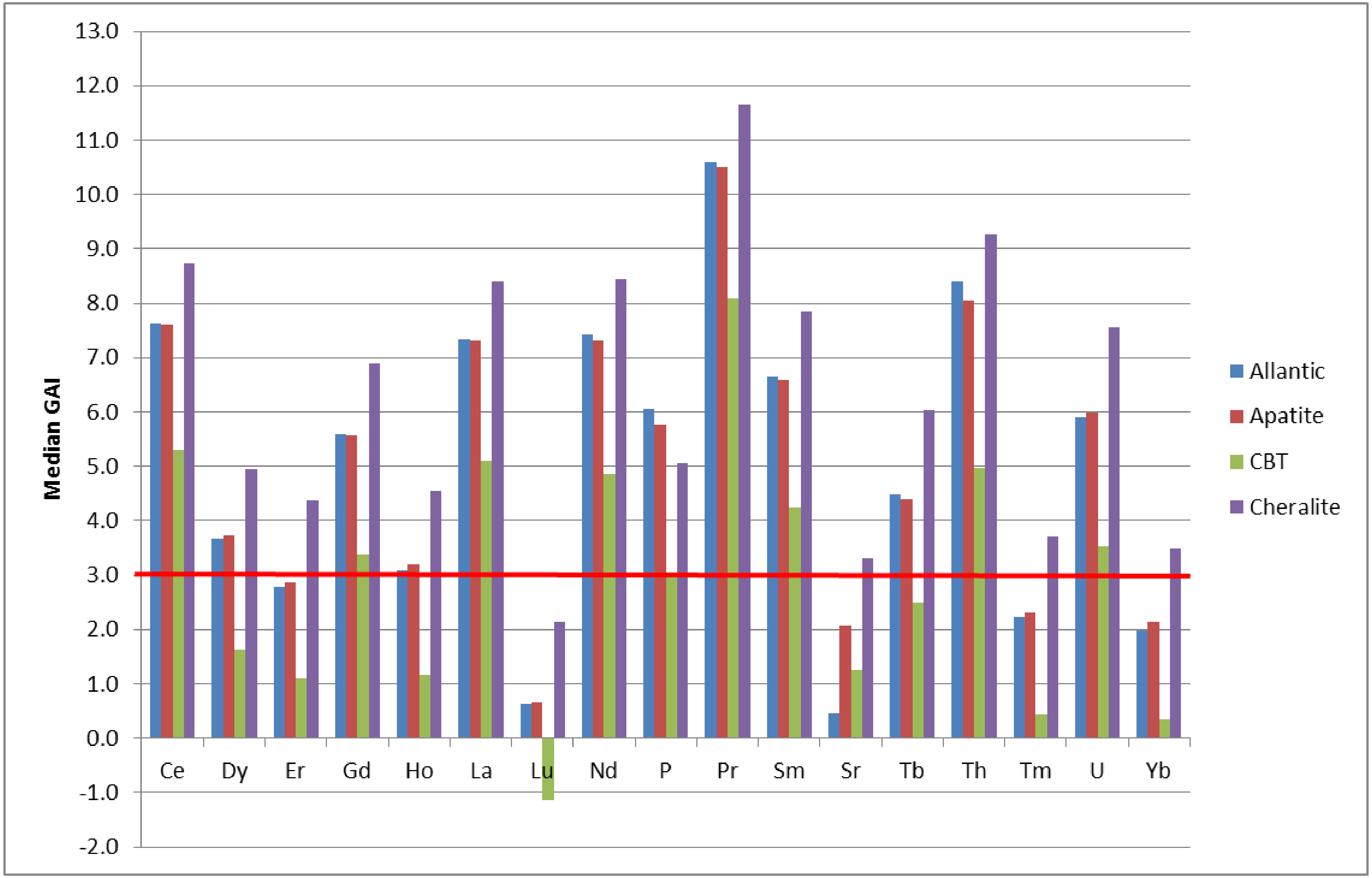

Figure 8 Median GAI Allanitic, Apatite, CBT and Cheralite

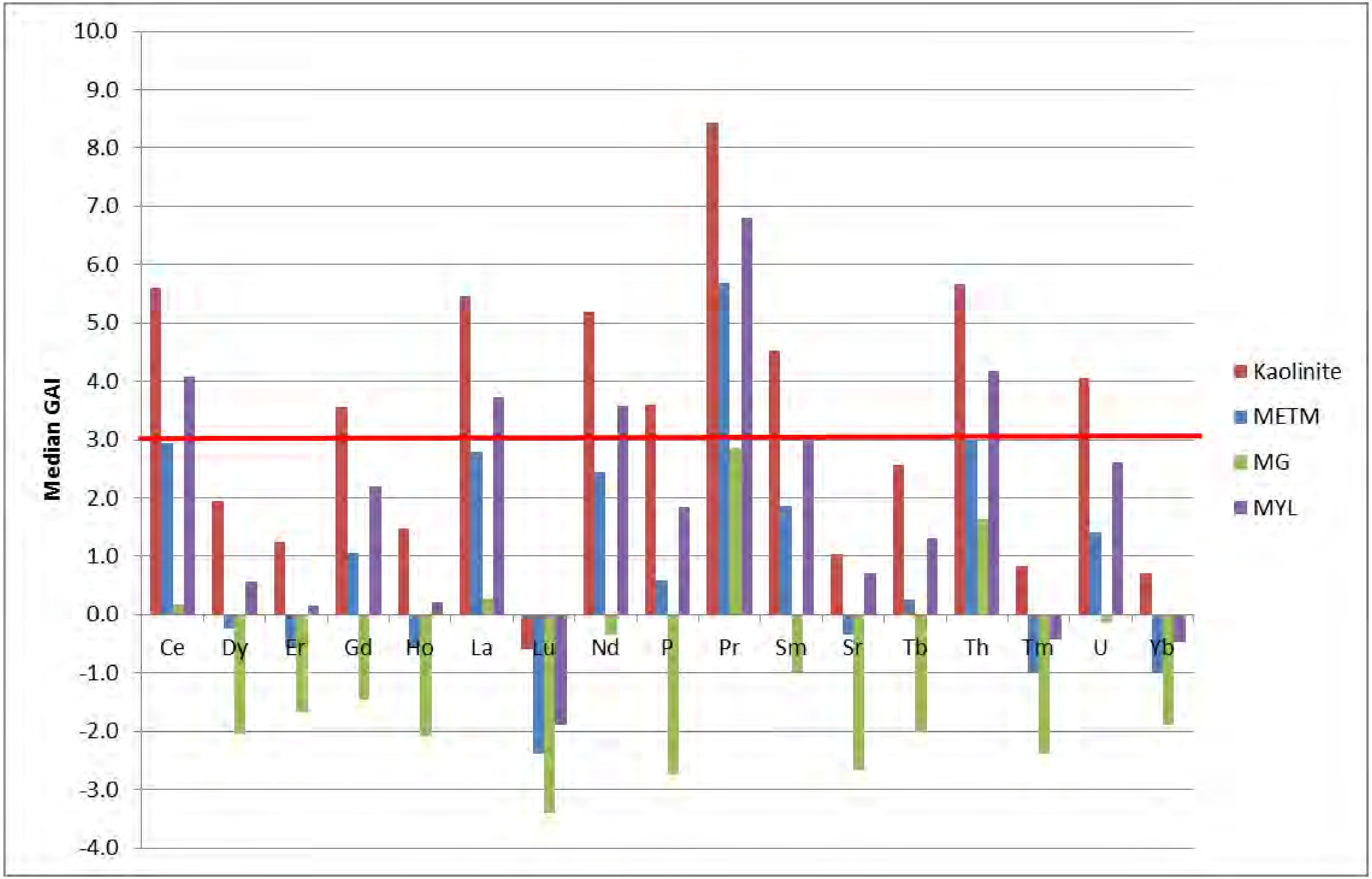

Figure 9 Median GAI Kaolinite, METM, MG and MYL

4.3.2 Assay-Derived Acid Base Accounting

Sulfur, calcium and magnesium assays were available from the Stage 1 and Stage 2 AMD testing, and have been used to determine theoretical acid generating and neutralising capacity.

Where calcium, magnesium and sulfur analyses are available, their relative stoichiometric proportions can give an indication of the potential for acid production by sulfide oxidisation based on a theoretical maximum potential acidity (MPA), or neutralisation by calcium carbonate based on a theoretical acid neutralising capacity (ANC). The combined lithology plot (Figure 10) shows that the vast majority of samples contain less than 10 kg/t H_2SO_4 and/or have a theoretical NPR of greater than 2, falling in the non-acid-forming (NAF) zone on the plot, indicating a low risk of acid formation.

The only sample that plots within the PAF zone of NPR less than 1 and MPA greater than 10 kg/t H_2SO_4 is a single sample of gneiss (GNE). The majority of the gneiss samples (18) lie in the NAF zone with 3 samples plotting in the Uncertain Low-Capacity zone (UC). Of the remaining waste rock types, 2 of 34 mineralised samples fall within the UC zone, 3 of 25 pegmatite samples and 7 of 70 schist samples, indicating that that sample had a generally low to moderate risk of acid formation, hence the requirement of the static testing to confirm.

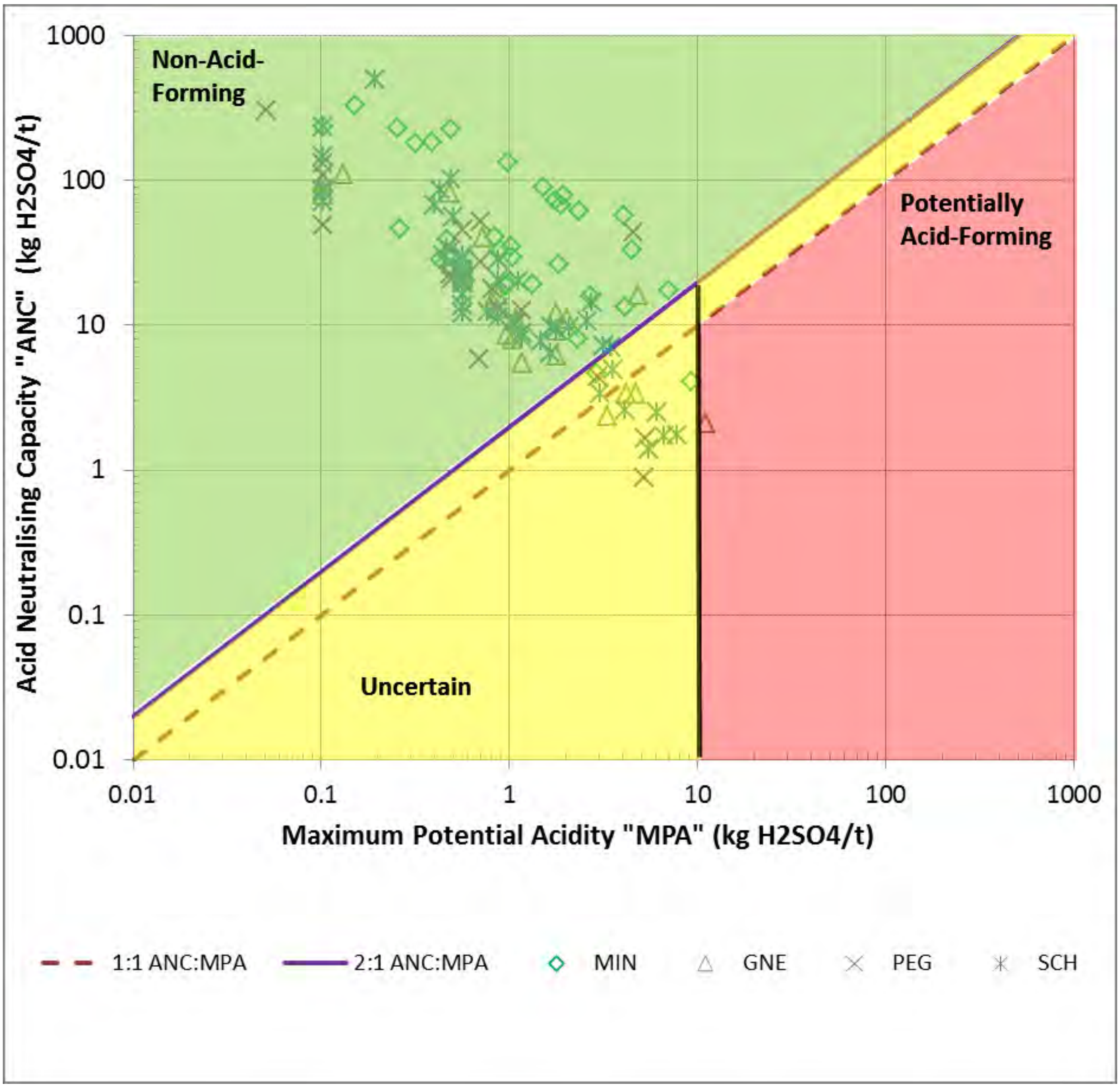

Figure 10 ANC Vs MPA Plot - All Samples

4.4 Stage 1 Static AMD Testing

To provide additional assessment, 154 static AMD tests comprising NAG and NAPP tests were carried out. Of the 154 samples, 25 samples represented pegmatite, 34 mineralisation, 25 gneiss and 70 schist.

4.4.1 Net Acid Producing Potential (NAPP)

Maximum Potential Acidity (MPA)

None of the samples analysed contained greater than 10 kg/t H_2SO_4, the value typically considered to represent an AMD risk, with the highest value of 0.65 kg/t H_2SO_4 being from a sample of pegmatite.

Acid Neutralising Capacity (ANC)

Titrated ANC values ranged from 4.0 kg/t H_2SO_4 to 229 kg/t H_2SO_4 with a median of 19.7 kg/t H_2SO_4 and a mean of 30.1 kg/t H_2SO_4. This indicates that most rock types have relatively high neutralising capacity.

Net Acid Producing Potential (NAPP)

NAPP ranged from a minimum, acid-consuming -192.5 kg/t H2SO4 in a sample of pegmatite, to a maximum acid-producing 0.6 kg/t H2SO4 in a sample of pegmatite, with median and mean values of -18.2 kg/t H2SO4 and -28.5 kg/t H2SO4.

A single sample (pegmatite) recorded a positive NAPP of 0.6 kg/t H2SO4 indicating the waste rock has a low Net Acid Producing Potential.

Neutralising Potential Ratio (NPR)

The NPR ranged from 0.9 to 494.9 with a median of 21.5 and a mean of 48.7, indicating a generally low risk of acid generation. Only 1 sample had an NPR of less than 1, indicating a high risk of acid generation. Of all the waste rock sample types analysed, only one sample of pegmatite had a NPR of less than 1 (0.9) that would indicate that particular sample has a moderate risk of acid generation.

4.4.2 Net Acid Generation - NAG

The NAG Vs NAPP plot (Figure 11), combines the direct post-oxidisation pH measurement of the NAG test with the acid-base accounting assessment of the NAPP test.

Only 1 pegmatite sample falls in the PAF zone of positive NAPP and NAG pH of less than 4.0. Three samples fall in the uncertain zone of negative NAPP but NAG pH of less than 4.5.

Overall, the NAG NAPP plot indicates good correlation between the NAG and NAPP tests and a low risk of acid generation by all but one of the pegmatite samples and possibly two of the schist samples; with potential for some AC material (mineralised) to be used to neutralise PAF. When plotted against NAPP (Figure 12) to further clarify the risk that a sample will generate acid, the plot shows all but a few samples are NAF with only one sample having both an NAG less than 4.5 and an NPR of less the 1 and pegmatite accounting for only 15% of the waste mass.

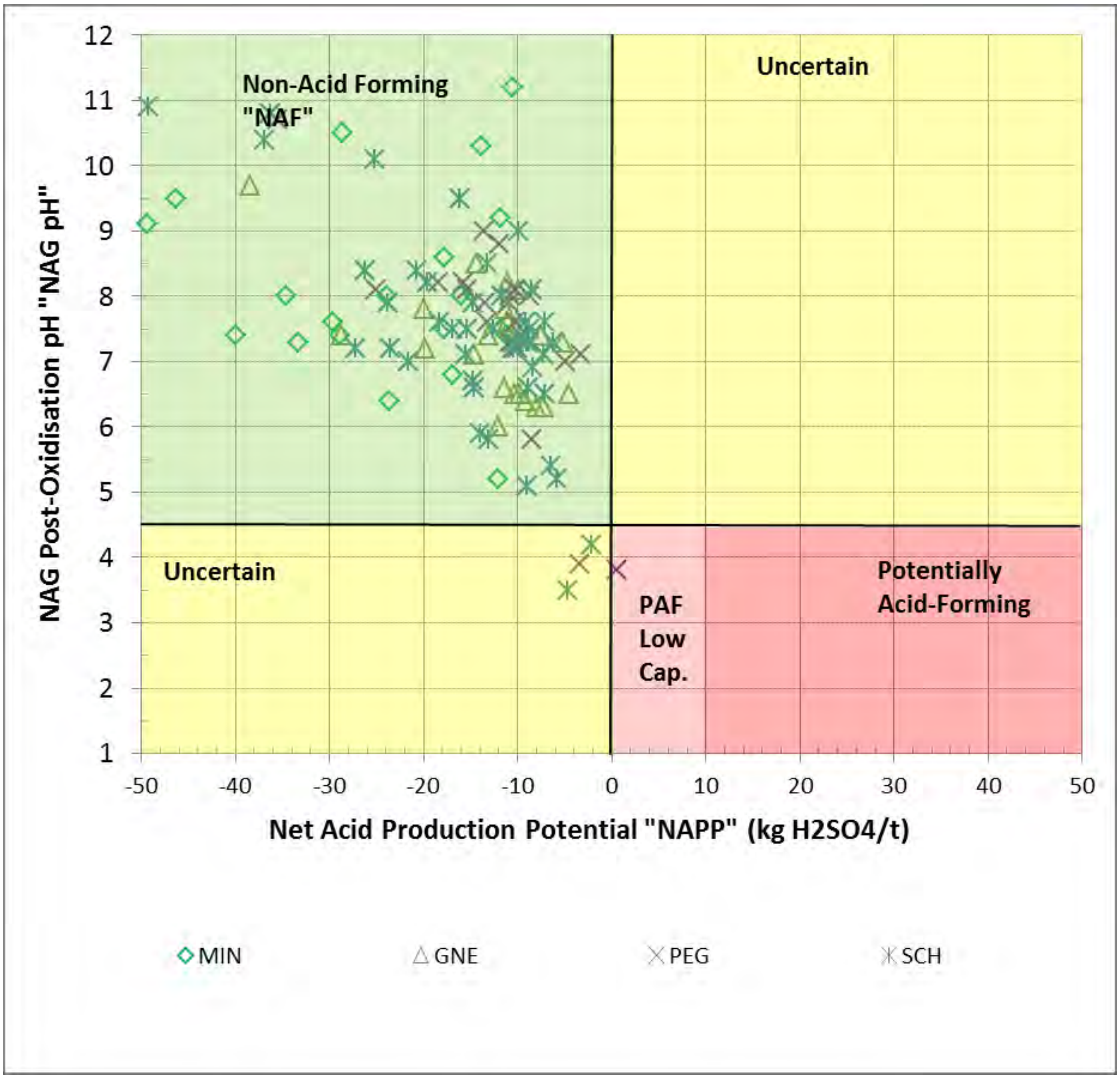

Figure 11 NAG Vs NAPP Plot - Full Range

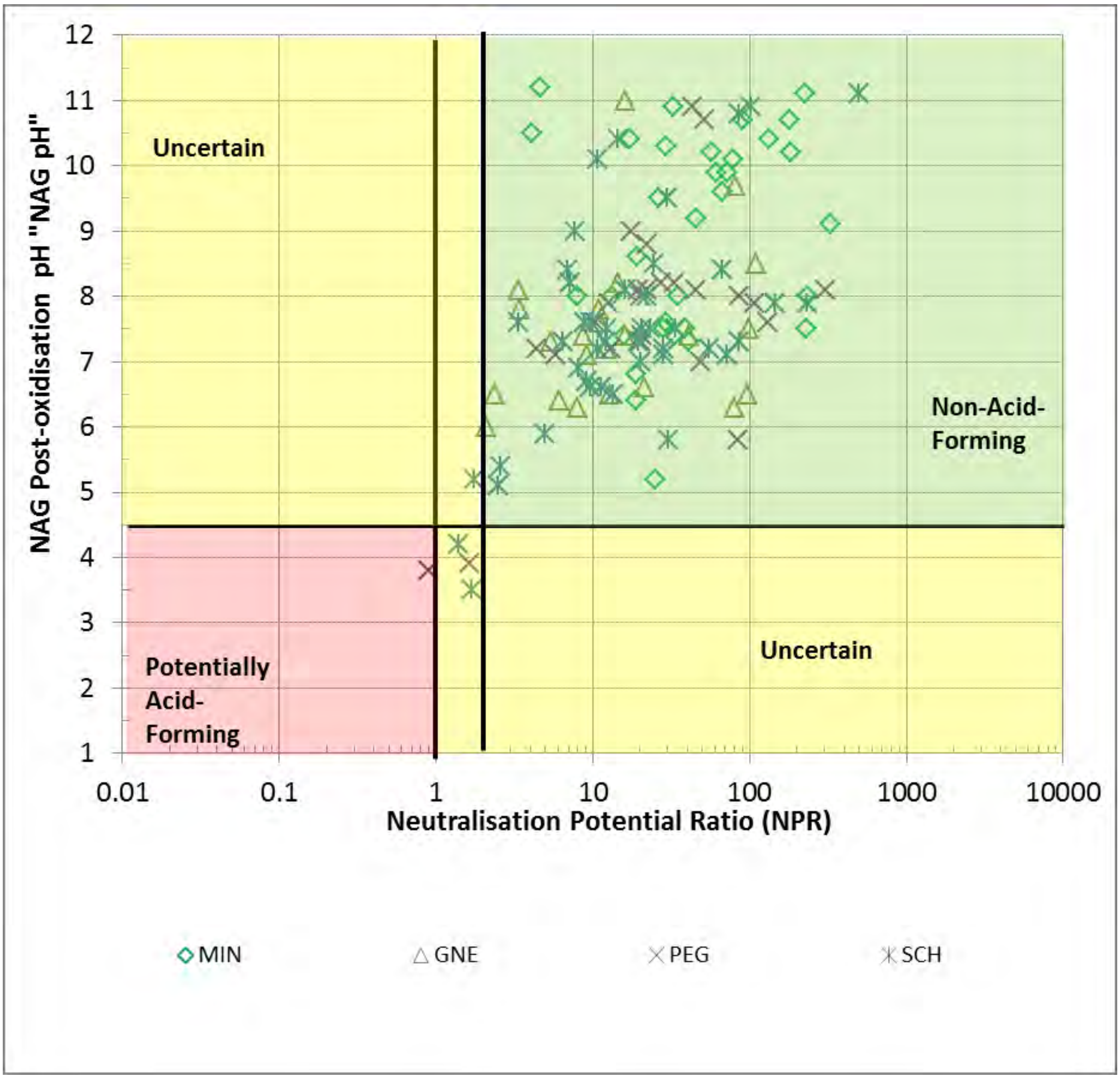

Figure 12 NAG vs NPR plot

4.5 Stage 2 Kinetic AMD and Leachate Testing

Selected samples of NAF, PAF and UC material were subjected to additional testing including:

- Kinetic NAG (KNAG) testing to gain an indication of time available for temporary stockpiling before the material begins to oxidise and produce acid
- Acid buffering characteristic curve (ABCC) analyses to determine if the apparent ANC is fully available
- ASLP testing to assess the risk of metalliferous drainage.

The results are summarised below.

4.5.1 Kinetic NAG testing

The kinetic NAG testing tended to confirm the initial static test results that classified the samples as being NAF. The NAG pH and final KNAG pH show a strong correlation to one another (Figure 13), with the exception of a few outliers, confirming that a static NAG test is broadly suitable for classifying material.

Most samples (23) were non-reactive to weekly reactive, showing flat temperature and pH, e.g. curves such as 2133329 (Figure 14) which showed a flat temperature and pH line.

One sample (2133119 mineralisation) showed a reaction with a rising pH, (Figure 15), and a rising temperature curve. This rise in pH was gradual with the steepest rise occurring after approximately 240 minutes, suggesting that the sample has a long period of acid buffering capacity before a reaction occurs. Temperature started to increase at the beginning of the test, which suggests an exothermic reaction; however, the rise in temperature peaked at 280 minutes and was decreasing towards the end of the test at 360 minutes. The curve suggests that there has been a reaction but as Total Sulfide is relatively low (0.1%S) is not likely related to excess sulfides. Although the sample is unlikely to release acid, such samples may release metals that are not pH sensitive, such as zinc.

One sample (2133727 Figure 16) recorded a weakly reactive plot with a falling pH, reaching a minimum pH of 4.3 after 360 minutes with the decline in pH starting after approximately 120 minutes, and a slight rise in temperature from 22.3°C at the beginning of the test to 27.3°C at the conclusion. This indicates that there is slightly less acid buffering capacity in this sample.

All samples maintained a pH of greater than 4.3 after 360 minutes. This indicates that the risk of acid generation is low in all samples. Based on general correlations between kinetic NAG and column leach testing lags (Stewart, Miller, & Smart, 2006) the times taken to produce acidic leachate is likely to be greater than 2 years although the static testing suggests none of the resampled material would generate acid at any stage.

Some materials may exhibit oxidation of sulfides, but with complete neutralisation within 1-2 months. This is consistent with the observed change in static NAG tests for sample 340461.

Based on the above results, the material is unlikely to generate acid within the proposed temporary stockpiling time on site, or in long-term storage. However, a small volume of pegmatite material with slightly elevated sulfur could oxidise and produce metalliferous leachate over the long term, if left unmanaged.

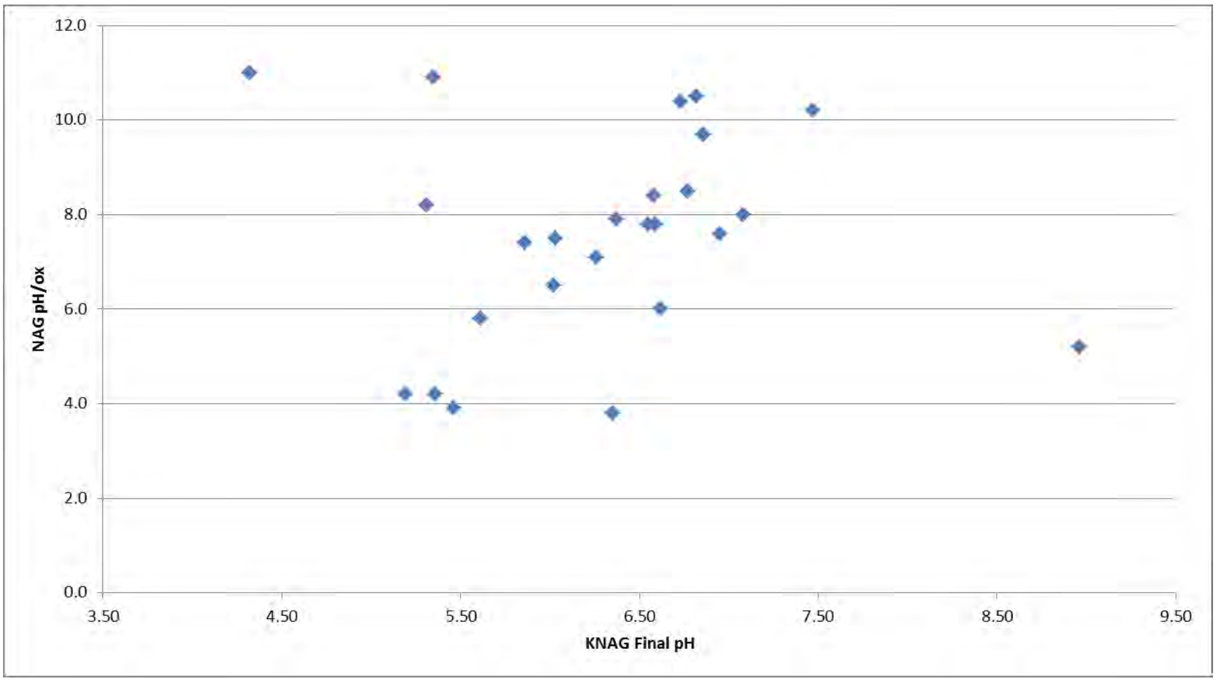

Figure 13 NAG pH KNAG pH Correlation Plot

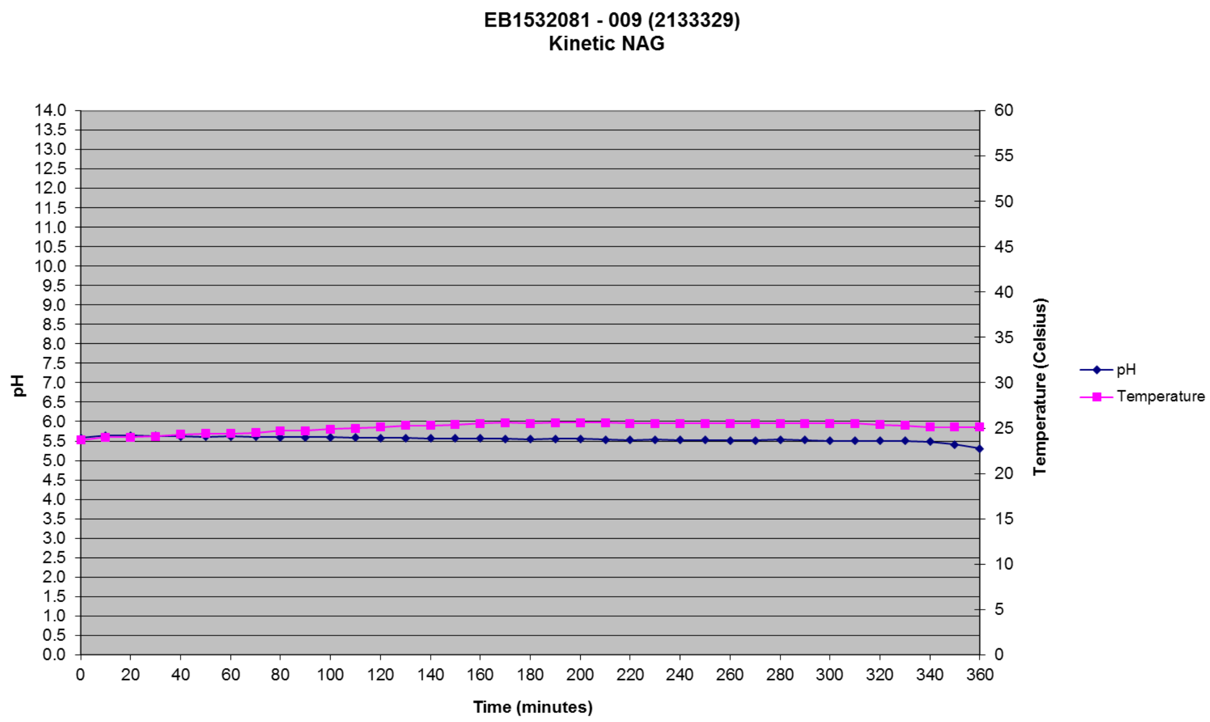

Figure 14 Flat Kinetic NAG Plot Sample 2133329

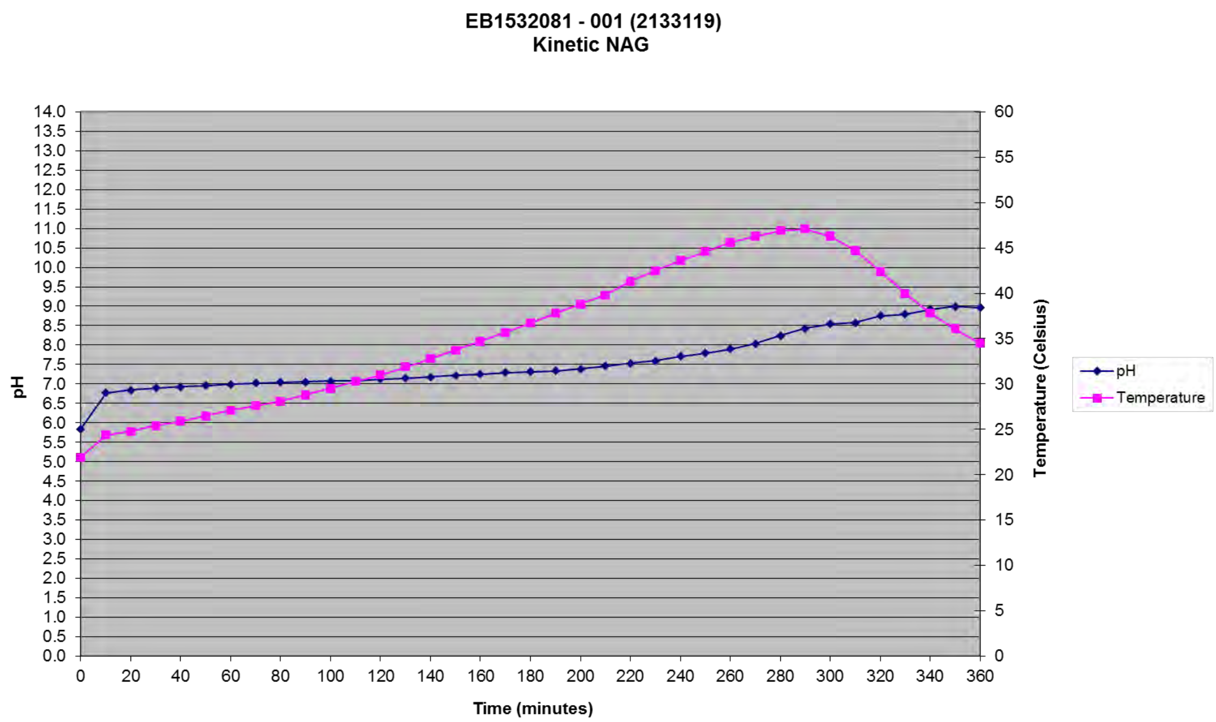

Figure 15 Reactive Rising Kinetic NAG Plot Sample 2133119 (mineralised)

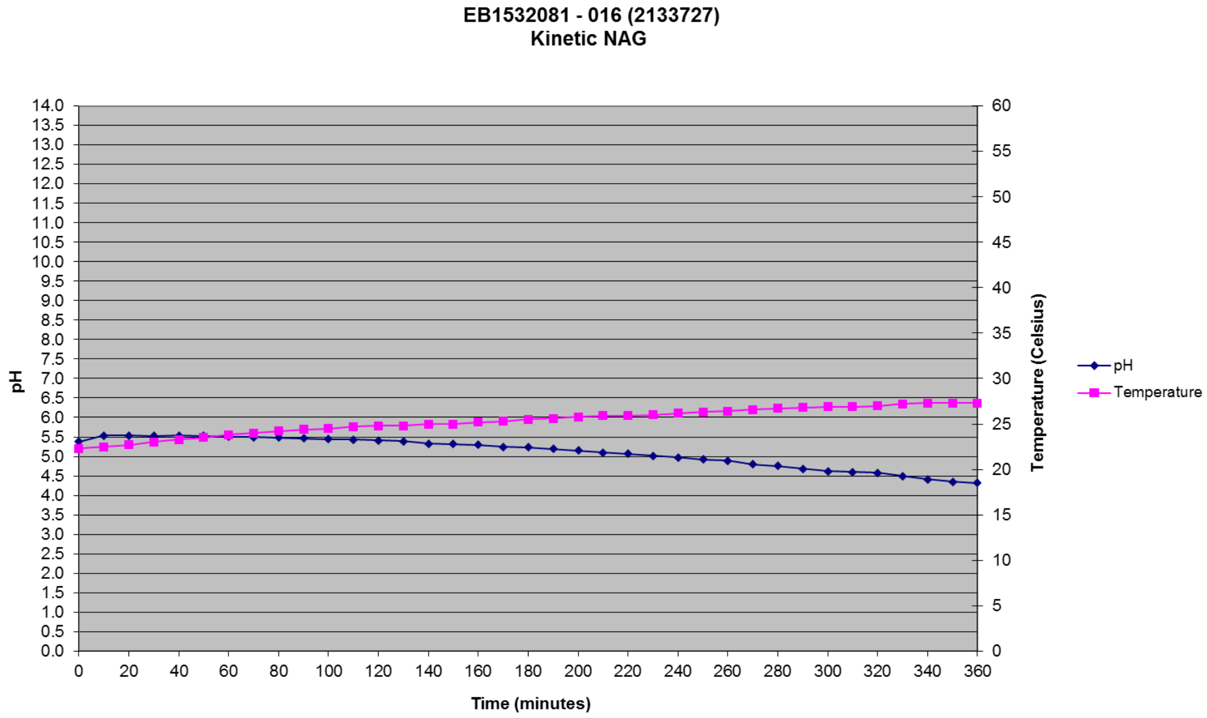

Figure 16 Reactive Falling Kinetic NAG Plot Sample 2133727 (Gneiss)

4.5.2 Acid Buffering Characteristic Curve (ABCC)

The Acid Buffering Characteristic Curves (ABCC) test involves the slow titration of a sample with acid while continually monitoring pH. This test is helpful in determining if a sulfidic sample with a NAPP <0 (all except a single sample from the Stage 1 testing) and a NAGpH=4.5 has enough readily available neutralising capacity to render it non-acid producing throughout the oxidisation process.

The ABCC curves and the ANC from the Stage 1 testing are presented in Appendix C. The steeply falling curves for most samples indicate a non-calcite source of neutralisation, such as micas, clays or silicates.

The difference between the titrated ABCC value and the initial Static ANC values is shown below in Table 7. The ABCC-derived acid neutralising capacity shows that the Static ANC values have generally overestimated the acid neutralising capacity of the waste rock although they still have an excess of acid neutralising capacity other than 2135497 (0.7 kgH_2SO_4/t) and 2133119 (25.6 kgH_2SO_4/t).

Table 7 ABCC Derived Neutralising Capacity and Static ANC Values

Sample	Waste Type	ABCC (kgH2SO4)	ANC (kgH2SO4)	ABCC-ANC (kgH2SO4)
2130745	GNE	2.0	29.5	-27.5
2132125	GNE	7.0	23.0	-16.0
2133727	GNE	2.0	78.0	-76.0
2134187	GNE	11.0	22.0	-11.0
2134597	GNE	15.2	14.5	0.7
2134886	GNE	6.9	16.0	-9.1
2134887	GNE	20.0	38.9	-18.9
2136002	GNE	4.0	16.4	-12.4

2130694	MIN	98.0	229.0	-131.0
2133119	MIN	38.2	12.6	25.6
2133257	MIN	30.6	35.6	-5.0
2133528	MIN	11.0	30.7	-19.7
2134651	MIN	18.4	37.8	-19.4
2130893	PEG	2.5	8.7	-6.3
2133148	PEG	4.4	4.6	-0.2
2133329	PEG	1.5	19.1	-17.6
2133686	PEG	3.9	197.0	-193.1
2133886	PEG	7.4	14.7	-7.4
2134104	SCH	11.8	39.6	-27.9
2134341	SCH	11.0	24.2	-13.2
2135832	SCH	2.5	13.5	-11.1
2113728_2113729	SCH	3.4	15.9	-12.5
2118644_2118645	SCH	3.5	7.7	-4.2

The Mineralisation waste rock would appear to have the greatest acid neutralising capacity followed by the gneiss. The mean and median neutralising capacity for each rock type is presented in Table 8.

Despite the possible overestimation of ANC from the static NAPP tests, it appears that most rock types have adequate neutralising capacity.

Table 8 Mean ABCC Acid Neutralising Capacity by Waste Rock Type

Waste Type	ABCC - Mean Acid Neutralising Capacity (kgH_2SO_4)	ABCC - Median Acid Neutralising Capacity (kgH_2SO_4)	Static ANC - Mean Acid Neutralising Capacity (kgH_2SO_4)	Static- Median Acid Neutralising Capacity (kgH_2SO_4)
Gneiss	8.5	6.9	29.8	22.5
Mineralisation	39.2	30.6	69.1	35.6
Pegmatite	3.9	3.9	48.8	14.7
Schist	6.4	3.5	20.2	15.9

4.5.3 Leachate Analysis

Australian Standard Leachate Protocol (ASLP) was performed to assess the potential of the stockpiled material to produce leachate. The test was performed on the crushed waste rock using deionised water (DI). The results were compared to a hierarchy of water quality guidelines (Appendix C) with only the samples that exceeded the adopted guidelines and the magnitude of exceedance shown in Table 9. That hierarchy comprises:

- ANZECC & ARMCANZ (ANZECC & ARMCANZ, 2000a) guidelines for protection of 95% of freshwater aquatic ecosystem species (FAE99%)
- ANZECC & ARMCANZ (ANZECC & ARMCANZ, 2000a) guidelines for protection Livestock watering
- Australian Drinking Water Guidelines 2011 (ADWG) (NHMRC, NRMMC, 2011)
- Guidelines for incidental contact (nominally 10 times the ADWG).

Given the relatively aggressive nature of the leaching procedure and the potential for dilution in the environment, a dilution factor of between 10 and 100 is applied to ASLP concentrations when considering their environmental significance.

Aluminium, boron, chromium, copper, lead and zinc were the only metals that exceeded FAE99 %. The results are presented along with their guideline percentage exceedance in Table 9 below. Aluminium and zinc exceed the guideline values in all waste rock types and all samples apart from two mineralisation samples for aluminium. Pegmatite sample 2133148 and Gneiss sample 2133727 exceeded the guideline values for all six metals. Lead, chromium and zinc were the only metals to exceed the guideline for incidental contact (nominally set at 10 times the ADWG Health guideline) with four samples containing chromium values exceeded by 200. A total 19 samples exceeded the adopted incidental contact guideline values across all waste rock types. No samples exceeded the ANZECC 2000 guideline for the protection of stock watering.

The ADWG health and aesthetic guideline values were exceeded, in one of more samples, for aluminium, dissolved iron, lead and fluoride (Table 10). Aluminium exceeded the aesthetic guideline value in all but five samples and the aesthetic guideline value for dissolved iron was exceeded in five samples across all waste rock types. ADWG health guideline values were exceeded for only for lead and fluoride once each in two separate samples (pegmatite and schist respectively).

Groundwater samples were obtained from Nolan Replacement Bore (RN1876) and dewatering bore (RN37197) the results of which have been reported in GHD 2012. Concentrations of aluminium, barium, chromium, copper lead, manganese, nickel, thorium and zinc exceeded the median groundwater concentration in one or more samples. The most significant exceedances, in terms of number of samples and exceedance factor, were by aluminium and lead, although that is in part due to their relatively low concentrations in groundwater.

Overall, the critical leachate constituents appear to be aluminium and zinc based on their consistent exceedance of FAE 99 %. However, as concentrations of these analytes is higher in the regional groundwater system any leachate that entered into the system would not likely affect the beneficial use of the water.

Table 9 Result and Amount by which Metals Exceed Freshwater Aquatic Ecosystems (99%) Trigger Values

Sample ID		Al		B		Cr		Cu		Pb		Zn	
Units		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)		(mg/L)	
ANZECC (2000) FAE 99%		0.027		0.09		0.00001		0.001		0.0010		0.002	
			Times exceed		Times exceed		Times exceed		Times exceed		Times exceed		Times exceed
Sample ID	Sample Lithology	Results	FAE99%	Results	FAE99%	Results	FAE99%	Results	FAE99%	Results	FAE99%	Results	FAE99%
2130694	Mineralisation	0.010	0.4	<0.05	<LOR	<0.001	<LOR	<0.001	<LOR	<0.001	<LOR	0.022	9.2
2133119	Mineralisation	0.070	2.6	0.150	1.7	<0.001	<LOR	<0.001	<LOR	<0.001	<LOR	0.025	10.4
2133257	Mineralisation	0.050	1.9	<0.05	<LOR	<0.001	<LOR	<0.001	<LOR	<0.001	<LOR	0.026	10.8
2133528	Mineralisation	0.060	2.2	<0.05	<LOR	<0.001	<LOR	<0.001	<LOR	<0.001	<LOR	0.031	12.9
2134651	Mineralisation	0.100	3.7	<0.05	<LOR	<0.001	<LOR	<0.001	<LOR	0.002	2.0	0.039	16.3
2130893	Pegmatite	0.720	26.7	0.130	1.4	<0.001	<LOR	0.003	3.0	0.005	5.0	0.008	3.3
2133148	Pegmatite	0.730	27.0	0.160	1.8	0.002	200.0	0.002	2.0	0.004	4.0	0.044	18.3
2133329	Pegmatite	0.920	34.1	0.190	2.1	<0.001	<LOR	0.001	1.0	0.058	58.0	0.028	11.7
2133686	Pegmatite	1.000	37.0	0.160	1.8	<0.001	<LOR	<0.001	<LOR	0.008	8.0	0.033	13.8
2134886	Pegmatite	0.530	19.6	0.150	1.7	<0.001	<LOR	<0.001	<LOR	0.002	2.0	0.038	15.8
2113728_2113729	Schist	0.950	35.2	0.170	1.9	<0.001	<LOR	0.002	2.0	<0.001	<LOR	0.032	13.3
2118644_2118645	Schist	0.820	30.4	0.140	1.6	<0.001	<LOR	0.002	2.0	<0.001	<LOR	0.035	14.6
2134104	Schist	0.340	12.6	0.160	1.8	0.002	200.0	0.001	1.0	0.002	2.0	0.043	17.9
2134341	Schist	0.540	20.0	0.140	1.6	<0.001	<LOR	0.002	2.0	0.002	2.0	0.035	14.6
2135832	Schist	1.570	58.1	0.230	2.6	0.002	200.0	0.001	1.0	0.006	6.0	0.031	12.9
2130745	Gneiss	0.910	33.7	0.190	2.1	<0.001	<LOR	<0.001	<LOR	0.004	4.0	0.013	5.4
2131103	Gneiss	0.930	34.4	0.150	1.7	<0.001	<LOR	0.01	10.0	0.003	3.0	0.013	5.4
2132125	Gneiss	0.870	32.2	0.190	2.1	<0.001	<LOR	0.004	4.0	0.004	4.0	0.013	5.4
2133727	Gneiss	1.980	73.3	0.190	2.1	0.002	200.0	0.012	12.0	0.005	5.0	0.036	15.0
2133886	Gneiss	0.870	32.2	0.140	1.6	<0.001	<LOR	0.001	0.0	0.003	3.0	0.032	13.3
2134187	Gneiss	0.520	19.3	0.130	1.4	<0.001	<LOR	0.008	8.0	0.003	3.0	0.056	23.3
2134597	Gneiss	0.370	13.7	0.150	1.7	<0.001	<LOR	<0.001	<LOR	0.002	2.0	0.053	22.1
2134887	Gneiss	0.240	8.9	0.160	1.8	<0.001	<LOR	0.001	1.0	0.002	2.0	0.024	10.0
2136002	Gneiss	1.060	39.3	0.100	1.1	<0.001	<LOR	0.003	3.0	0.004	4.0	0.028	11.7

Exceeds FW99%

Exceeds FW99% less than 10 times guideline

Exceeds FW99% greater than 10 times guideline

Table 10 Result and Amount by which Metals Exceed ADWG Health and Aesthetic Guidelines

	Parameters	Al		Fe Dissolved		Pb		F	
	Units	(mg/L)		(mg/L)		(mg/L)		(mg/L)	
	ADWG (2011) Health	-		-		0.01		1.5	
	ADWG (2011) Aesthetic	0.2		0.3		-		-	
			Times exceed		Times exceed		Times exceed		Times exceed
Sample ID	Sample Lithology	**Results**	ADWG (A)	**Results**	ADWG (A)	**Results**	ADWG (H)	**Results**	ADWG (H)
2133148	Pegmatite	0.73	3.7	0.09	0.30	0.004	0.40	0.70	0.47
2133886	Pegmatite	0.87	4.4	0.13	0.43	0.003	0.30	0.50	0.33
2133686	Pegmatite	1.00	5	0.21	0.70	0.008	0.80	0.40	0.27
2133329	Pegmatite	0.92	4.6	0.46	1.53	**0.058**	**5.8**	0.50	0.33
2130893	Pegmatite	0.72	3.6	0.08	0.27	0.005	0.50	0.40	0.27
2118644_2118645	Schist	0.82	4.1	0.27	0.90	<0.001	<LOR	0.50	0.33
2113728_2113729	Schist	0.95	4.8	0.76	2.53	<0.001	<LOR	**1.80**	1.2
2134104	Schist	0.34	1.7	0.11	0.37	0.002	0.20	0.50	0.33
2134341	Schist	0.54	2.7	0.20	0.67	0.002	0.20	0.60	0.40
2135832	Schist	1.57	7.9	1.22	4.07	0.006	0.60	0.90	0.60
2133727	Gneiss	1.98	9.9	1.94	6.47	0.005	0.50	0.60	0.40
2134187	Gneiss	0.52	2.6	0.06	0.20	0.003	0.30	0.40	0.27
2134887	Gneiss	0.24	1.2	0.07	0.23	0.002	0.20	0.40	0.27
2130745	Gneiss	0.91	4.6	0.68	2.27	0.004	0.40	0.60	0.40
2136002	Gneiss	1.06	5.3	0.19	0.63	0.004	0.40	0.50	0.33
2132125	Gneiss	0.87	4.4	0.17	0.57	0.004	0.40	0.70	0.47
2134597	Gneiss	0.37	1.9	0.07	0.23	0.002	0.20	0.30	0.20
2134886	Gneiss	0.53	2.7	0.15	0.50	0.002	0.20	1.00	0.67
2131103	Gneiss	0.93	4.7	0.19	0.63	0.003	0.30	0.80	0.53

Exceeds ADWG (Aesthetic)
Exceeds ADWG (Health)

4.6 Geochemical Assessment Summary

The results of static NAG testing indicate that approximately 95% of the material is non-reactive and non-acid-forming (NAF). Kinetic NAG pH showed that single addition NAG pH is suitable for identifying PAF and that reaction times are relatively slow, with a very low risk of acid generation either during short-term storage of ore, or long-term storage of waste rock.

Given the abundance of NAF and ACM material, a PAF cut-off of 0.3 %S or 10 kg/t H_2SO_4 would be a generally conservative initial value. As the one recorded PAF sample had a relatively low MPA coupled with a low ANC, confirmatory field NAG testing could be carried out on samples with a sulfur content of greater than 0.15%, unless pre-production testing provides sufficient information for a revised cut-off.

Leachate testing indicated that most of the waste rock was non-sulfidic and relatively benign, with small amounts of material with slightly elevated sulfur, some of which is likely to be in the form of non-acid generating sulfate. Although neutralised by the excess acid-neutralising capacity, the material may contain metals such as zinc that form soluble forms when their sulfide forms are oxidised and neutralised. However, consistent with its occurrence in the proposed waste rock, groundwater in the area already has elevated metal concentrations, including uranium, that exceed environmental, stock and drinking water guidelines. Consequently, leachate from waste rock is unlikely to degrade the useability of the groundwater. Leachate salinity was low and fluoride was only slightly elevated in one sample, hence the risk of generation of saline or fluoride-rich leachate is low.

Although one sample of pegmatite produced ASLP leachate with a lead concentration 1054 and 5.8 times the average groundwater concentrations (due to the low concentration in groundwater) and ADWG respectively, the critical leachate constituents appear to be aluminium and zinc based on their consistent exceedance of FAE 99 % and ambient groundwater concentrations. As the average exceedance factor was less than 4 for aluminium, it is unlikely that leachate from the waste rock dumps will affect existing poor quality groundwater or ephemeral surface water quality when typical dilution factors are considered. It will be important, however, to ensure leachate (or ambient groundwater) is not allowed to discharge to the surrounding creeks and concentrate through evaporation.

Based on the overall geochemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is low and the material can generally be managed as NAF waste, although the management plan should have a contingency for management of, nominally, 1 % of material being PAF.

5. AMD Risk Assessment

The following AMD ecological and human health risk assessment was undertaken to determine the AMD risk associated with the material identified at the Nolans Bore. It has been undertaken within the context of, and considering:

- PAF material identified during the geochemical assessment
- Metal (including radioactive metals such as thorium and uranium) leaching potential of the excavated material
- The mine plan and schedule
- Baseline environment and any sensitive receptors as identified GHD (2015).

The AMD risk assessment is a source-focused risk assessment in that it is not an exhaustive study of downstream impacts. It has been completed to provide a high level understanding of AMD source risk on a greenfield mine site within the context of the mine plan, such that any potential impacts from mismanaging the mine wastes may be identified based on the geochemical information as reported above. In that regard, it uses INAP's (INAP, 2011) source→pathway→receptor model as shown below in Figure 17.

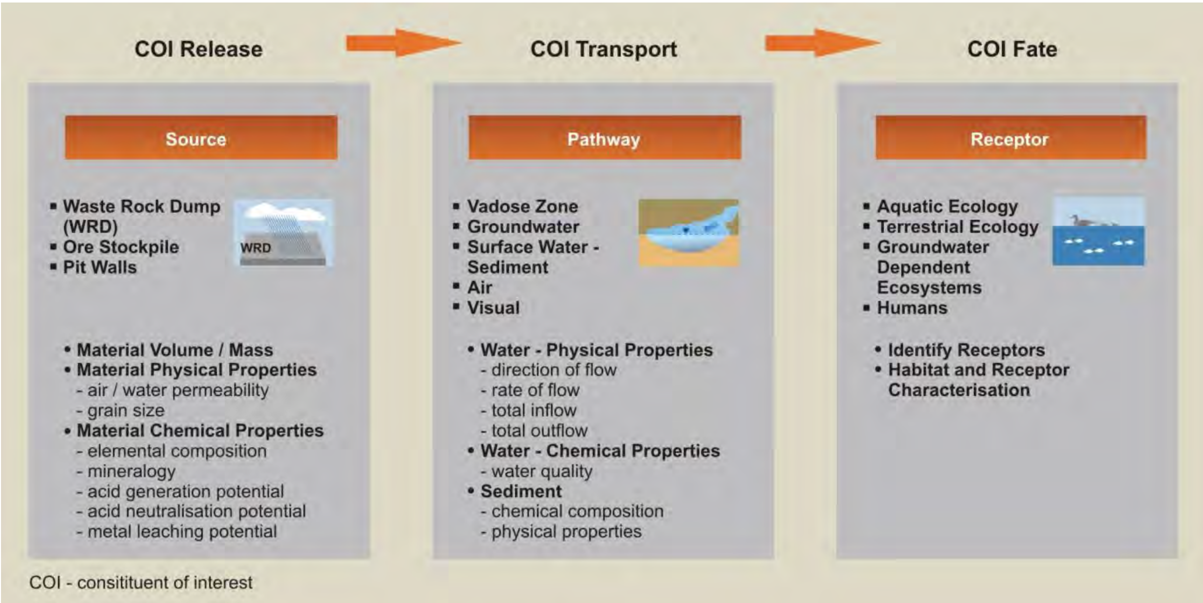

Figure 17 The AMD Source→Pathway→Receptor Model

The general approach to the risk assessment followed standards and leading practice guidelines including:

- AS/NZS 4360:2004 Risk Management
- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines
- Managing Acid and Metalliferous Drainage (DITR, 2007)
- The Global Acid Rock Drainage Guide (INAP, 2011).

The outcomes of the AMD risk assessment have informed the AMD management strategy and Plan.

5.1 AMD Risk Assessment & Management Process

5.1.1 Introduction

INAP (INAP, 2011) notes that the geochemistry and risk assessment techniques related to AMD for a new mining development are not calibrated for all situations. There will therefore remain a degree of uncertainty in terms of the confidence in the data collected and the reliability of the analysis and output. For this reason, a precautionary approach and contingency planning is an integral part of this AMD risk assessment, as it informs the AMD Management Plan.

The risk assessment recognises the limitations of the input data, including the absence of kinetic ABA testing and limited column leaching tests. However, the use of a large laboratory dataset and site sulfur (samples) and metal assay/gamma spectrometry dataset (30,000 samples) has provided a suitably sized input for the stated purposes of assessing AMD risk, and developing high level management strategies for site implementation throughout the operational mine stage, and into closure.

The risk assessment has also acted as a gap analysis, with any data gaps proposed to be filled by the collection of additional geochemical samples with subsequent analysis throughout the pre-production and operational stages. Additional data collected in the future will be fed back into the AMD management plan to better inform the process such that AMD management strategies may be fine-tuned as required.

INAP (INAP, 2011) notes that the level of acceptable risk will vary from the local, regional, and national communities. In addition, the level of acceptable risk will change over time. Acceptable risks today may not be acceptable in the future, therefore, this risk assessment should be revised commensurate with updates to the AMD Management Plan.

5.1.2 Risk Management

Risk is defined as the probability or likelihood that a certain event (hazard) will happen, multiplied by the consequence of the event INAP (2011); Equation 6).

Equation 6

Equation 6: $$\textit{Risk} = \textit{Probability} \times \textit{Consequence}$$

Risk Management is essentially a five step process including:

Step 1 – Establish the Context

Step 1 of the process as shown in Figure 18 relates to the mining proposal at Nolans Bore including the mine Plan and schedule as discussed in Section 1.4, in addition to the existing environment at the site.

Step 2 – Identify the Risks

Step 2 of the process as shown in Figure 18 relates to geochemical assessment reported above. The information in Steps 1 and 2 were combined to generate a conceptual site model for AMD risk at the site (refer to Section 5.1.4).

Step 3 – Analyse and Evaluate the Risks

Step 3 is the risk assessment provided in Table 15.

Step 4 – Treat the Risks

Management strategies to address the steps are articulated in the AMD Management Plan.

Step 5 – Monitor and Review

Step 5 relates to the AMD Monitoring Plan discussed in Section 6 of the AMD Management Plan, the site validation procedure presented in Section 4 of the AMD Management Plan, and the continuous improvement feedback loop as discussed above.

Throughout each step it is essential that there is consultation and communication with all key stakeholders as they relate to AMD management. Figure 18 shows the process schematically.

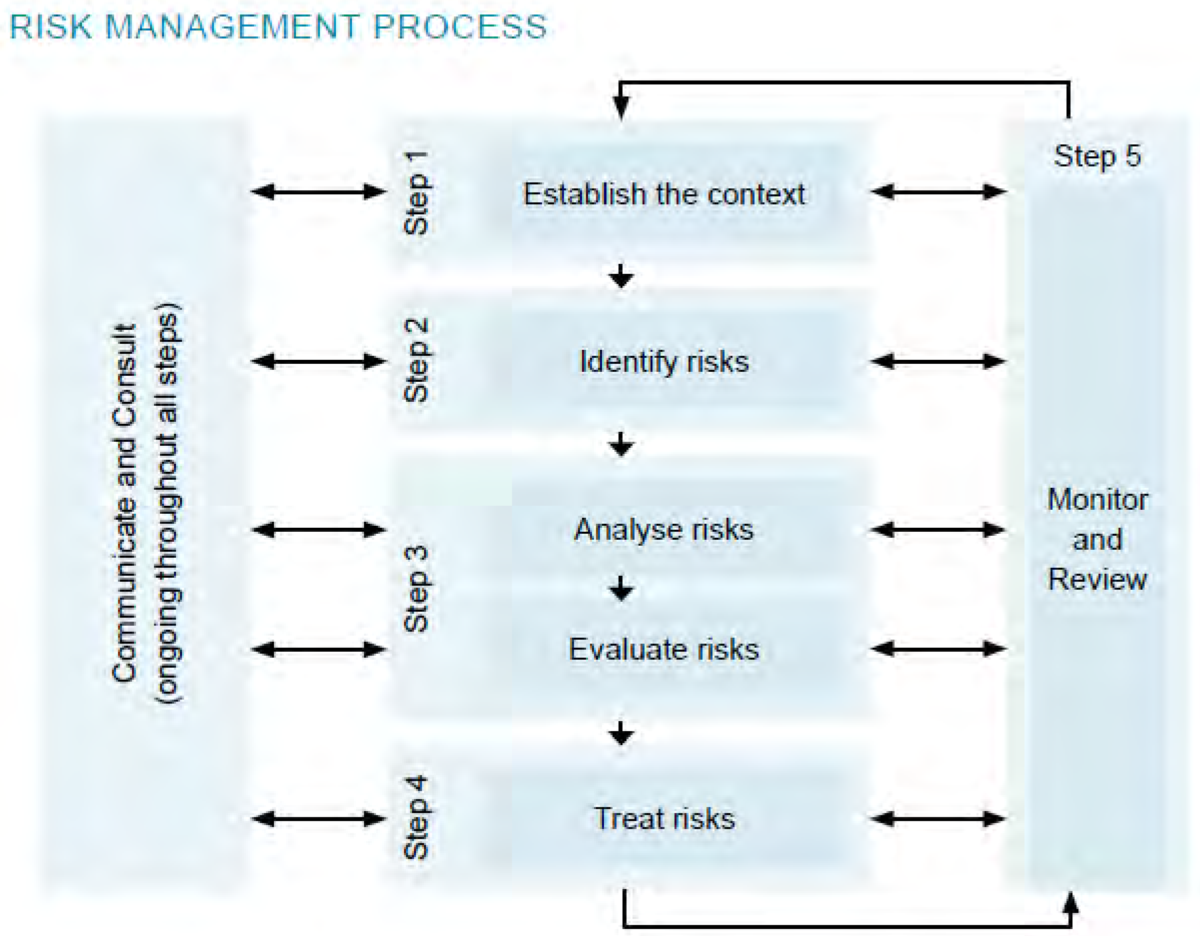

Figure 18 Risk Management Process

5.1.3 Likelihood, Consequence and Risk Ranking

Step three of the risk management process, as described briefly above, includes semi-quantifying the risk using Equation 6, above, by using applicable likelihood and consequence scales. Table 11 provides the likelihood scales used herein, while Table 12 provides the consequence scale.

Multiplying likelihood and consequence provides a semi-quantitative risk ranking

Table 13 which can be used to allocate design and operational level risk mitigation and management strategies on a hierarchical basis as appropriate through a risk score and priority ranking system (Table 14). The risk ranking is then reconsidered with the design or operational level management control in place (e.g. a waste rock dump with PAF encapsulation cells). The residual risk ranking is then re-allocated a residual risk score and priority ranking system, with monitoring to assess the residual risk and the relative success of the design or operational level management strategy implemented.

Table 11 Likelihood Scale

Rating	Likelihood	Approximate Frequency	Probability of occurrence (%)
5	Almost Certain A very high likelihood of occurrence.	Weekly	≈ 91 to 100
4	Likely A high likelihood of occurrence.	Monthly	≈ 51 to 90
3	Possible Moderate likelihood of occurring.	Annually	≈ 11 to 50
2	Unlikely A low likelihood of occurrence.	Once in a decade	≈ 1 to 10
1	Rare A very low likelihood of occurrence.	Once per 100 years	≈ <1

Table 12 Consequence Scale

Rating	Consequence	Approximate Frequency
5	Catastrophic. Widespread irreversible environmental harm.	Most environmental objectives not achieved, and/or several severely affected.
4	Major. Widespread environmental impact, not immediately contained.	Several environmental objectives affected with considerable effort to rectify.
3	Moderate. Reversible environmental harm extending beyond site boundary, immediately contained.	Several environmental objectives affected with limited effort to rectify, or a single environmental objective affected with significant effort to rectify.
2	Minor. Reversible environmental impact; immediately contained.	A single environmental objective affected with limited effort to rectify.
1	Low. Very low environmental impact; localised.	A very small impact, rectified by normal processes.

Table 13 Risk Score

	Consequence				
Likelihood	**1. Insignificant**	**2. Minor**	**3. Moderate**	**4. Major**	**Catastrophic**
5. Almost Certain	5 - Medium	10 - High	15 - High	20 - Extreme	25 - Extreme
4. Likely	4 - Medium	8 - Medium	12 - High	16 - Extreme	20 - Extreme
3. Possible	3 - Low	6 - Medium	9 - Medium	12 - High	15 - High
2. Unlikely	2 - Low	4 - Low	6 - Medium	8 - Medium	10 - High
1. Rare	1 - Low	2 - Low	3 - Low	4 - Low	5 - Medium

Table 14 Risk Score and Priority Ranking

Risk score	Risk Priority
Extreme (16+)	1
High (10 – 15)	2
Medium (5 – 9)	3
Low (1 – 4)	4

5.1.4 AMD Conceptual Site Model

The following conceptual site model (Figure 19) considers INAP's (2011) source→pathway→receptor model as shown in Figure 18. The source material risk has been assessed in the geochemical assessment, and the receptors are drawn from the EIS (GHD 2015). It considers the overall AMD risk based on the life of mine for the Nolans project.

Conceptual AMD Site Model – Nolans project		
Source	*In situ* sulfides	*Ex situ* sulfides
	Pit walls. Only trace elevated sulfide mineralisation expected in pit walls.	Mined and placed PAF on ROM Pad or WRDs. Low risk as only trace PAF identified in pit and only minor non-PAF waste stored outside pit.
	Metals: Some elevated metals in whole rock assays using the geochemical abundance index method.	
	Metals leaching: Low to moderate.	
	Sulfate leaching: Low.	

Pathway	Groundwater	Surface water	Sediment	Windborne Dust

Receptors	Aquatic flora and fauna in ephemeral surface waters. Potential springs and Groundwater Dependent Ecosystems (e.g. riparian vegetation). Potential future groundwater users.

Figure 19 Nolans Bore AMD Conceptual Site Model

Table 15 AMD Risk Assessment

Ref.	Impact pathway			Planned Controls to Manage Risk (as per Project Description, and elements of Standards / Codes of Practice	Initial Risk			Level of Certainty	Additional Controls Recommended to Reduce Risk	Residual Risk			Level of Certainty	Comment	Applicable Technical Report / EIS chapter
	Potential event (how the Project interacts with assets, values, uses and location. Include clear description of the cause)	Environmental Factor / Receptor	Description of consequences (Clearly understand what is the final impact. Describe whether it is construction, operation or decommissioning)		Consequence	Likelihood	Risk Rating			Consequence	Likelihood	Risk Rating			
20	Seepage from Tailings Storage Facility (TSF) at Mine Site, including failure of low permeability soil liner system	Groundwater	Seepage of tailings water containing metals at levels exceeding guideline thresholds, with localised contamination of groundwater and discharge to surface water.	- Installation of low permeability soil liner system; - Groundwater monitoring program; - Thickener on benefactor to reduce volume of entrained water entering the TSF; - Supernatant reclaim; - Testing to confirm chemical properties; - Tailings storage facility management and water discharge; - Ongoing AMD sampling and analysis; - Mine Management Plan; - Sediment and Erosion Control Plan; - Controlled and managed site drainage and release to adequately dilute fluoride; - Water cover to minimise dust generation until capped.	Minor	Likely	Medium	Low Level	- Seepage interception and collection system; - Avoid placement of future stock bores within close proximity	Minor	Likely	Medium	Low Level	• Low sulfur and significant contained neutralising capacity in likely tailings stream as tailing discharged as an alkaline waste stream following neutralisation around pH10. • Static and kinetic AMD and leachate testing to confirm mobility is underway. • Assumes that ongoing AMD validation monitoring is undertaken, and material classified, handled and placed according to the AMD Management Plan. • Additional AMD testing to be undertaken pre-production and during production. Sound understanding of the subsurface and location of shallow palaeochannels near both sites will enable prompt intervention if required.	Appendix L, Chapter 8 - Groundwater
29	Uncontrolled AMD seepage from in-pit and ex-pit AMD material at Mine Site, including pit walls, ROM pad or storage	Groundwater	Contamination of a groundwater resource, including acidity, salinity or metals.	- Testing to confirm chemical properties. Only trace AMD material identified in material likely to make up pit walls or be dewatered by mine drainage; - PAF encapsulation cells within ex-pit WRDs; - Dumps and fill areas profiled to shed and capture runoff; - Clean, dirty and contaminated water drainage systems; - Surface water management basins; - On completion of mining, pit will re-flood above the level of any significant AMD in the aquifers surrounding the pit, preventing further oxidisation; - AMD Management Plan, with regular review. Including ongoing AMD sampling and analysis; - Mine Management Plan; - Sediment and Erosion Control Plan; - Water Management Plan; - Selective materials handling and placement using mine schedule and geochemical model; - Controlled and managed site drainage and release; - Compaction of construction material and waste rock; - Rapid recovery of groundwater levels to prevent further PAF oxidisation and post mining	Minor	Unlikely	Low	Medium Level	No additional controls	Minor	Unlikely	Low	Medium Level	Low sulfur content and significant apparent neutralising capacity in most lithologies and waste streams. NAPP ranges between -225 kg/H2SO4 to 0.6 kg/H2SO4 with median and mean values of -13.9 kg/t H2SO4 and -27.3 kg/t H2SO4. Low total metals –Be, Ce, Eu, La, Mo, ND, PR, Sb, Se, Ta, Th, Ti, Tl, Hg had mean concentrations exceeding a GAI of 3 but low (TBA) content in groundwater suggests limited mobility. Leachate testing to confirm mobility is underway. Assumes that ongoing AMD validation monitoring is undertaken, and material classified, handled and placed according to the AMD Management Plan. Additional AMD testing to be undertaken pre-production and during production.	Appendix L, Chapter 8 - Groundwater
30	Waste rock dump cover material and/or design allowing for erosion and exposure of waste rock and excessive leachate generation	Groundwater	Contamination of a groundwater resource, including acidity, salinity or metals.	- Use of appropriate cover material; - Physical isolation of radioactive material by non-radioactive material; - Compaction of PAF waste in cell limiting infiltration; - Addition of ACM to PAF to neutralise leachate/runoff; - Provision for capture and treat via polishing pond and wetland (if required); - Cover materials resource assessment; - Cover trials to determine a suitable cover design; - Mine Management Plan; - Sediment and Erosion Control Plan; - Water Management Plan; - Controlled and managed site drainage and release; - Controlled placement of cover material; - Controlled and managed site drainage and release.	Insignificant	Unlikely	Low	Medium Level	No additional controls	Insignificant	Unlikely	Low	Medium Level	Preliminary assessment indicates suitable material available. Formal cover material resource assessment to be carried out as part of pre-production-detailed design work. Ongoing WRD cover materials testing and design trials required.	Appendix K, Chapter 8 - Groundwater
		Radiation	Rain water comes in contact encapsulated radioactive material resulting in mobilisation of radionuclides and their movement into the ecosystem		Insignificant	Rare	Low	Medium Level	No additional controls	Insignificant	Rare	Low	Medium Level		Appendix P, Chapter 12 - Radiation
31	'First flush' surge of stored oxidation products (AMD / NMD / SD) generated in mine storage facilities at Mine site (Waste Rock Dump, Long Term Stockpile, ROM Pad etc) over extended dry periods, discharging downstream	Surface water	Contamination of ephemeral waterways and subsequently groundwater from uncontrolled release resulting in impact on ecosystem health and/ or public water supply.	Sediment control ponds	Insignificant	Unlikely	Low	Medium Level	No additional controls	Insignificant	Unlikely	Low	Medium Level	First flush is not likely to occur based on chemistry of waste rock and climatic conditions	Appendix I, Chapter 7 - Surface water
		Groundwater	Release to groundwater of leachate (elevated levels of radioactive material). Contamination of a significant groundwater resource. Impact on Ti Tree groundwater basin and consequential impacts to water supply (domestic, agricultural)		Insignificant	Unlikely	Low	Low Level	No additional controls	Insignificant	Unlikely	Low	Low Level	Radionuclides aren't soluble in normal environmental conditions. Ti Tree Basin margin is 20km north of mine site. Pit will act as a groundwater sink changing groundwater flow direction around the pit.	Appendix K, Chapter 8 - Groundwater
79	Rehabilitation activities or constructed landforms not conforming or performing to design due to ineffective implementation of design or poor rehabilitation execution or design failure.	Mine closure	Environmental damage caused during rehabilitation works and delays to effective rehabilitation, with unremediated Project site potentially acting as source of ongoing environmental hazard.	- Prepare preliminary closure plan; - Develop detailed designs and tender documents for closure activities during operations and prior to closure works; - Prepare Decommissioning and Rehabilitation plan; - Employ closure project manager; - Undertake inspections & monitoring	Moderate	Rare	Low	Medium Level	- Review plan and design performance and amend as required; - Undertake rework on rehabilitation	Moderate	Rare	Low	Medium Level		Appendix W, Chapter 18 - Rehabilitation, Decommissioning and Closure

5.1.5 AMD Risk Assessment Conclusions

Given the low sulfur content, generally low metal toxicant content and low metal and salt leachability of wast rock and tailings, the primary (pre-management) risk level is currently medium. It is likely that with the proposed additional pre-production testing the primary risk will be lowered. Taking into consideration the proposed AMD management Plan (Section 6), including separate storage of all separable PAF material, blending of any minor PAF with NAF and ACM, encapsulation of radioactive material and saturation of tailings to prevent dust generation, the residual (managed) risk becomes low.

The risk assessment was informed by the geochemical assessment provided above, and the proposed project mine Plan and schedule. The geochemical assessment provided information pertaining to AMD risk by waste/ore stream and by geological unit.

The AMD risk assessment as informed by the geochemical assessment also acted as an information gap analysis. This gap analysis has shown that the laboratory acid-base accounting data set and the metals leaching data set are appropriate, given the early stage of the project and the low risk posed by a low sulfur ore body and waste rock. Additional confidence is provided by the large assay dataset, which enabled additional MPA assessment, which also indicated a low risk of acid generation.

To improve confidence in these data sets, additional sampling and analysis will be undertaken as detailed in the site procedure in the AMD Management Plan. The results will be used to validate AMD risk and management strategies in subsequent revisions of this document.

Additional testing to be done in the pre-production phase will include:

- Identification of suitable capping/encapsulation material and testing for dispersion, exchangeable cation, and general capping geotechnical parameters
- Additional laboratory static NAG and NAPP testing including sulfate (or chromium reducible) sulfur
- Column and or barrel leach tests to commence to provide long-term leachate generation information
- Additional metals to be added to laboratory and field XRF analyses to cover the range of potentially elevated or mobile metals.

In addition to the laboratory ABA / NAG and metals leaching data sets, exploration data and laboratory metal and sulfur analyses were used to inform the AMD risk assessment. The laboratory data set showed that there was only minor PAF material present within the proposed pit area, and if encountered during mining, PAF within the current pit shell can be managed with encapsulation within a large body of NAF within the main WRD. The static AMD and assay data set also showed that there were moderately elevated metals concentrations present in some samples of the main lithological units on site relative to the median abundance of those same metals in similar lithologies, however leachate testing indicates that the elevated metals are relatively immobile, and leachate quality is likely to be better than existing local groundwater quality, in terms of potential use.

The AMD risk assessment presented in Section 5 shows that with appropriate design and operational control measures, the residual AMD risk on site is low. This residual risk would be monitored (AMD Management Plan below) to confirm that the design and operational control measures are effective.

6. AMD Management Plan

6.1 AMD Risk

The static and kinetic AMD and geochemical testing indicates that the proposed waste rock, ore and pit wall material has a low risk of generating acidic, metalliferous or saline leachate.

Although the AMD risk is therefore considered low, based on the data assessed, the management plan has taken the highest risk material into account.

6.2 Waste Rock and Ore Management

Details of the mining process, including waste rock management to minimise AMD risk are detailed in the Mine Management Plan, and have been summarised in Section 1.5 and 5 of this document. The key components of the waste rock management include detailed pre-production delineation of PAF/AMD material and avoidance, blending or encapsulation of any PAF identified.

6.3 AMD Monitoring

6.3.1 Introduction

AMD monitoring provides critical feedback to confirm that the AMD controls are effective for their stated aim. In that regard, the following will be monitored:

- In-situ material scheduled for mining
- Constructed landforms; being WRDs, the ROM Pad, and mineralised waste stockpiles
- Water (surface water and groundwater).

An outcomes-based approach, informed by adaptive management would be used to meet site-specific trigger values that would be developed over time as data is gathered. Currently, the 99% species survival trigger values (ANZECC & ARMCANZ 2000) have been nominated to remain consistent with the main EIS documents.

The following section provides an overview of the monitoring requirements. Note that the surface and groundwater monitoring is wholly captured by the Project's Water Management Plan (GHD 2015) therefore, it has not been reproduced herein. Please refer to that document for monitoring details.

6.3.2 Geochemical Monitoring

Additional geochemical data requirements as described below, will be collected as part of the pre-production phase of the project. The sampling plan is based on the assumption that, as a minimum, S, Ca, Mg, Sb, U and Th by XRF and gamma spectroscopy will be analysed as part of the standard AMD suite during infill drilling and sampling, in addition to the rare earth elements.

Note that blast hole geochemical analysis to determine AMD risk during mining will be undertaken with a suitable lead time; by having XRF analysis run in an on-site NATA accredited laboratory or by hand-held testing with the appropriate range of analytes, level of reporting and resolution.

Additional Data Requirements

Static Testing

Conformation of the sulfur content and species and neutralising capacity are required to validate a simple XRF sulfur-based PAF cut-off. This will be achieved by having sulfate sulfur analysed in conjunction with additional NAG and NAPP testing, with corresponding S, Ca and Mg XRF analyses, to enable correction for non-acid-forming oxidised sulfur. Recommended numbers as determined by the geochemical assessment are provided in the table below and are split in to pre-production testing, and validation testing spread over the life of the mine.

Additional testing for a wide range of metals is required to add confidence to the observation of low GAIs, pre-production and during mining.

Additional ASLP leachate testing is also recommended to compliment column leach testing and confirm the mobility of various metals.

The nominal sample numbers (Table 16) will be analysed, based on the sampling densities discussed in Section 4.1. Pre-production total and leachable metals will be analysed a with complimentary field XRF analysis. Leachate will also be analyses for pH, EC and major ions. The need for production-phase testing will be reviewed based on the results of the pre-production testing.

Table 16 Recommended Additional Static Samples

Geological Unit	Approx. final pit mined tonnes (MT)	Pre-Production	Mine Production
Mineralisation	46	162	162
Pegmatite	56	178	178
Schist	50	169	169
Gneiss	221	344	344
TOTAL	373	853	853

Note all samples to have corresponding S, Ca, Mg, Sb, U and T XRF analyses as a minimum

Kinetic Testing

The relative production of acid and neutralisation over time has been established and confirms that if any acidity is developed, it can be readily neutralised and give an indication of the relative time taken for acid to develop, if at all, to inform appropriate stockpiling times prior to encapsulation of any PAF encountered. To more accurately simulate conditions in the various stockpiles over time, leach columns are recommended using either the AMIRA (2002) free-draining column leach test method or similar, ensuring that the columns are representative of the different lithologies. This would require a total 8 columns, assuming duplicate columns for each major lithology. Leachate will be regularly analysed for pH, EC, major ions and metals, as indicated by the results of the total and leachable metals testing.

Table 17 Recommended Additional Kinetic Samples

Geological Unit	Column Leach Tests
Mineralisation	2
Pegmatite	2
Schist	2
Gneiss	2
Total	8

Soil Cover Testing

The suitability of cover material will be assessed by delineating available capping resources and testing for cation exchange capacity (CEC) 1:5 pH and EC exchangeable sodium percent and Emerson class. A pre-detailed design geotechnical testing program will be developed to determine the detailed testing requirements.

6.3.3 Block Model Review

On completion of the additional pre-production sampling noted above, the suitability of using one or more of:

- Total sulfur
- XRF-based NPR
- XRF-based NAPP
- Total metal content.

to delineate AMD risk within the pit shell and to determine appropriate management of WR and MW streams will be determined. The AMD block model, currently based on coarse sampling and a conservative 0.25% S PAF cut-off, will then be re-developed, including lithological modelling, based on the revised algorithm and closer-spaced, pre-production sampling.

6.3.4 Surface and Groundwater Monitoring

The locations, sampling procedures and schedule and analytes for AMD surface and groundwater monitoring are entirely consistent with the Project Water Monitoring Plan and are therefore not reproduced herein. Analytes with specific reference to AMD monitoring include pH, EC, acidity and alkalinity, sulfate and metals. Baseline water quality data is also included in the Water Monitoring Plan.

Decreasing alkalinity is generally a good early indicator of deteriorating conditions in leachate from a WRD containing PAF material, and can therefore be tracked as an ‘early warning’ mechanism. Metals concentrations and declining pH values generally lag behind declining alkalinity; therefore, corrective actions can be implemented early should alkalinity decline.

Other trends that highlight the onset of AMD include increasing sulfate, increasing sulfate / alkalinity and sulfate to chloride ratio, decreasing pH values and an increase in soluble metals as a result.

6.3.5 AMD Management Plan Implementation and Review

Implementation

The Plan is to be implemented throughout the pre-production and operational stages as well as any care and maintenance periods and in the closure period of the Project. It will be updated as the project progresses.

Review

This plan will be reviewed and revised as necessary until two years after the closure of the mine. Furthermore, any activity not previously authorised under the approved plan will be incorporated into a revised plan for review and approval by the appropriate state authorities. Revised plans would not be approved unless they provided equivalent or improved environmental outcomes over time.

This Plan will also be used to inform future revisions of Project's *Rehabilitation and Closure Plan;* which also form an Attachment to the Mining Management Plan.

6.3.6 Contingency Planning

Contingency plans are developed for those failure modes where residual risk remains after the application of AMD prevention and control approaches. A contingency plan should include targeted monitoring, trigger levels for actions, and specific responses in case a certain event occurs. For example, if a failure mode is the potential for AMD seepage from a waste rock pile, then monitoring can be established for sulfate concentrations in waste rock seepage as an early indicator of potential AMD formation. If significant increases in sulfate concentrations are measured, then contingency measures such as covers or drainage collection amendment might be implemented.

Contingency plans specific to AMD management at the site would include an exceedance in the ground or surface water monitoring against site-specific trigger values. The approach would be to undertake a 'root cause' analysis whereby the causal link for the water quality exceedance would be determined. Adaptive management would then seek to implement an appropriate alternate management strategy to eliminate any future risk of a repeat, given the nature of the incident.

Future revisions of this document would also inform forward AMD risk management by providing a more robust data set to inform AMD risk, and therefore, any adjusted management strategy.

7. References

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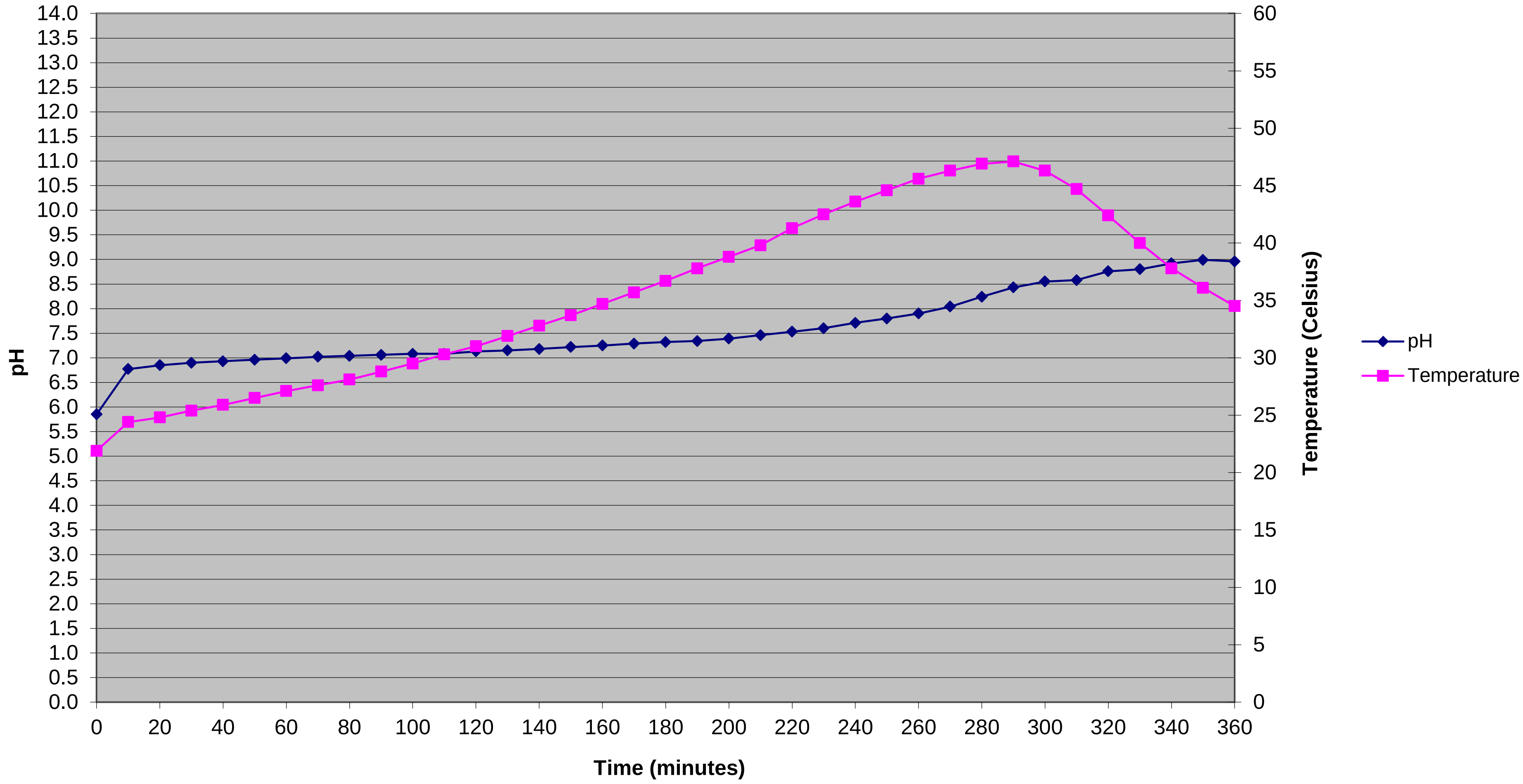
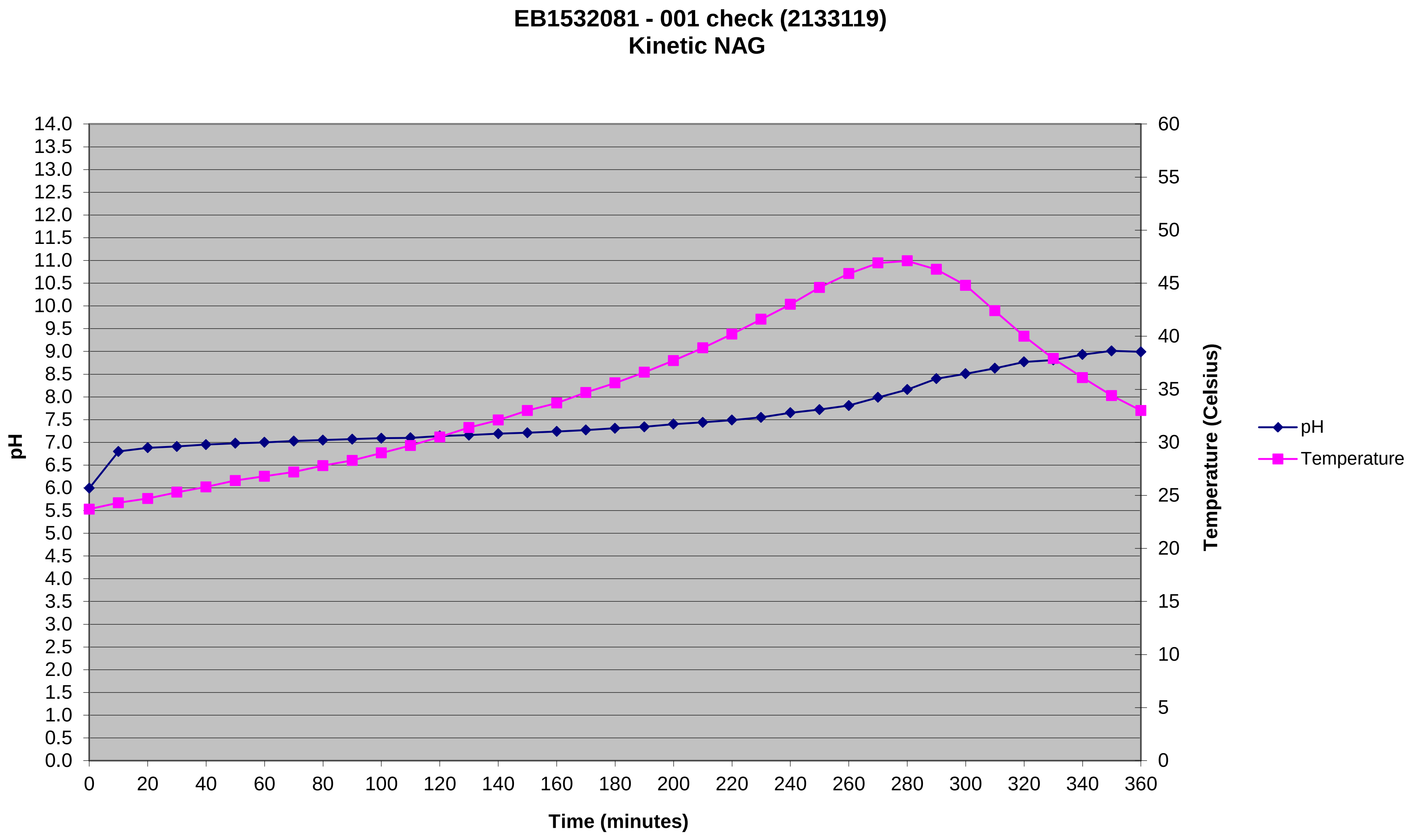
Appendices

Appendix A – Kinetic NAG Curves

EB1532081 - 001 (2133119)
Kinetic NAG





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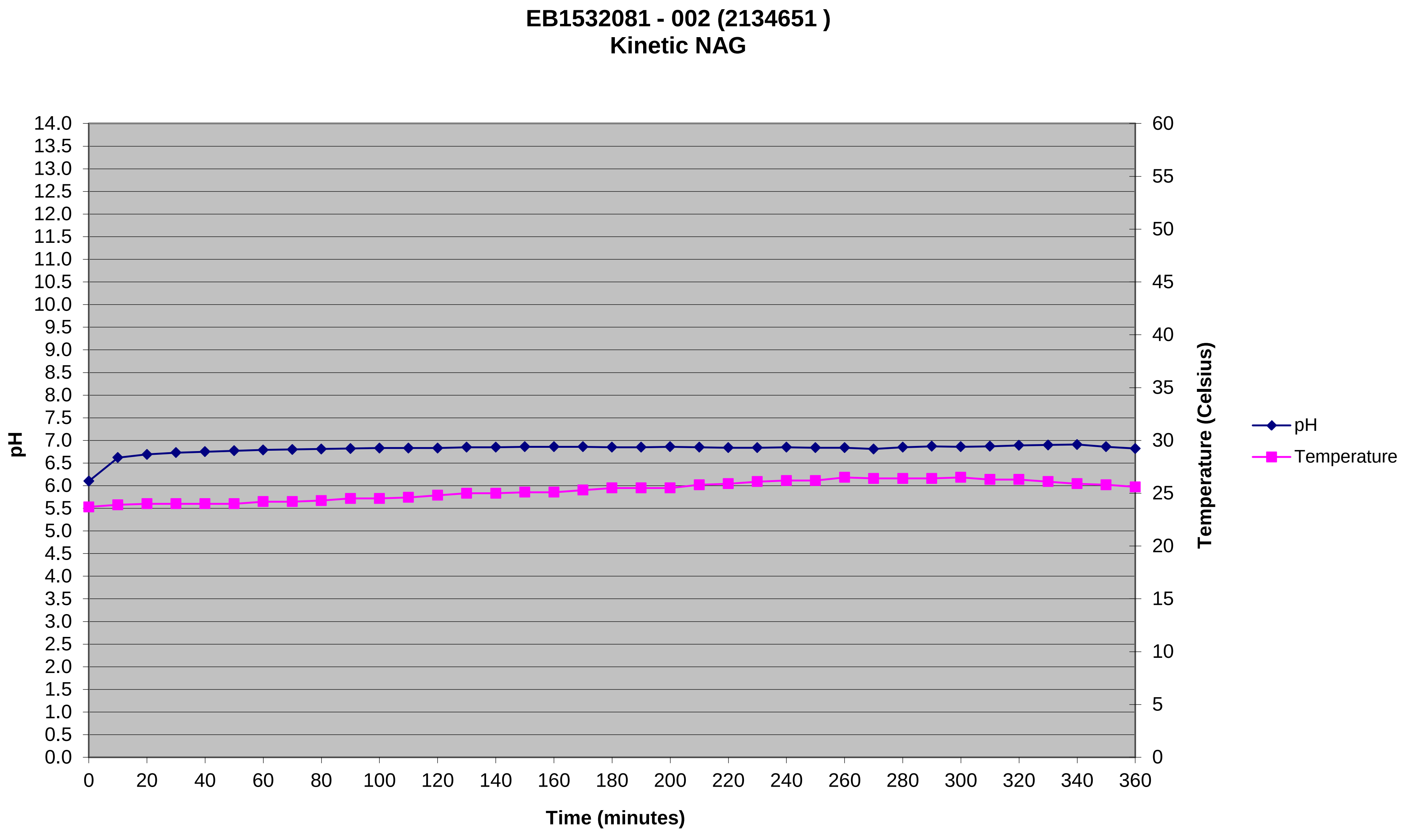
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature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Temperature (Celsius)
Time (minutes)
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Temperature
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11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
60
55
50
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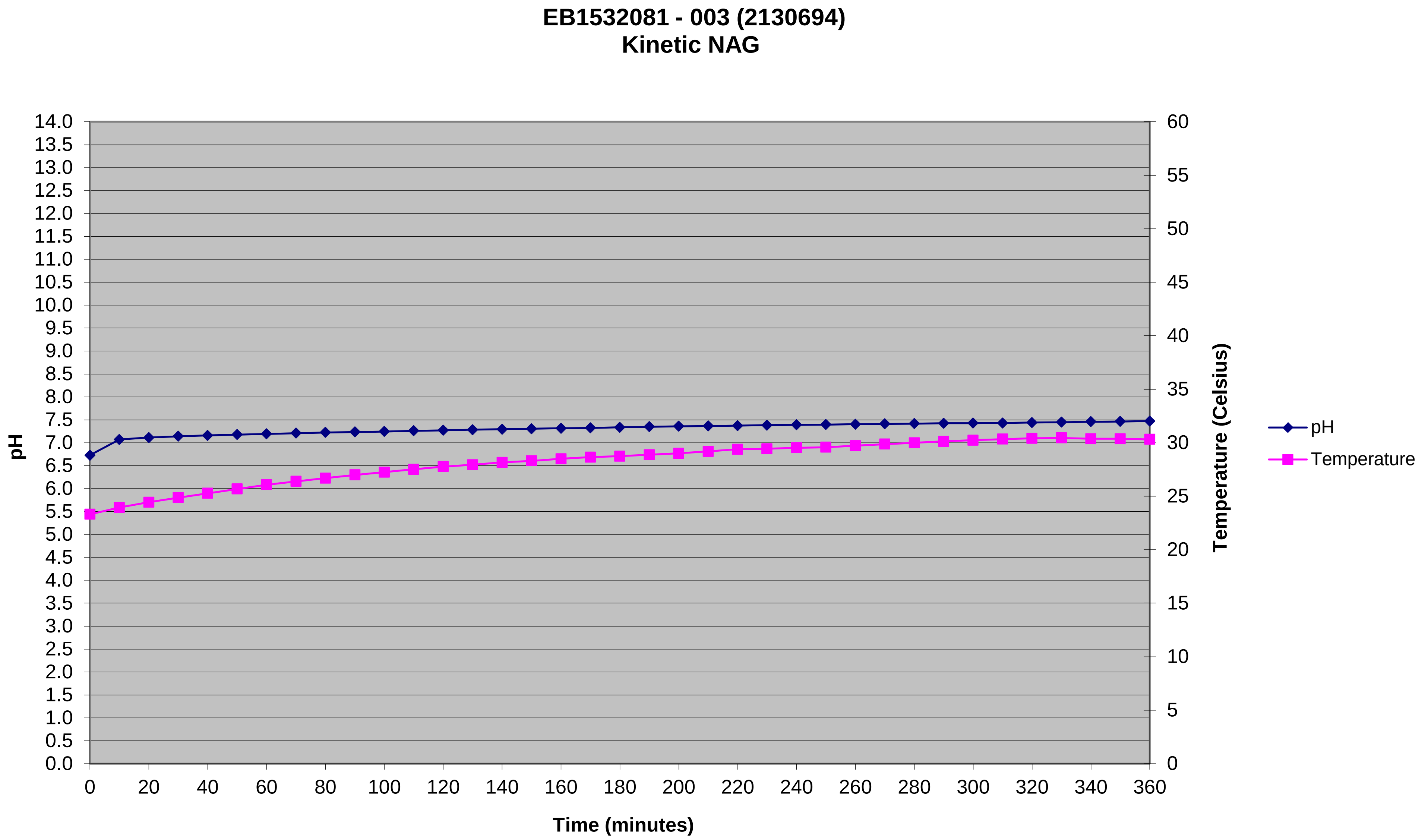
40
35
30
25
20
15
10
5
0
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360



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Temperature (Celsius)
Time (minutes)
pH
Temperature
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6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
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55
50
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40
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30
25
20
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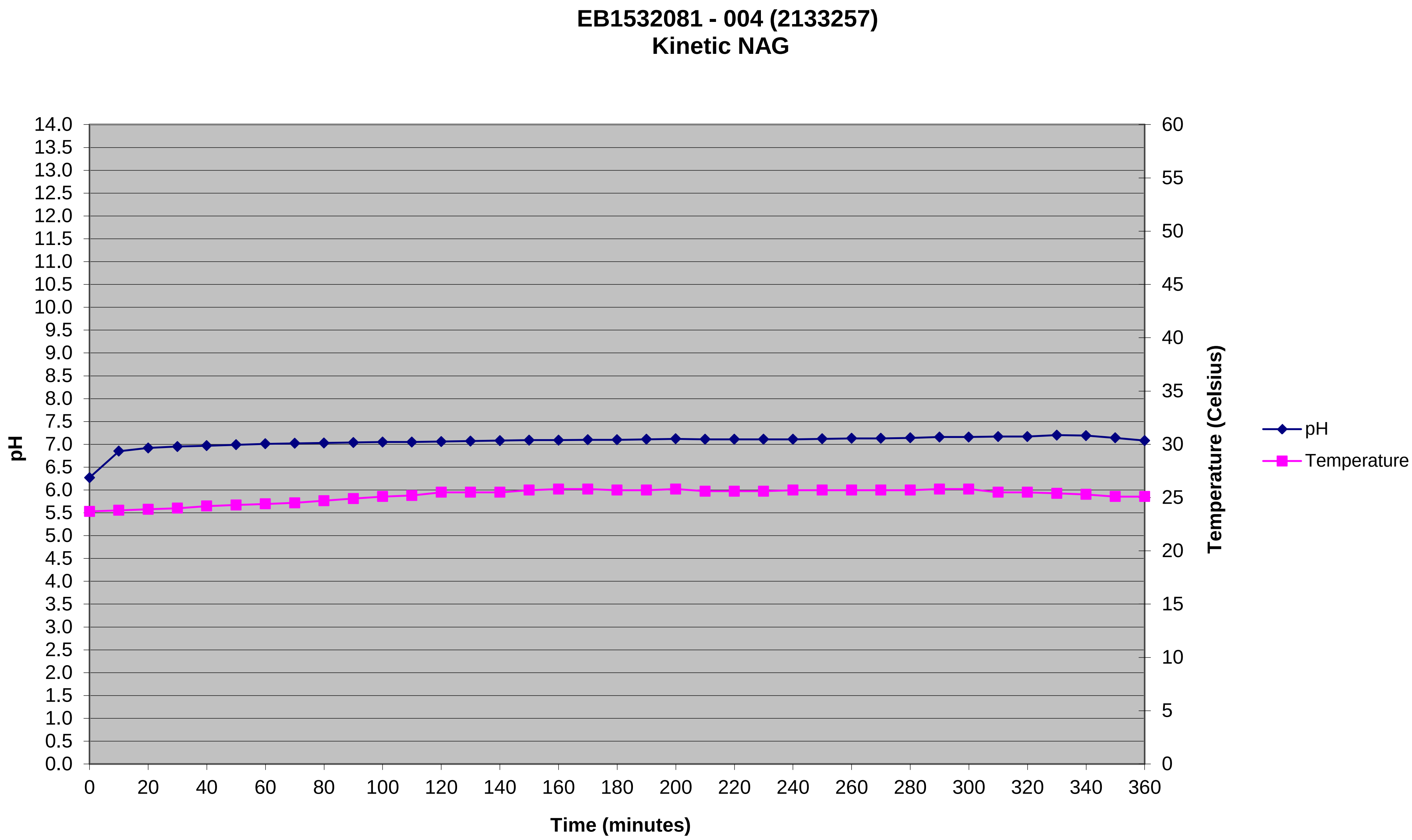

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Kinetic NAG
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature
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1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
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12.0
12.5
13.0
13.5
14.0
0
5
10
15
20
25
30
35
40
45
50
55
60
0
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40
60
80
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360

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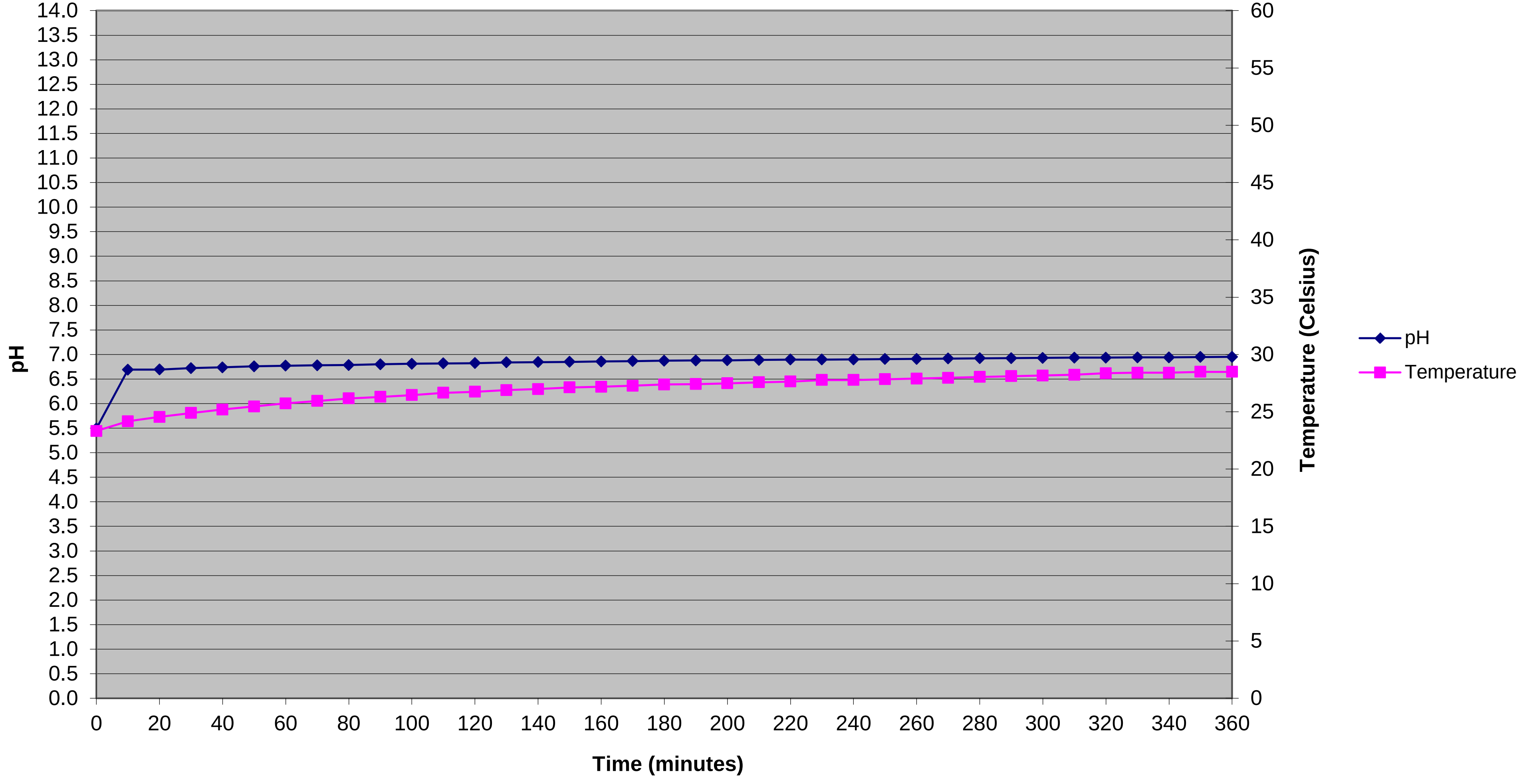
Kinetic NAG



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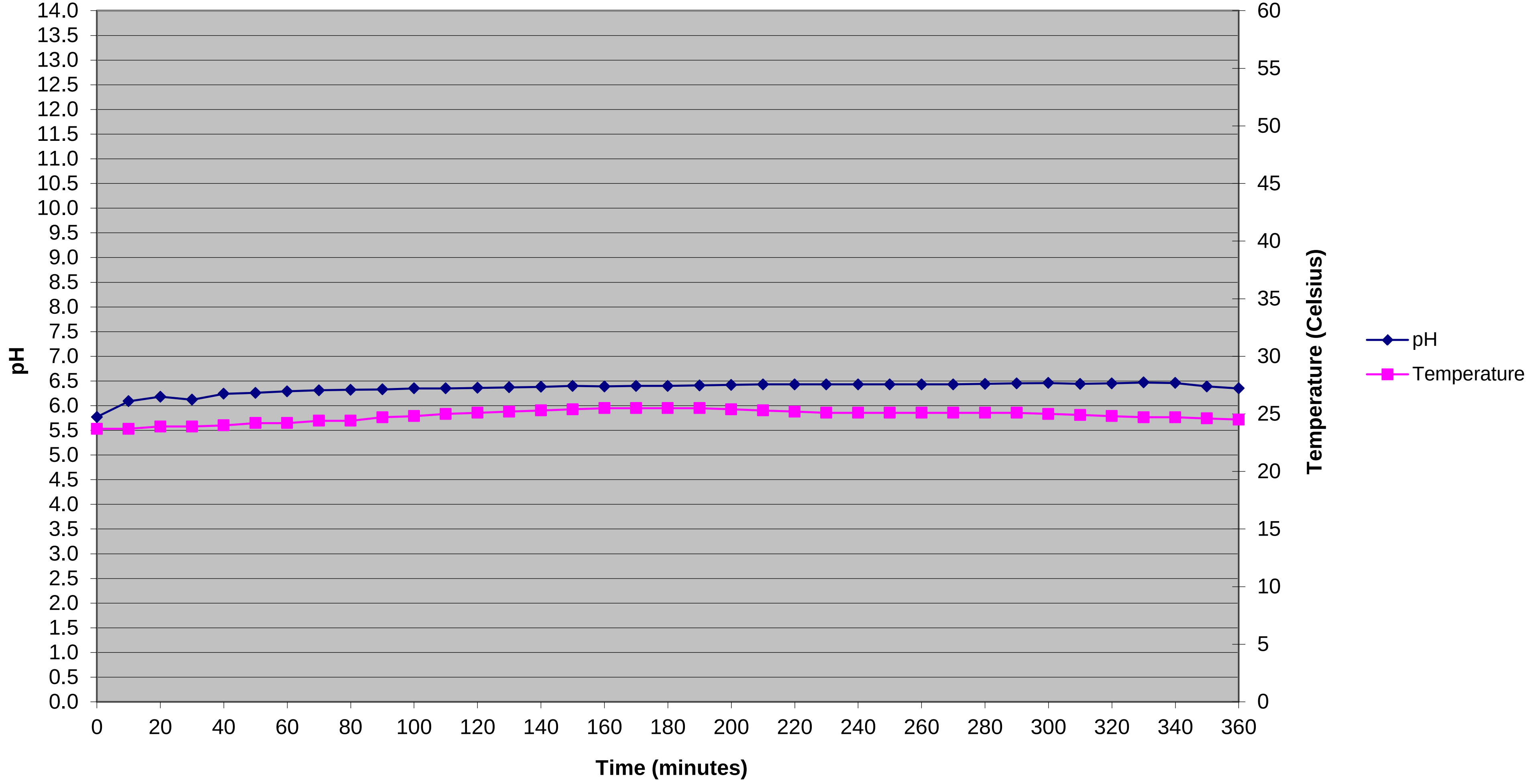
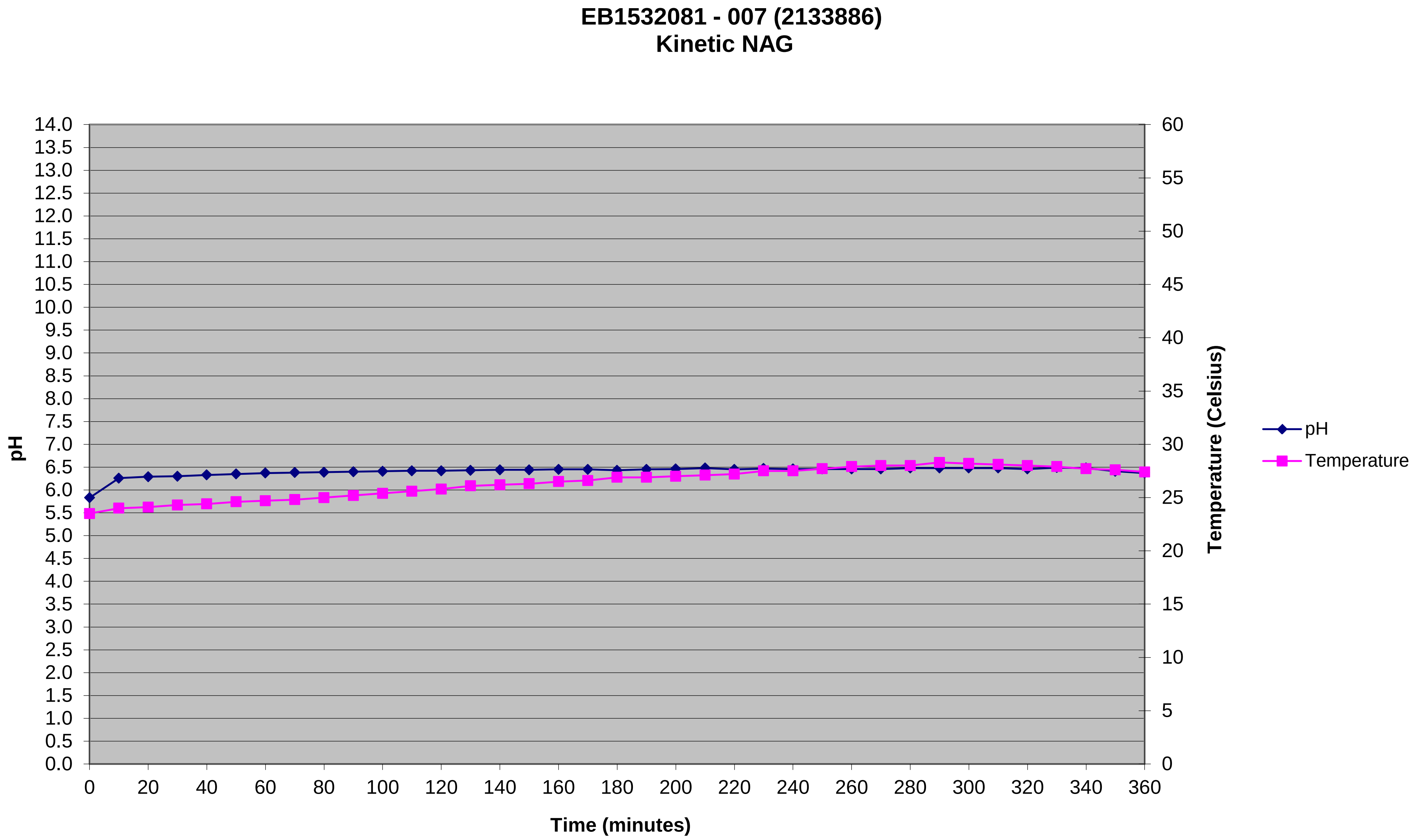
Kinetic NAG

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Temperature (Celsius)
Time (minutes)
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Temperature
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6.5
6.0
5.5
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4.5
4.0
3.5
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2.5
2.0
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1.0
0.5
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340
360

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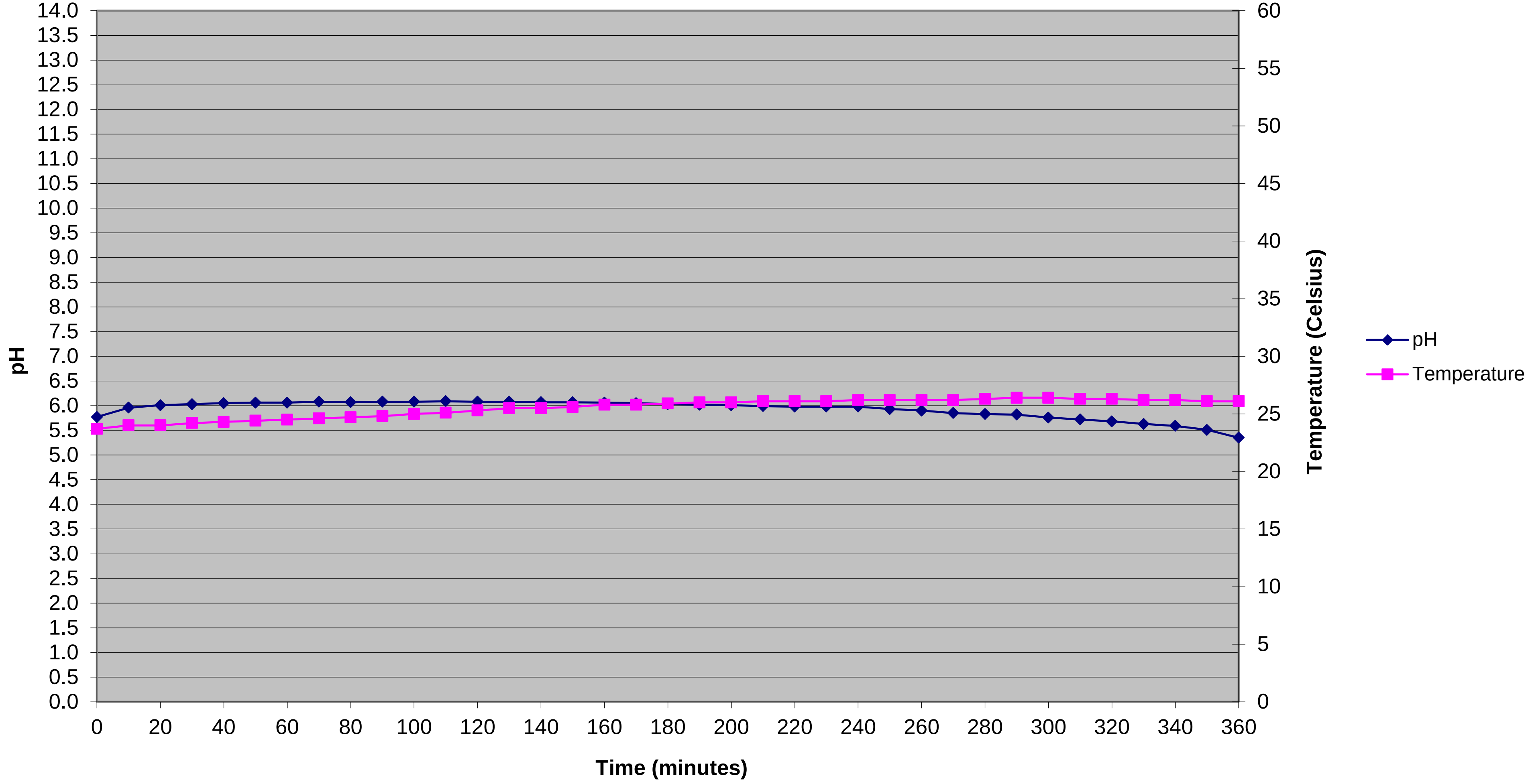
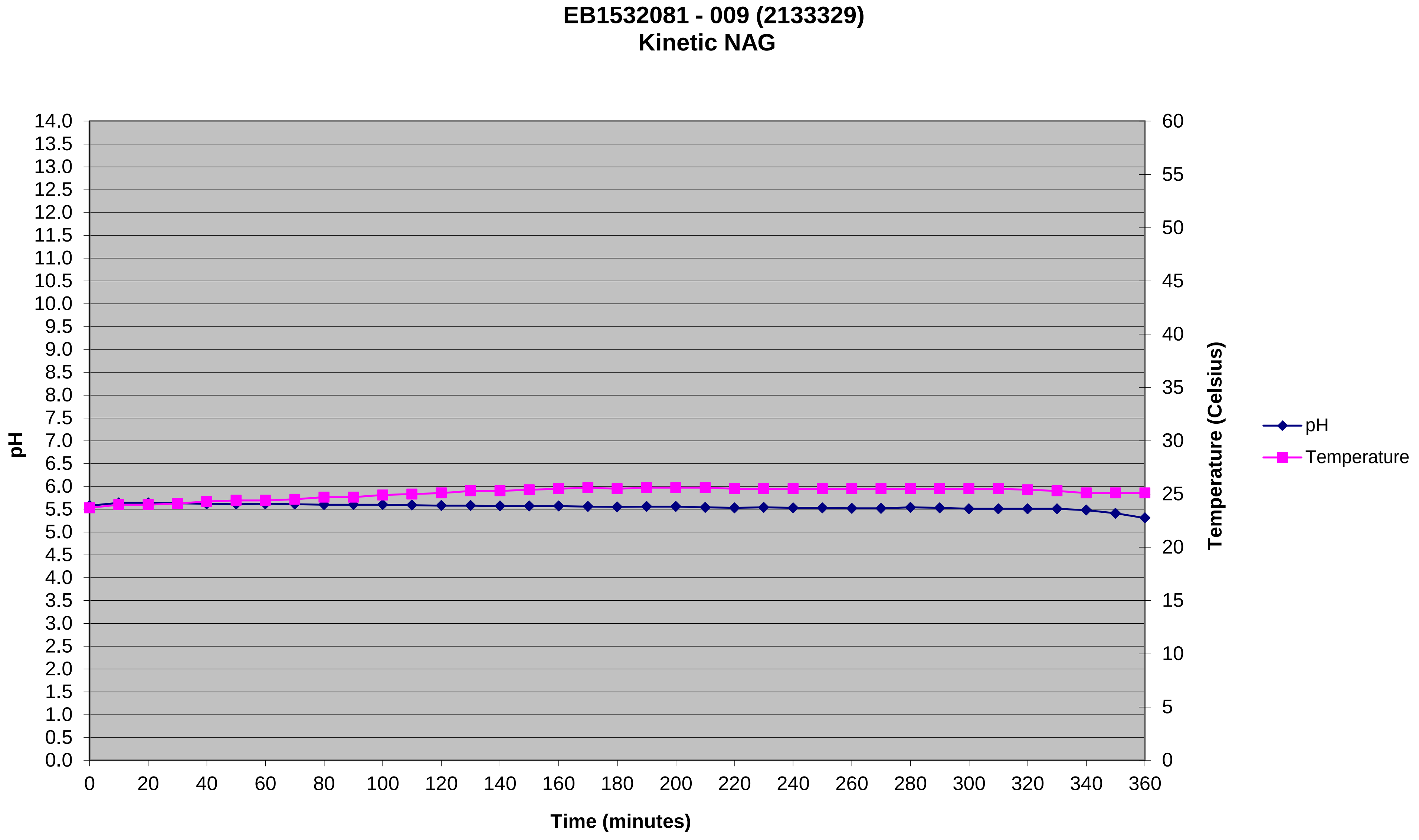
Kinetic NAG





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Temperature (Celsius)
Time (minutes)
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11.5
11.0
10.5
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8.0
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6.5
6.0
5.5
5.0
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4.0
3.5
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2.5
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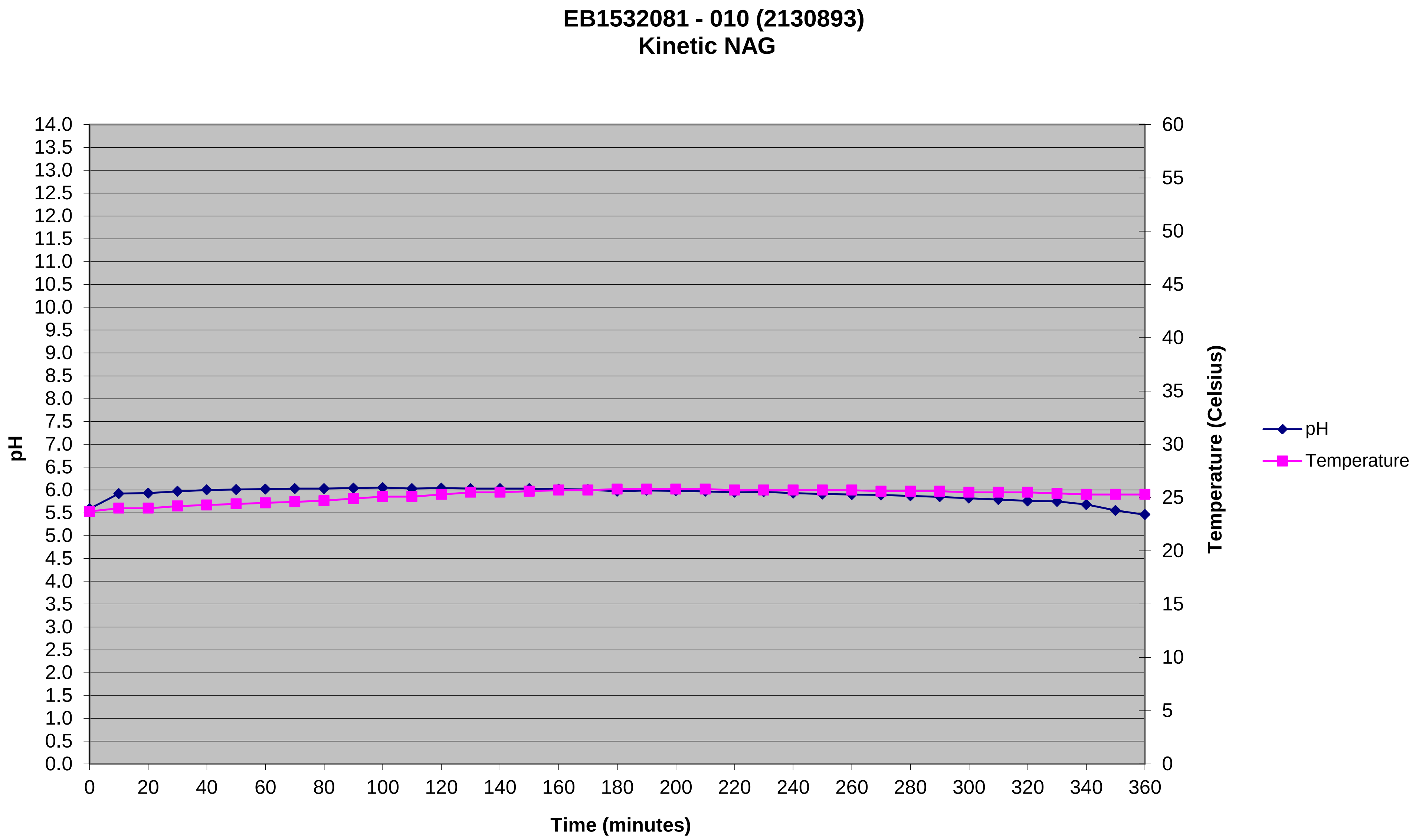
pH
Temperature



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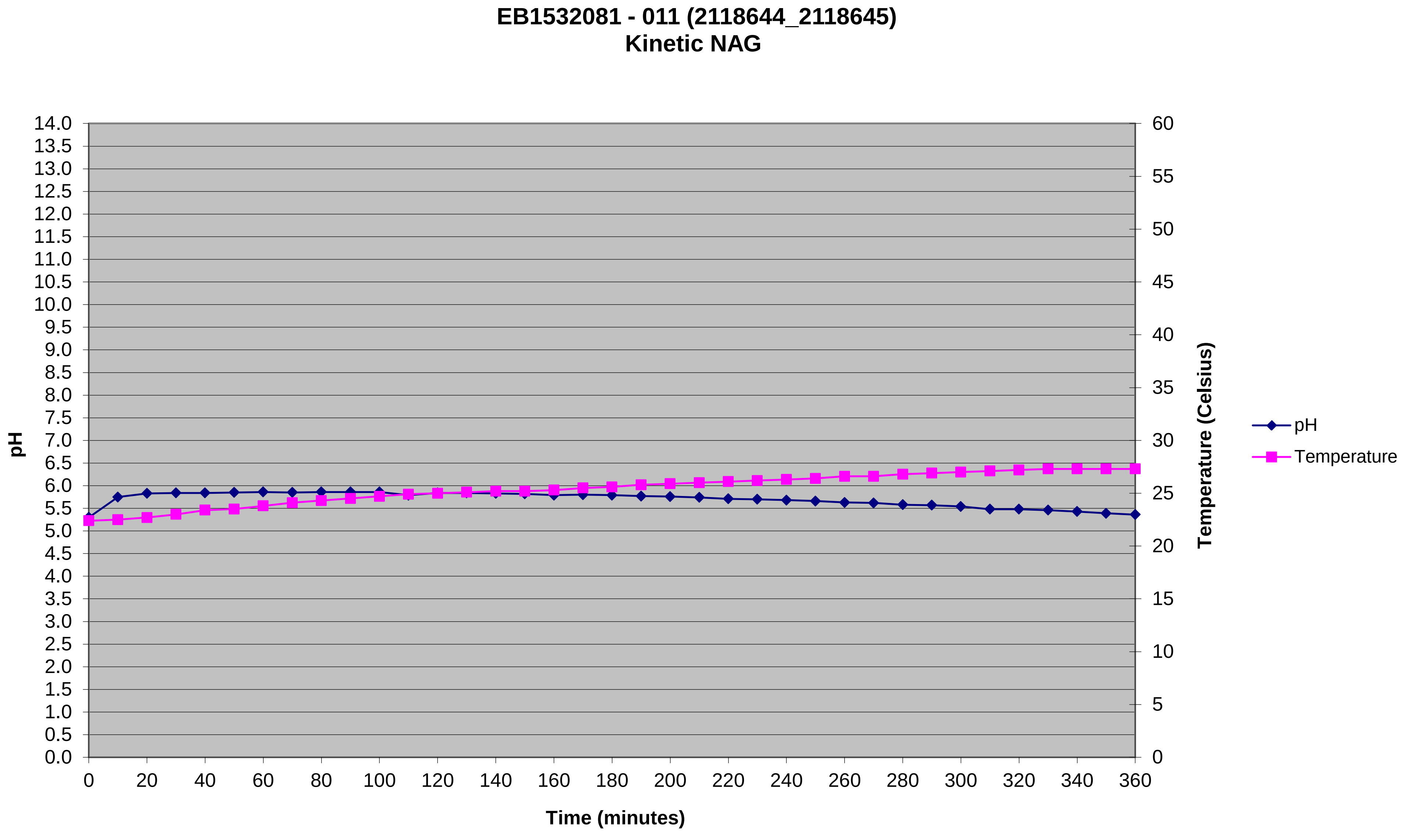
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature



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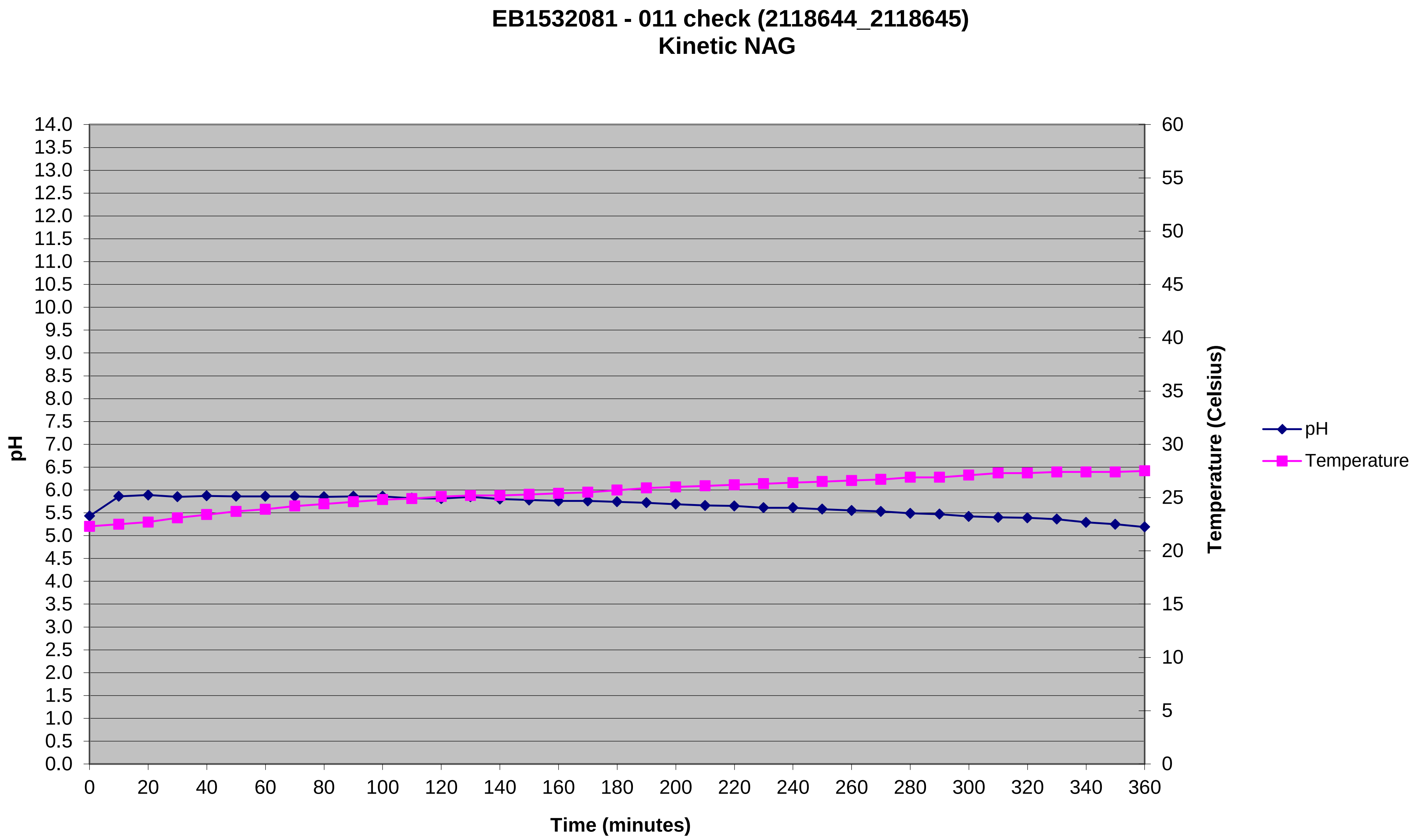
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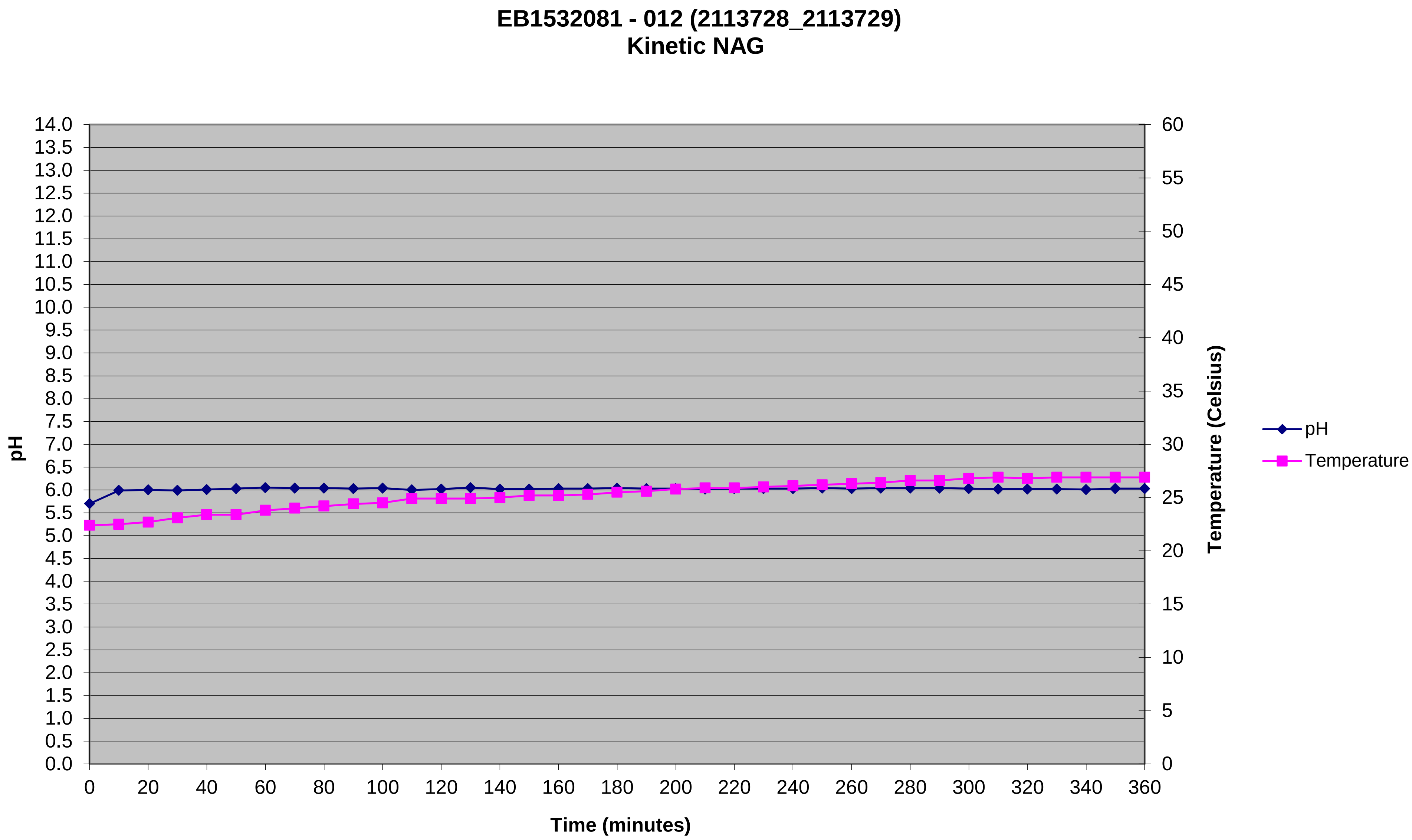
Temperature (Celsius)
Time (minutes)
pH
Temperature


EB1532081 - 012 (2113728_2113729)
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Temperature (Celsius)
Time (minutes)
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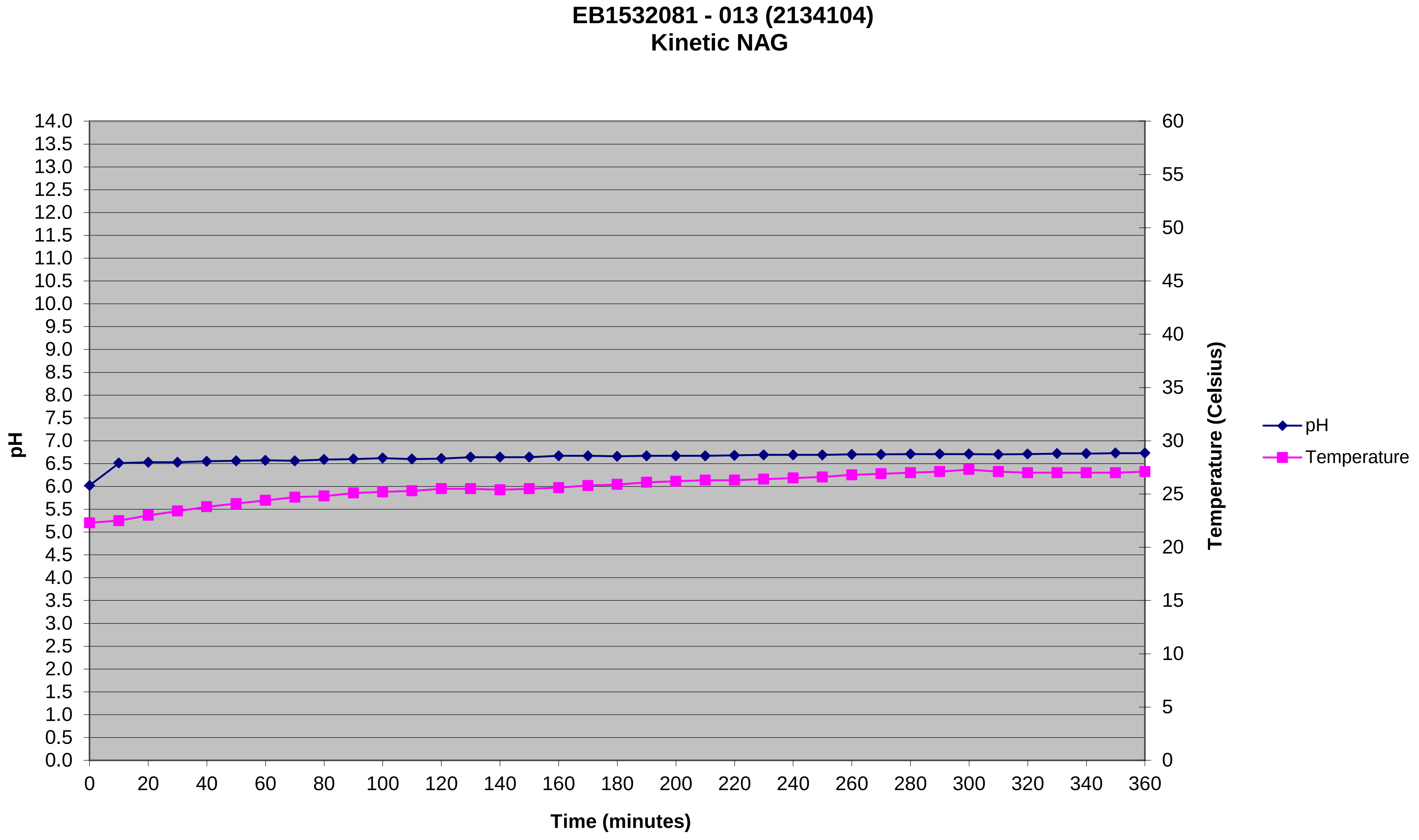
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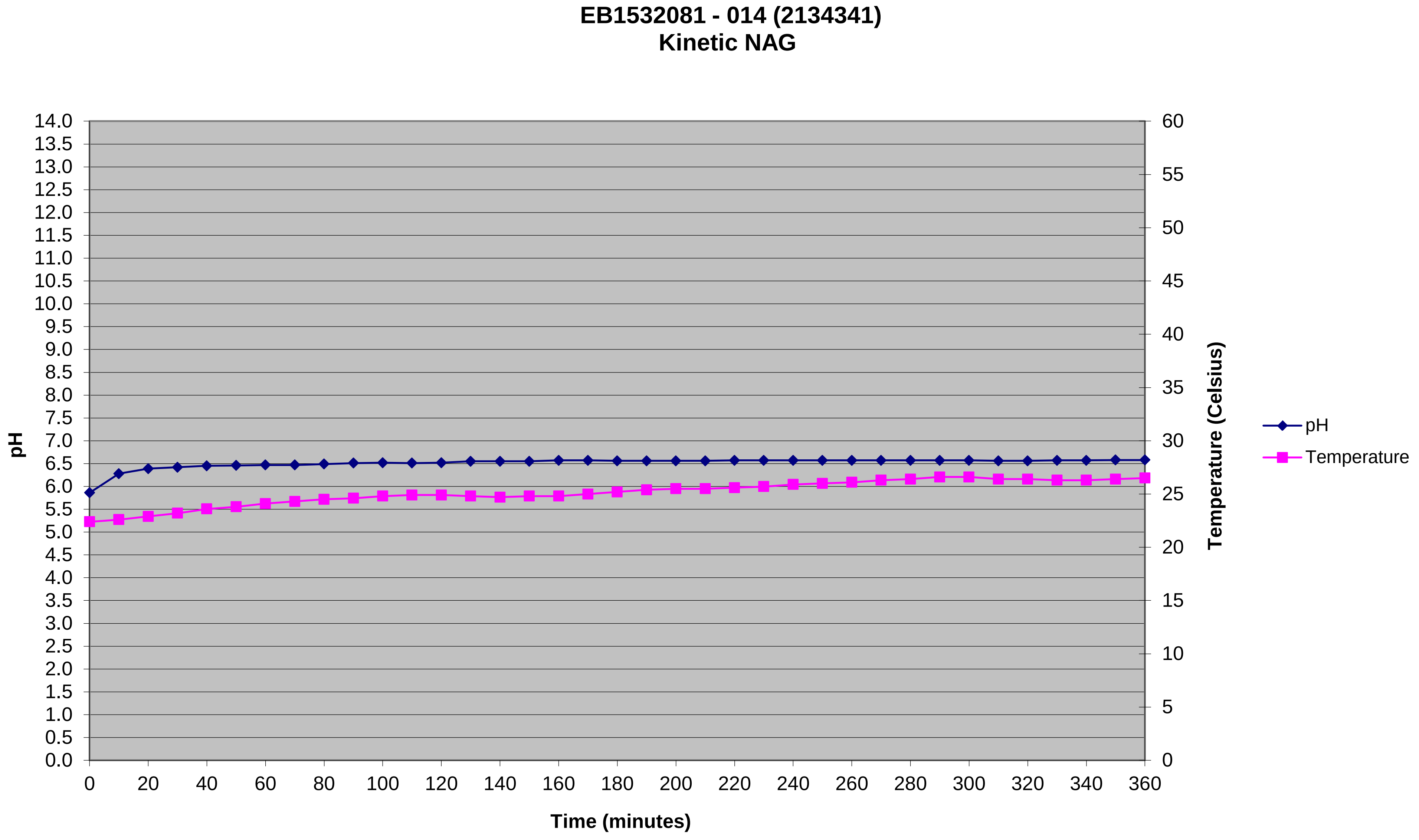

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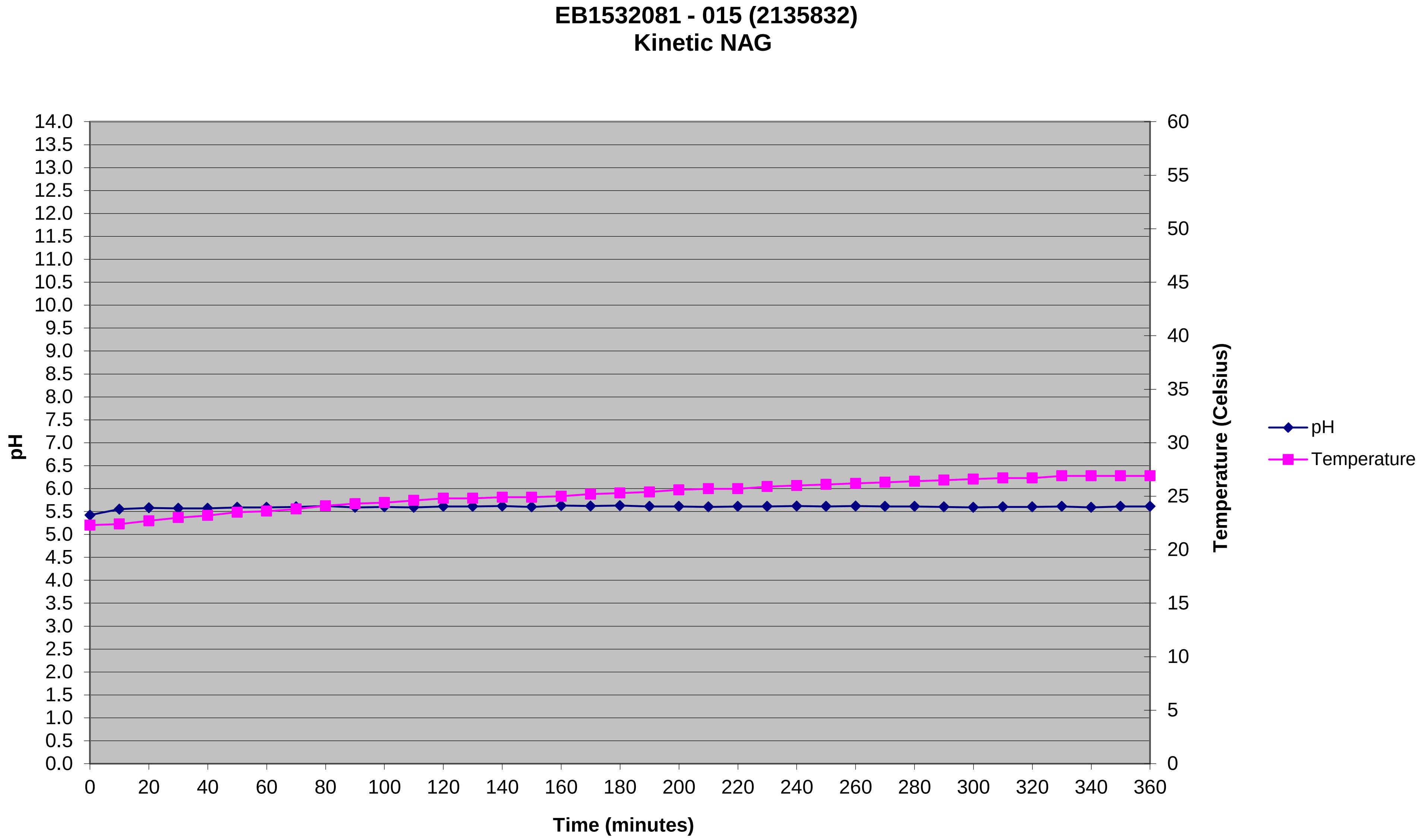
Temperature (Celsius)
Time (minutes)
pH
Temperature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Temperature (Celsius)
Time (minutes)
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Temperature
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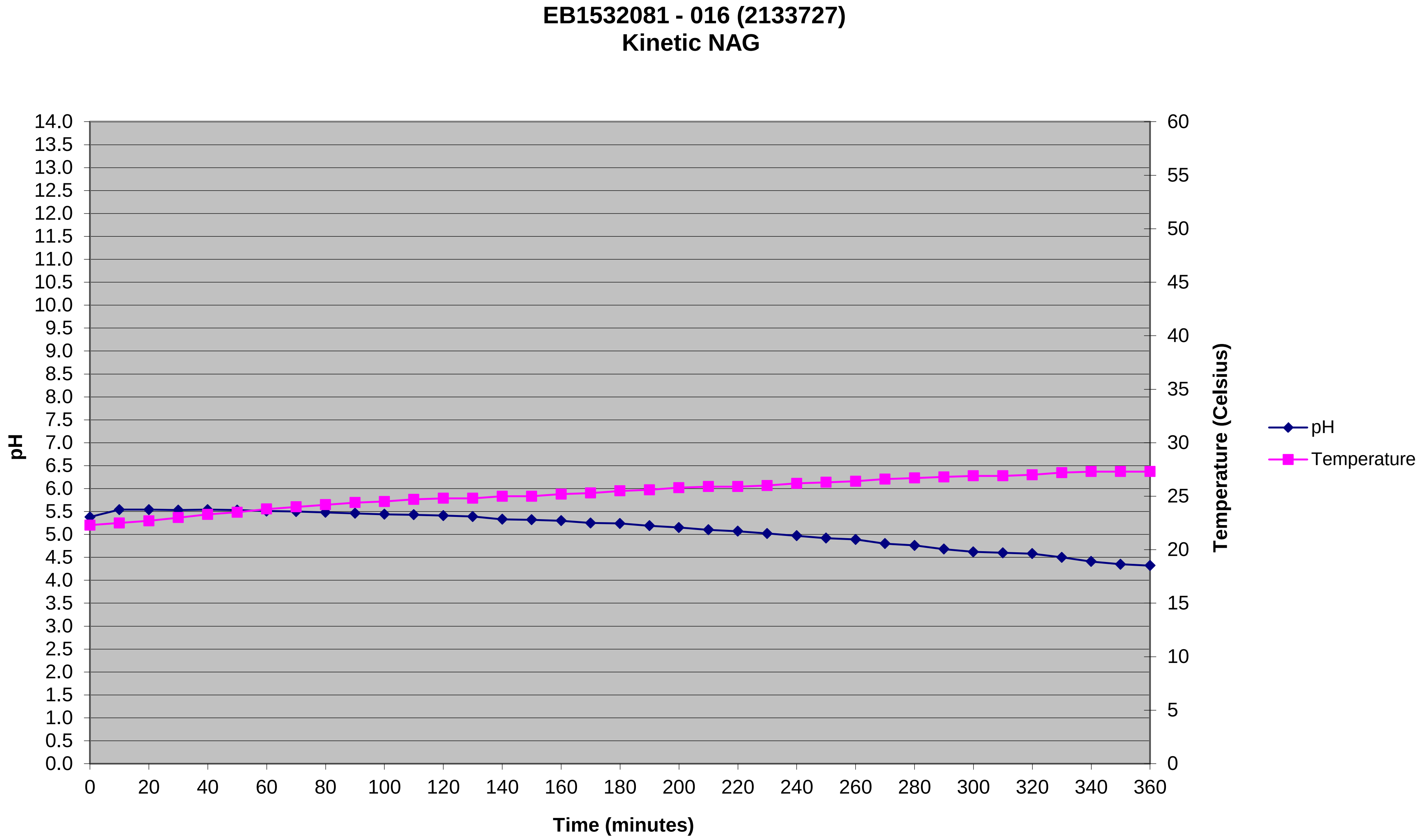
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Time (minutes)
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Temperature
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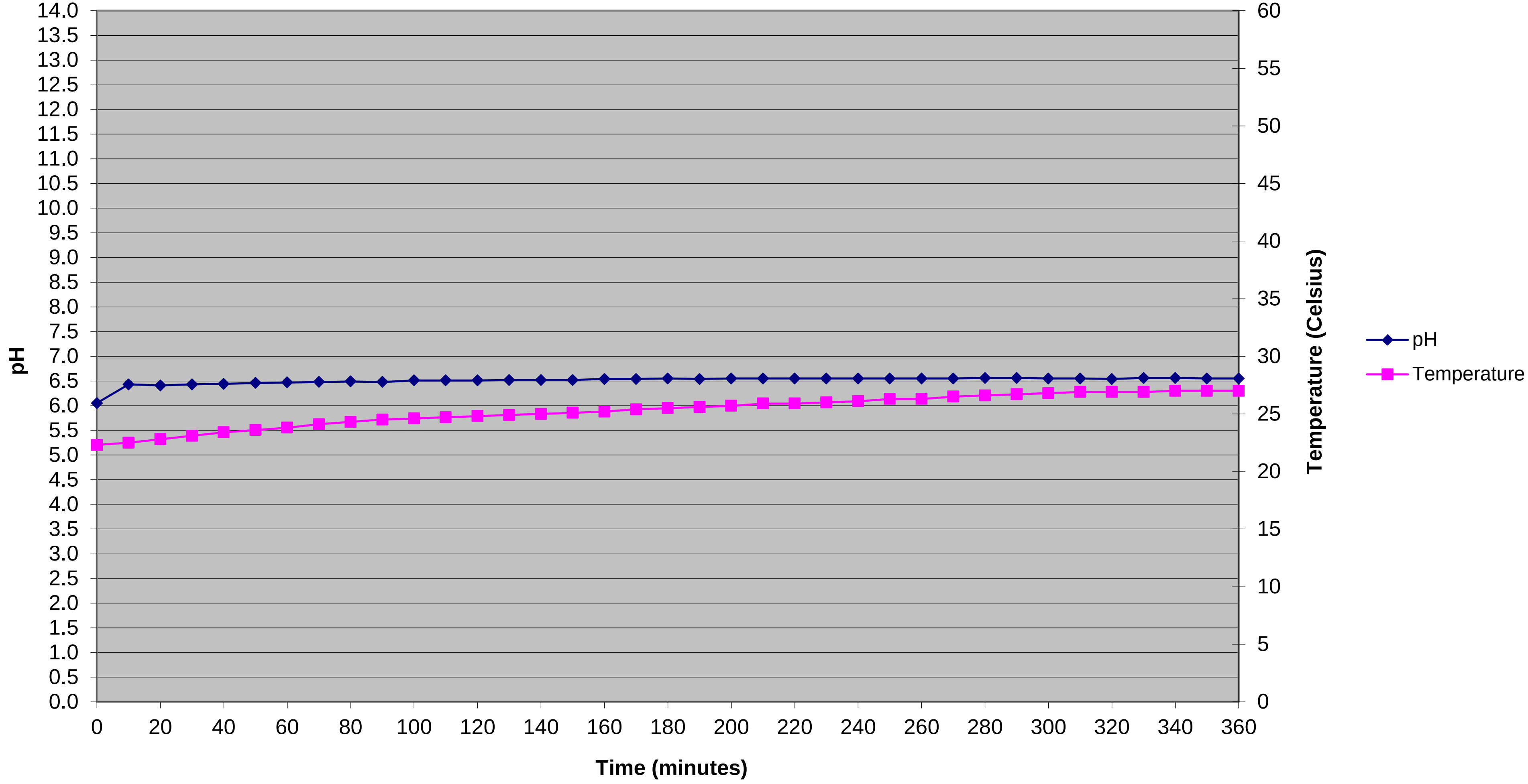
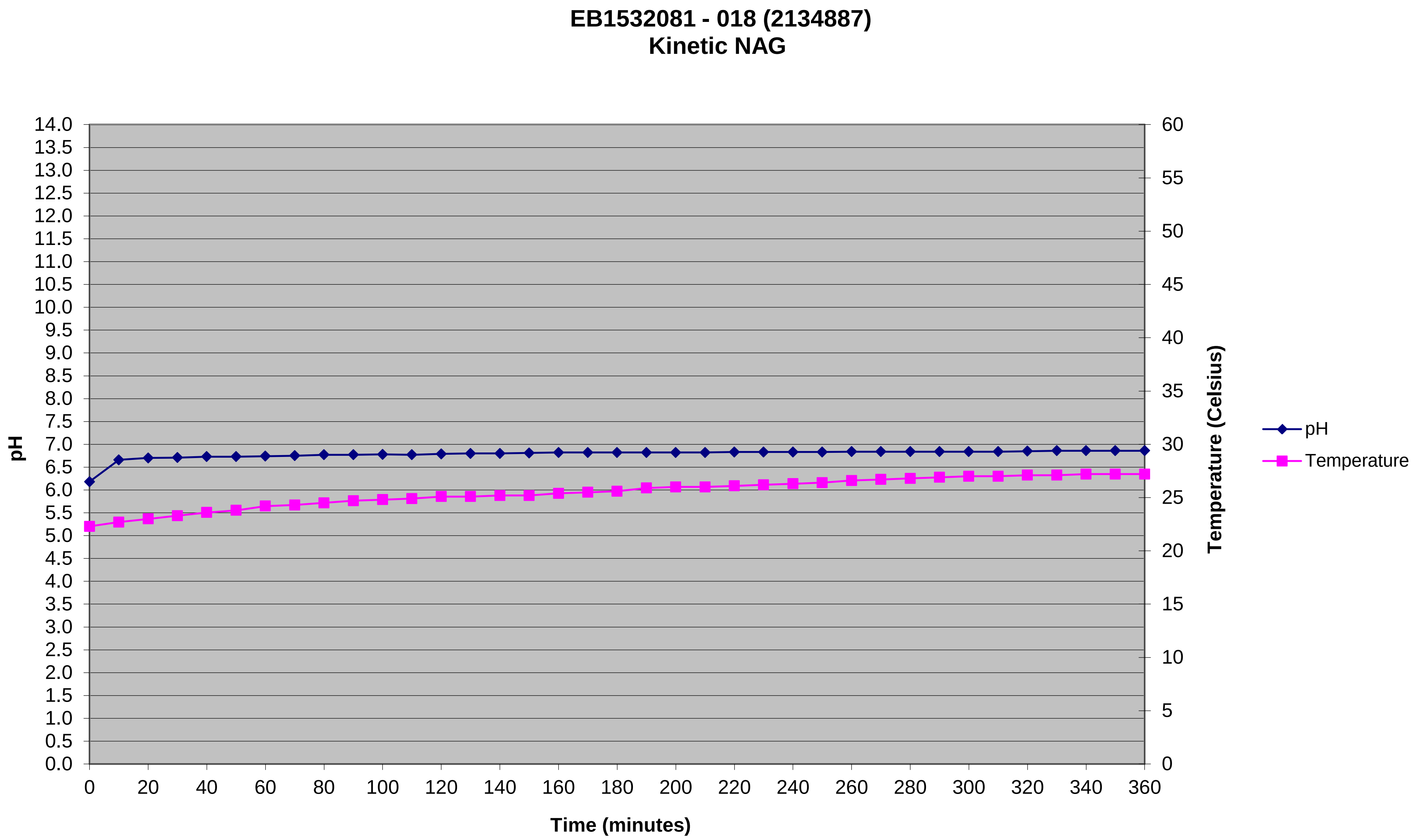
340
360

EB1532081 - 017 (2134187)
Kinetic NAG





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Kinetic NAG
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Temperature (Celsius)
Time (minutes)
pH
Temperature
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1.5
2.0
2.5
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3.5
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300
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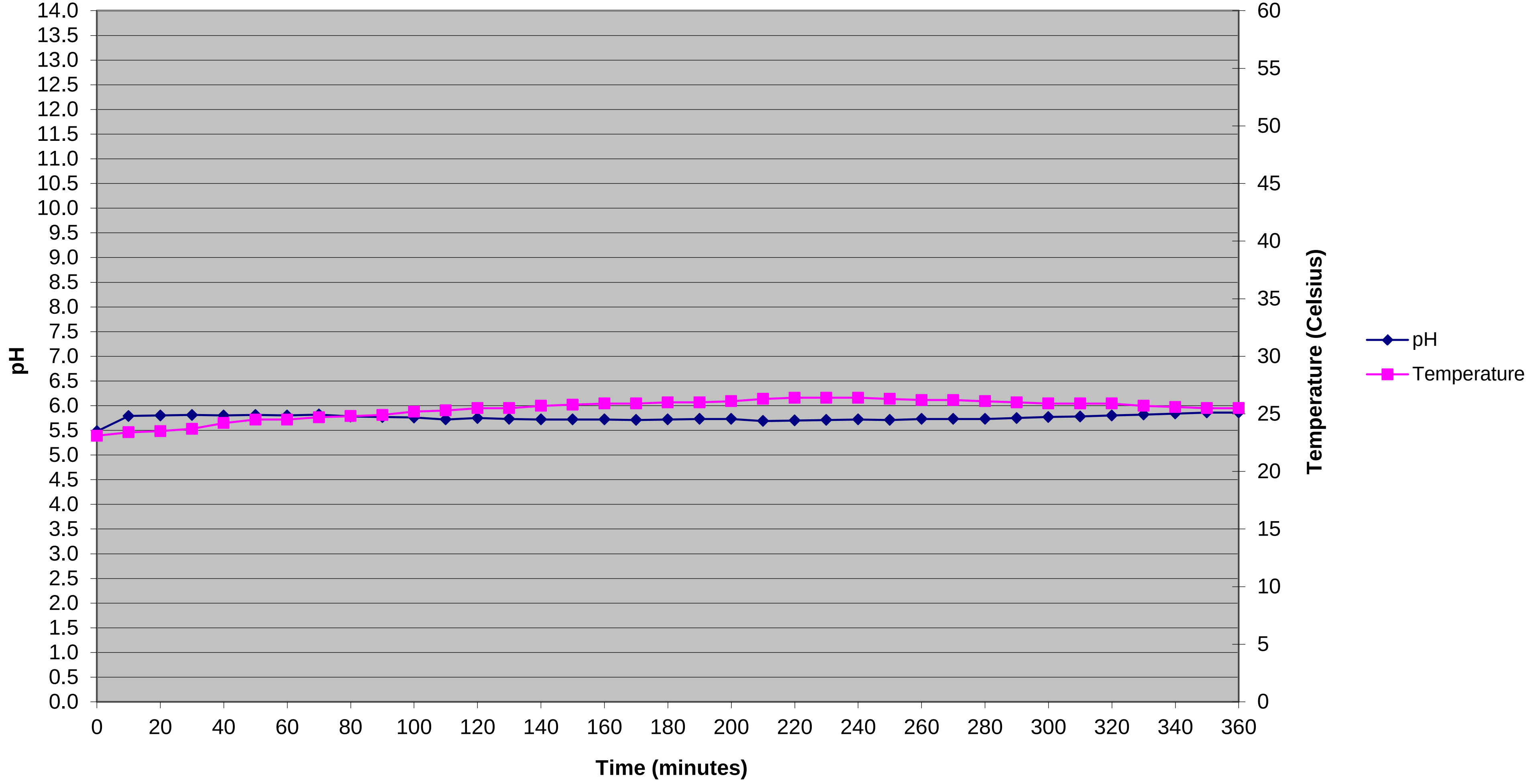
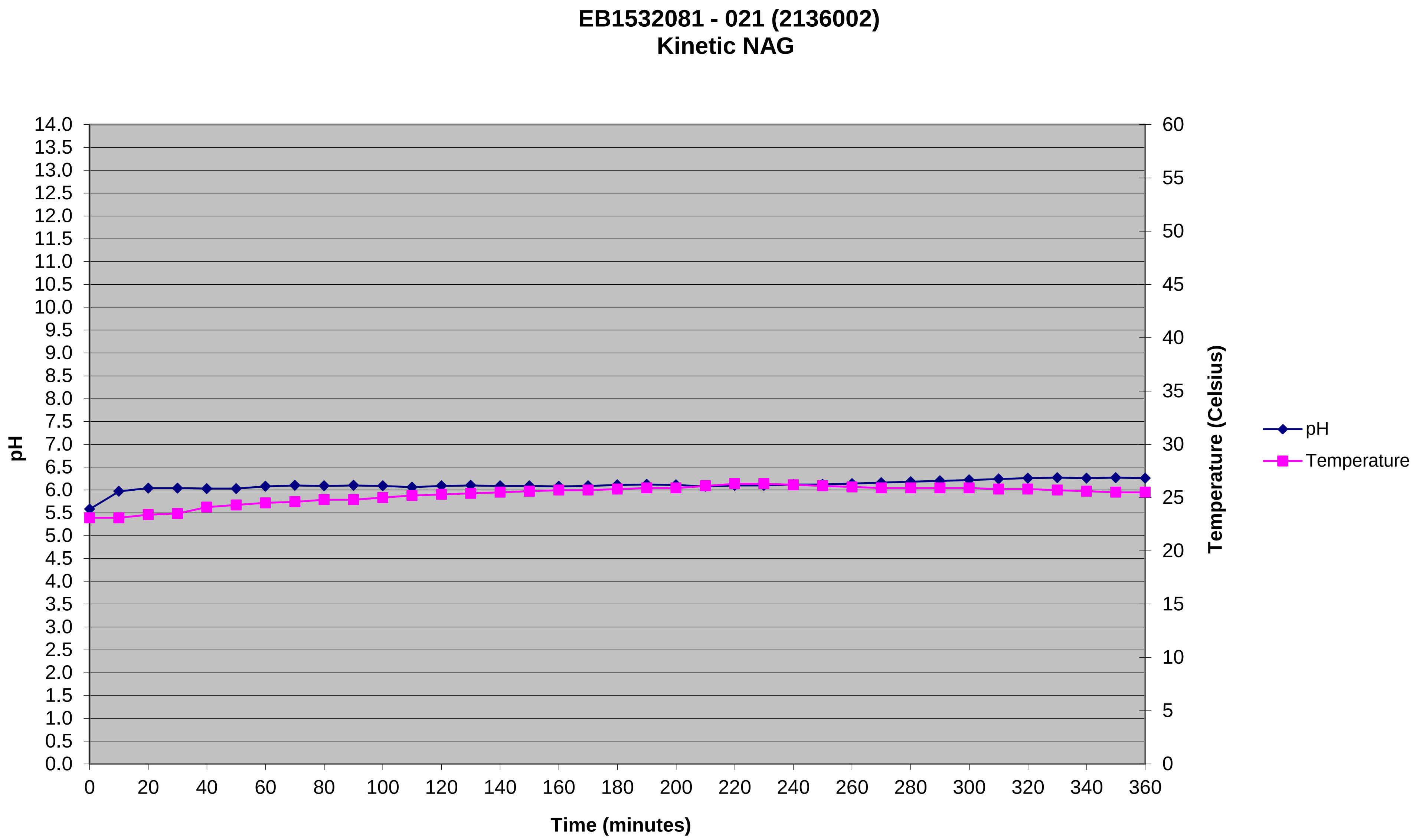
340
360

EB1532081 - 020 (2130745)
Kinetic NAG




EB1532081 - 021 (2136002)
Kinetic NAG
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature
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12.5
12.0
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4.0
3.5
3.0
2.5
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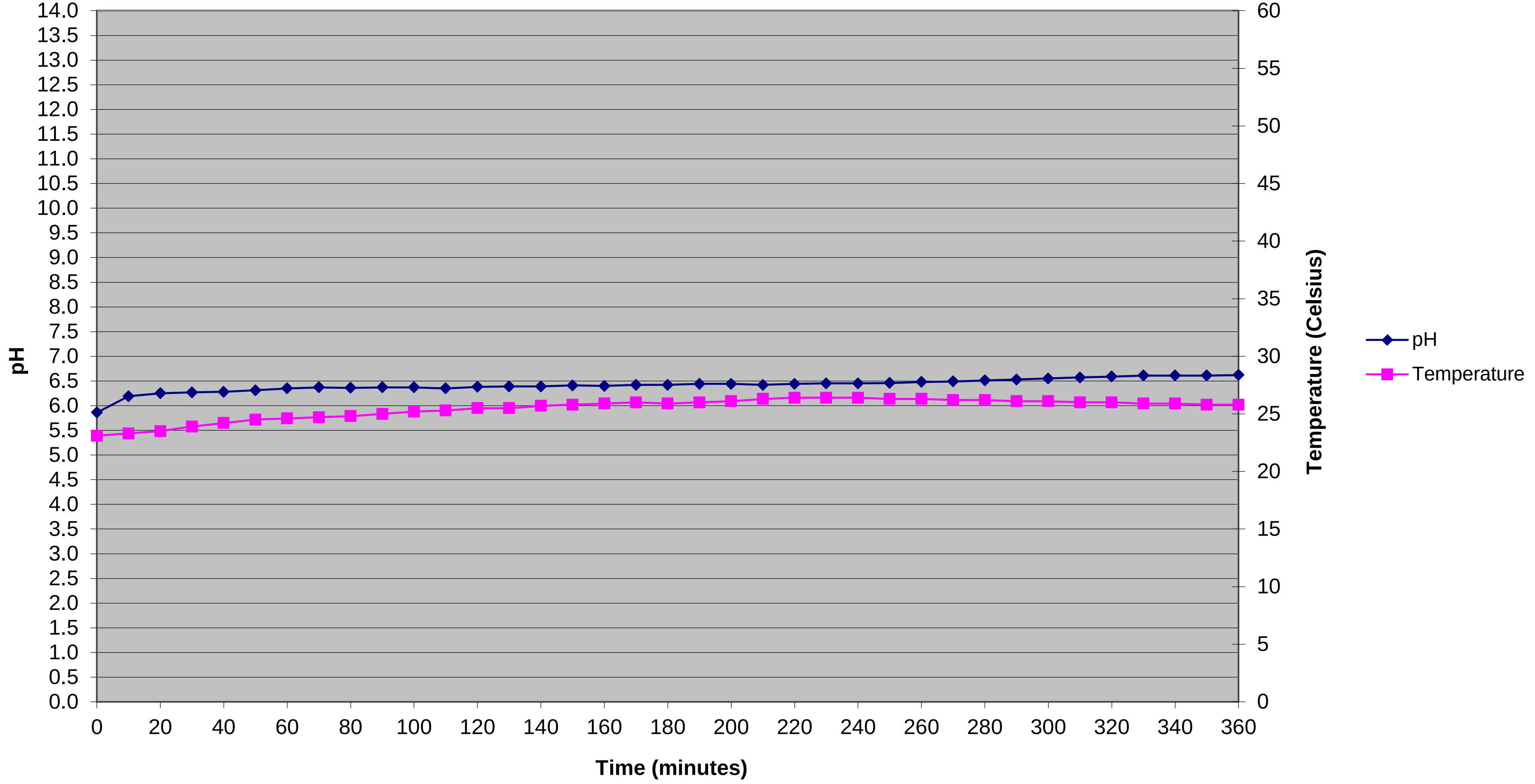
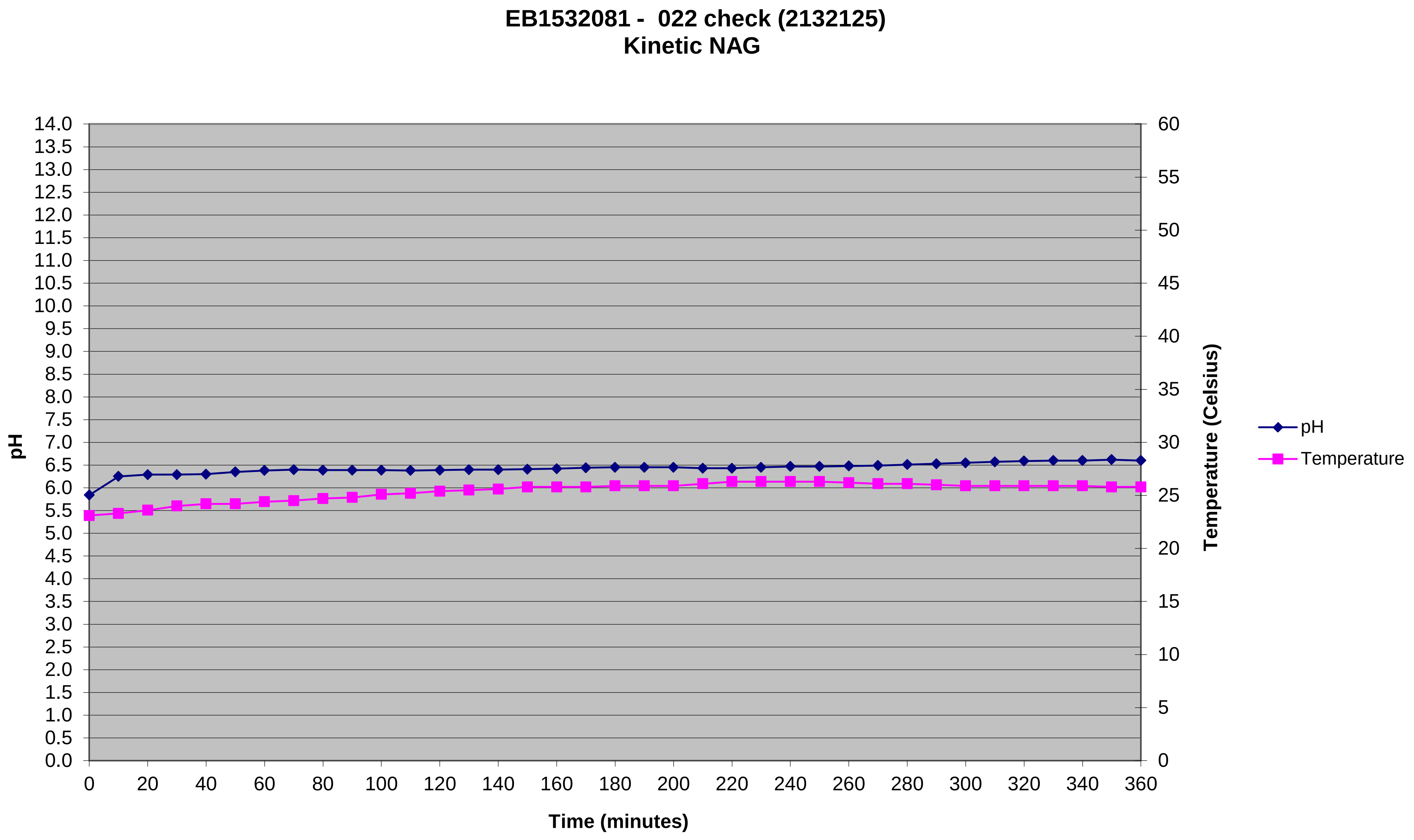
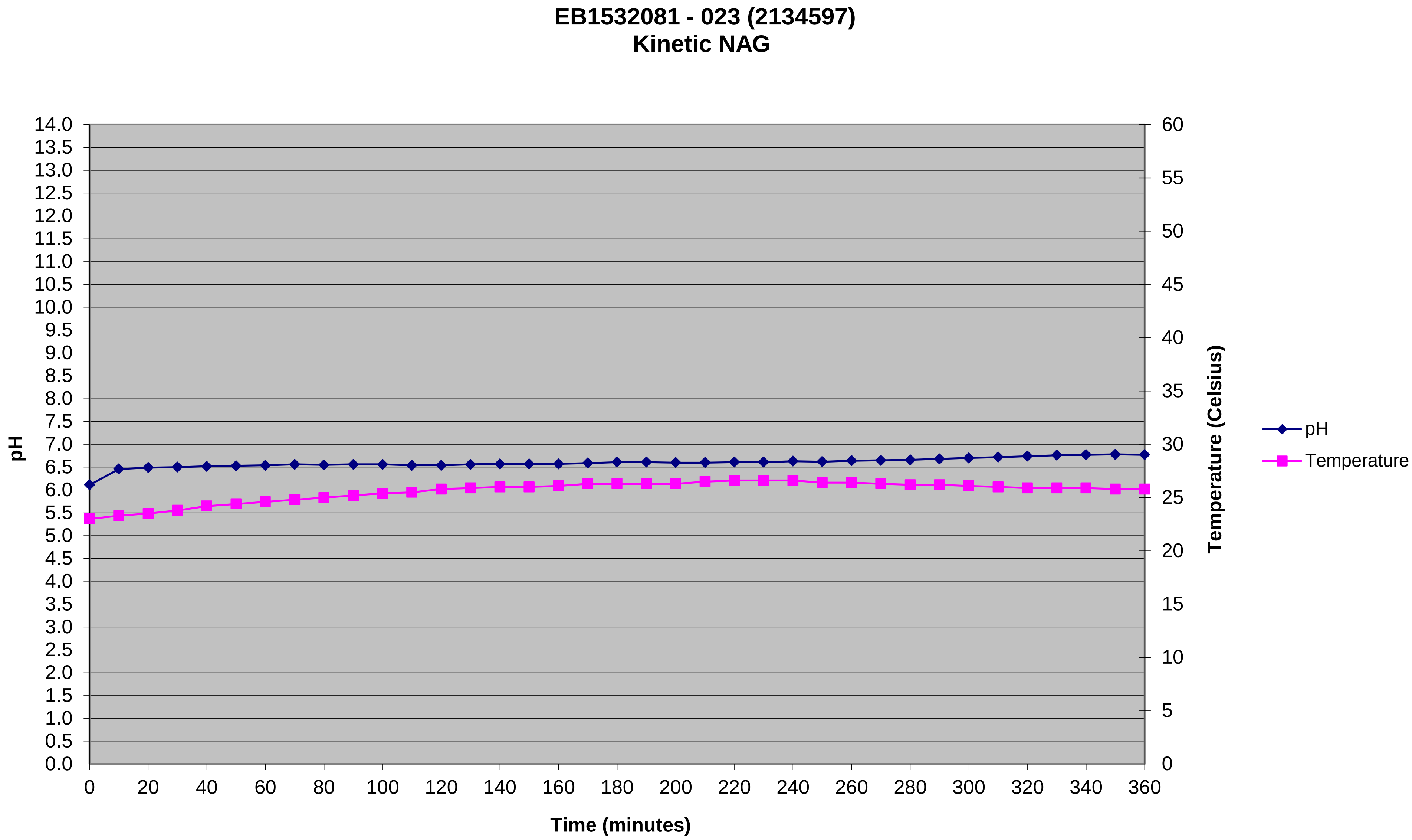
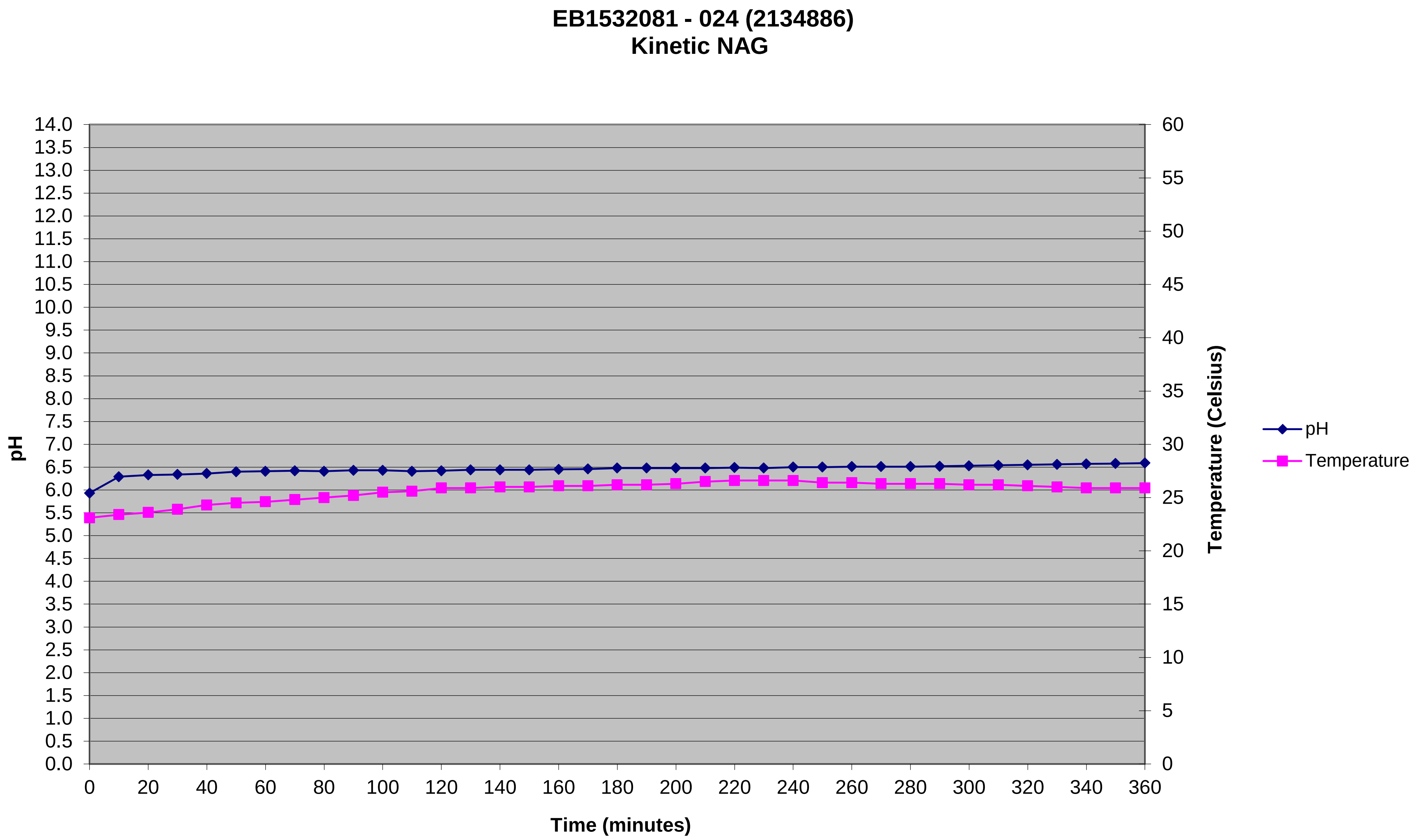
260
280
300
320
340
360

EB1532081 - 022 (2132125)
Kinetic NAG

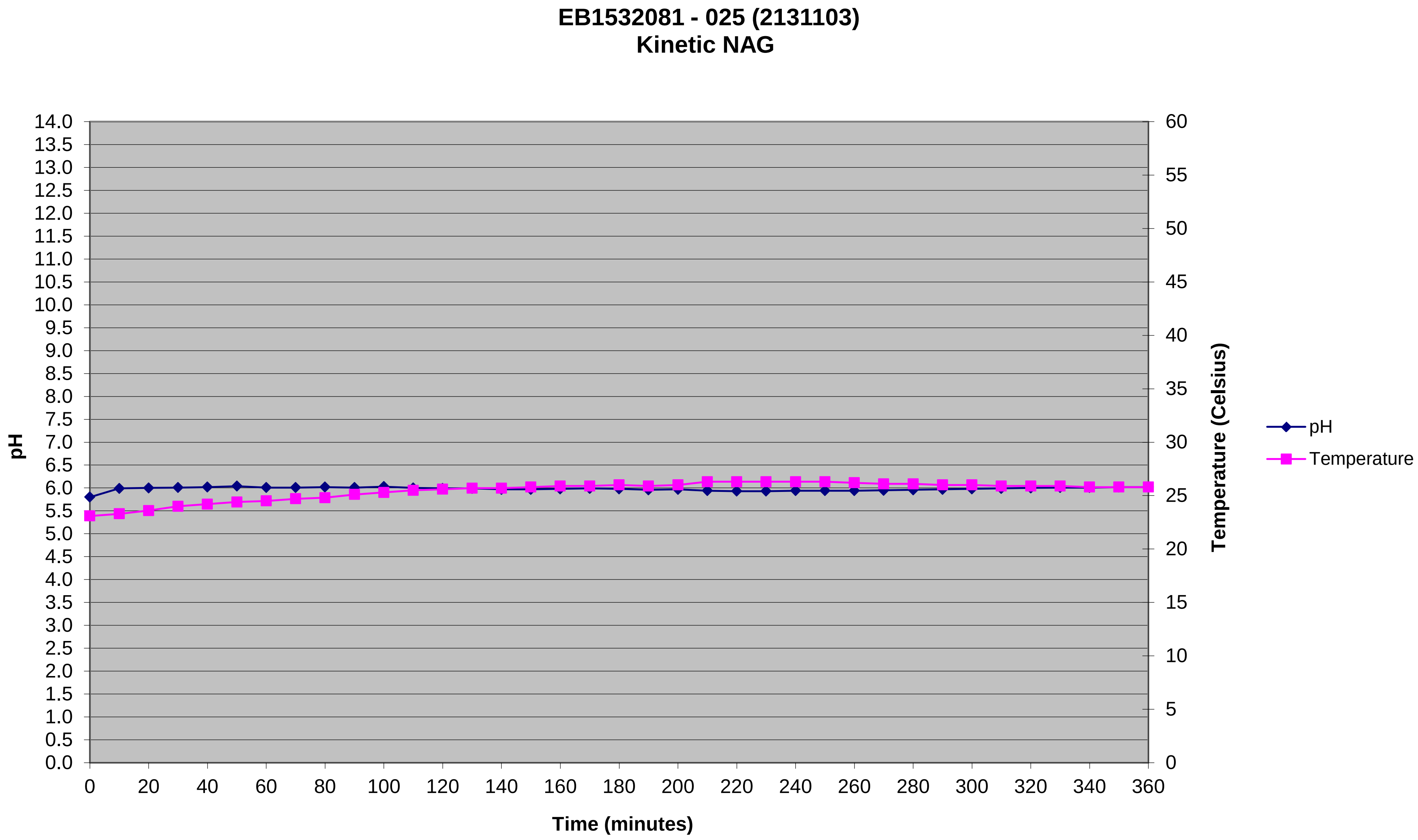



EB1532081 - 022 check (2132125)
Kinetic NAG
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature


EB1532081 - 023 (2134597)
Kinetic NAG
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
60
55
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

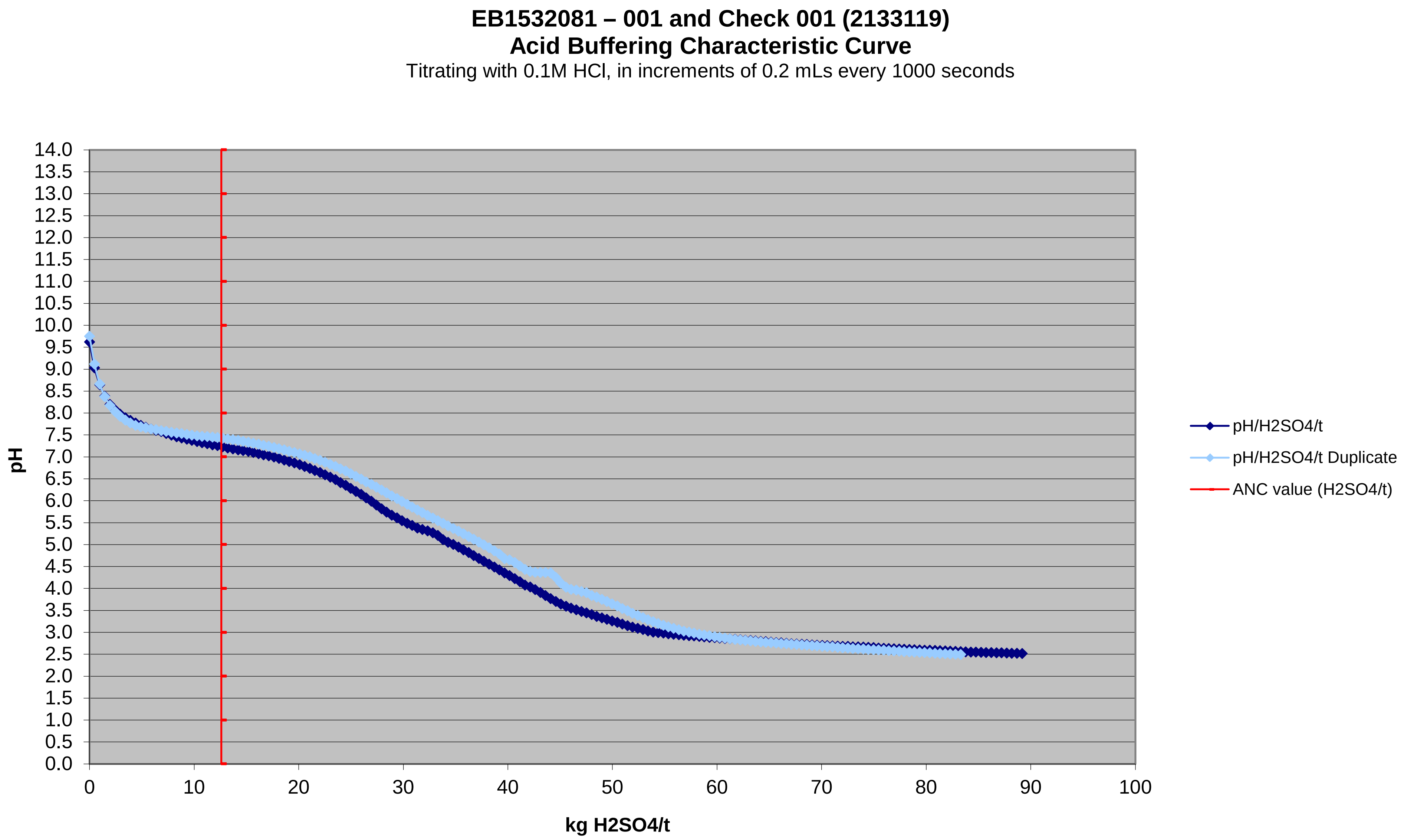


EB1532081 - 024 (2134886)
Kinetic NAG
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature

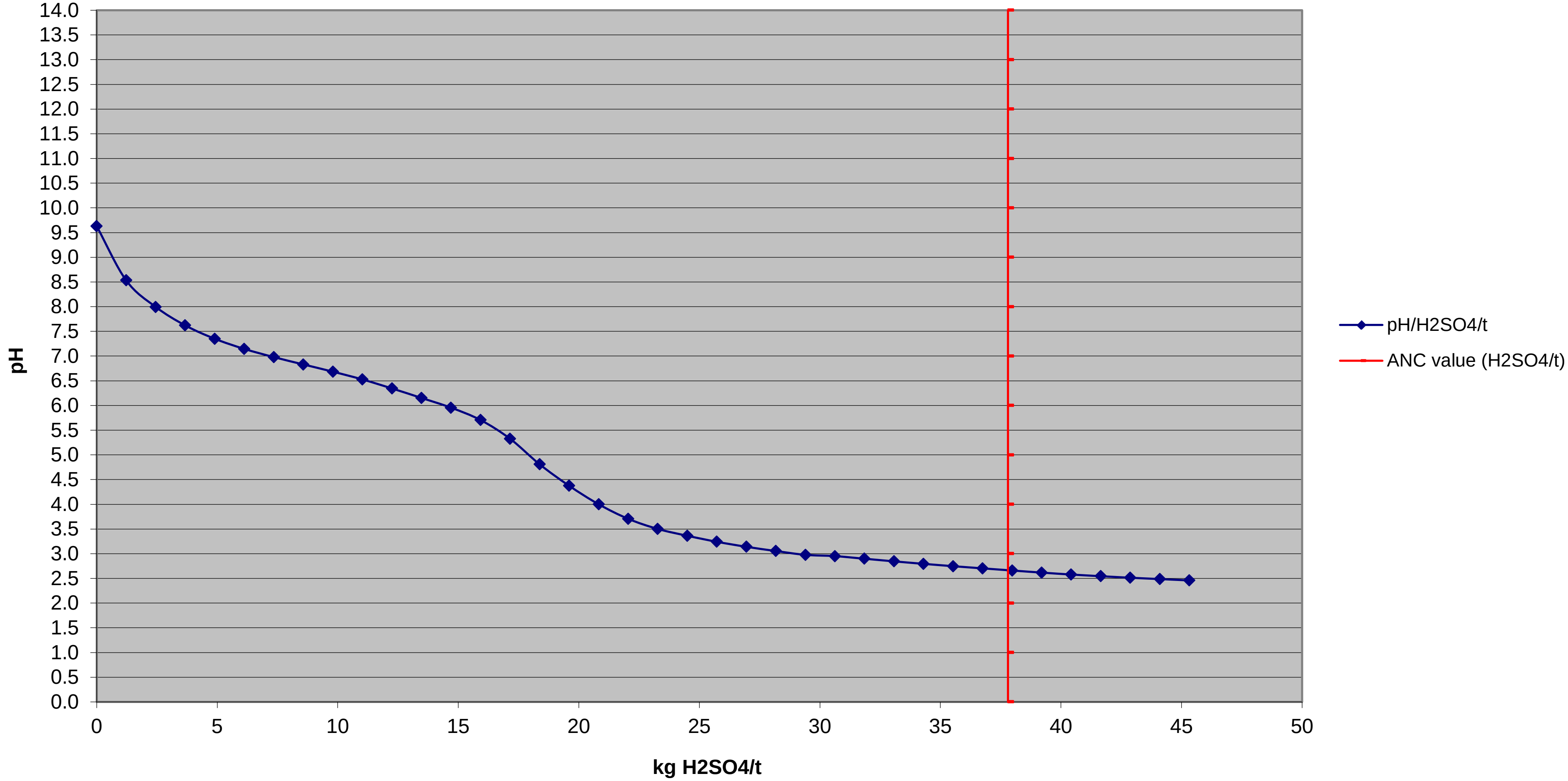


EB1532081 - 025 (2131103)
Kinetic NAG
pH
Temperature (Celsius)
Time (minutes)
pH
Temperature

Appendix B – Acid Buffering Capacity Curves


EB1532081 – 001 and Check 001 (2133119)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds
pH
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
90
100
kg H2SO4/t
pH/H2SO4/t
pH/H2SO4/t Duplicate
ANC value (H2SO4/t)

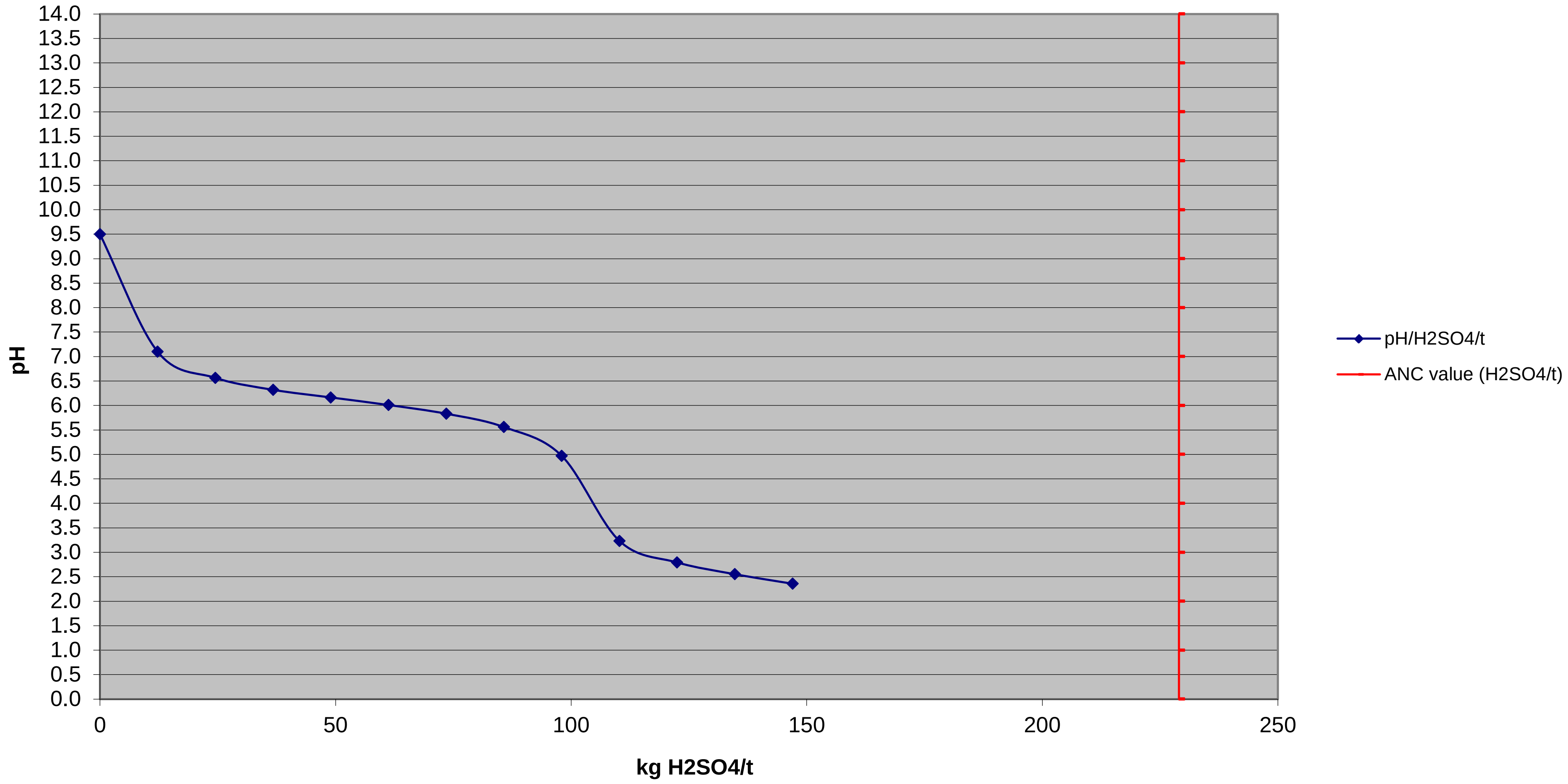
EB1532081 – 002 (2134651)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds

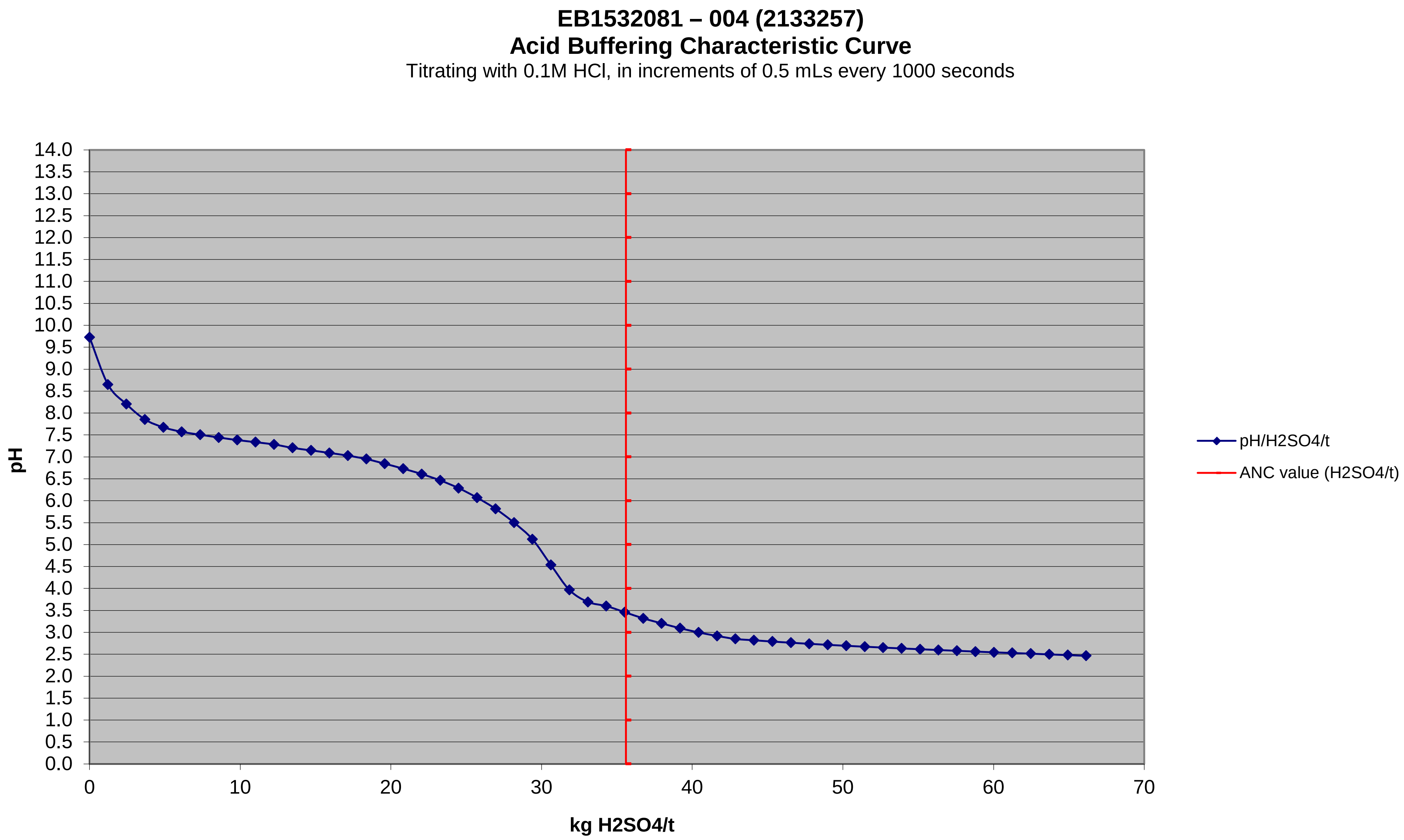


EB1532081 – 003 (2130694)

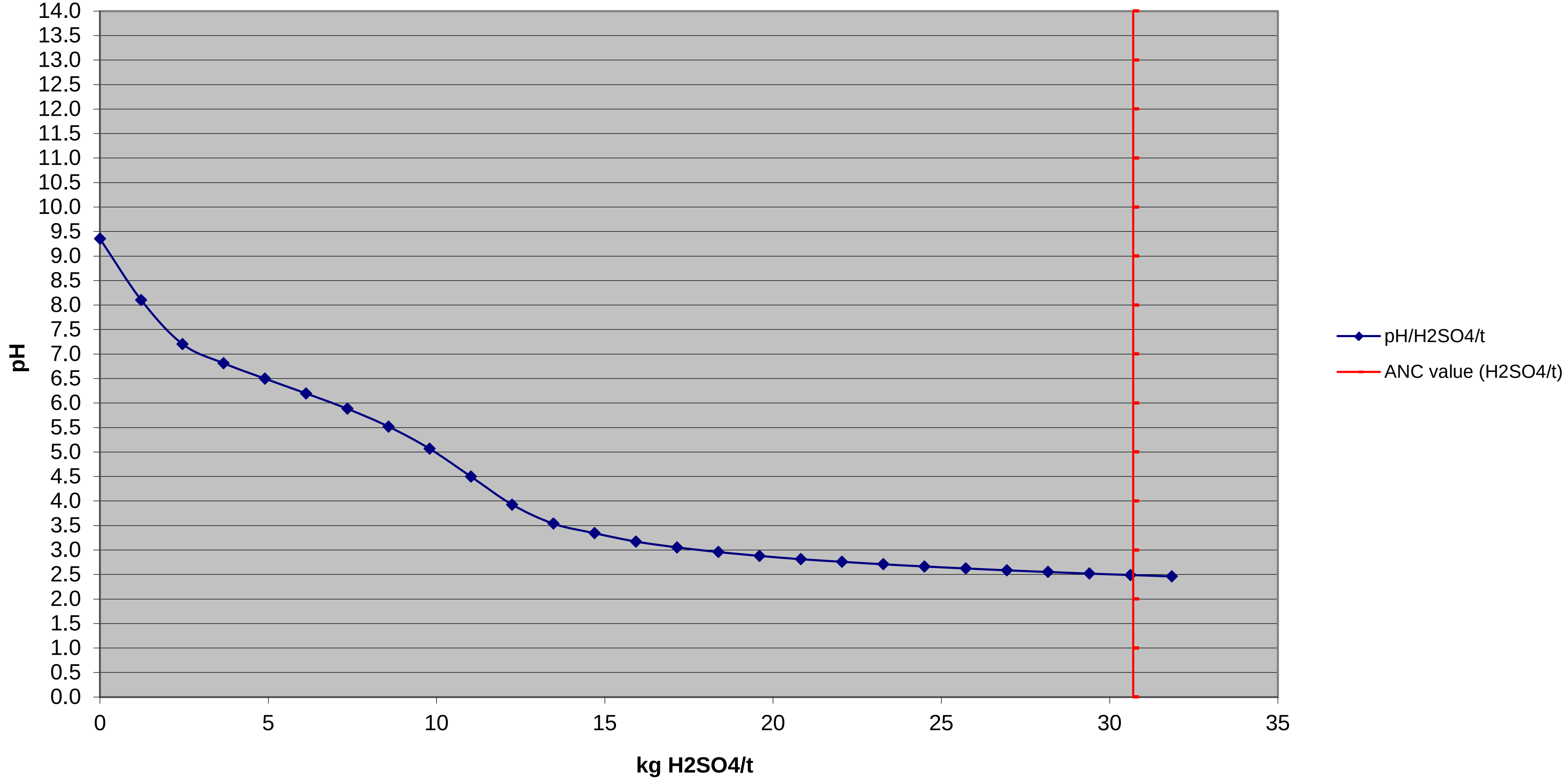
Acid Buffering Characteristic Curve

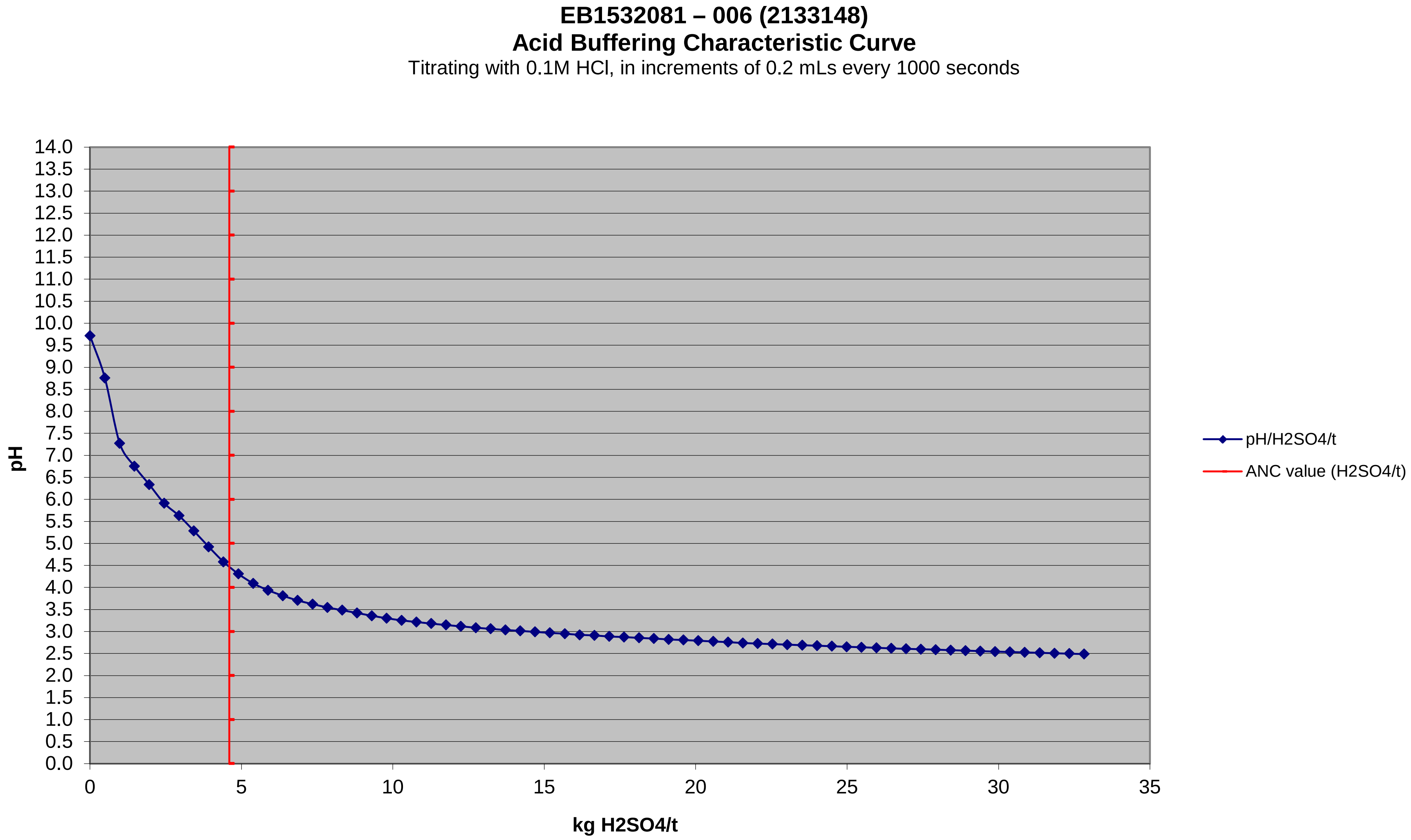
Titrating with 0.5M HCl, in increments of 1.0 mLs every 1000 seconds

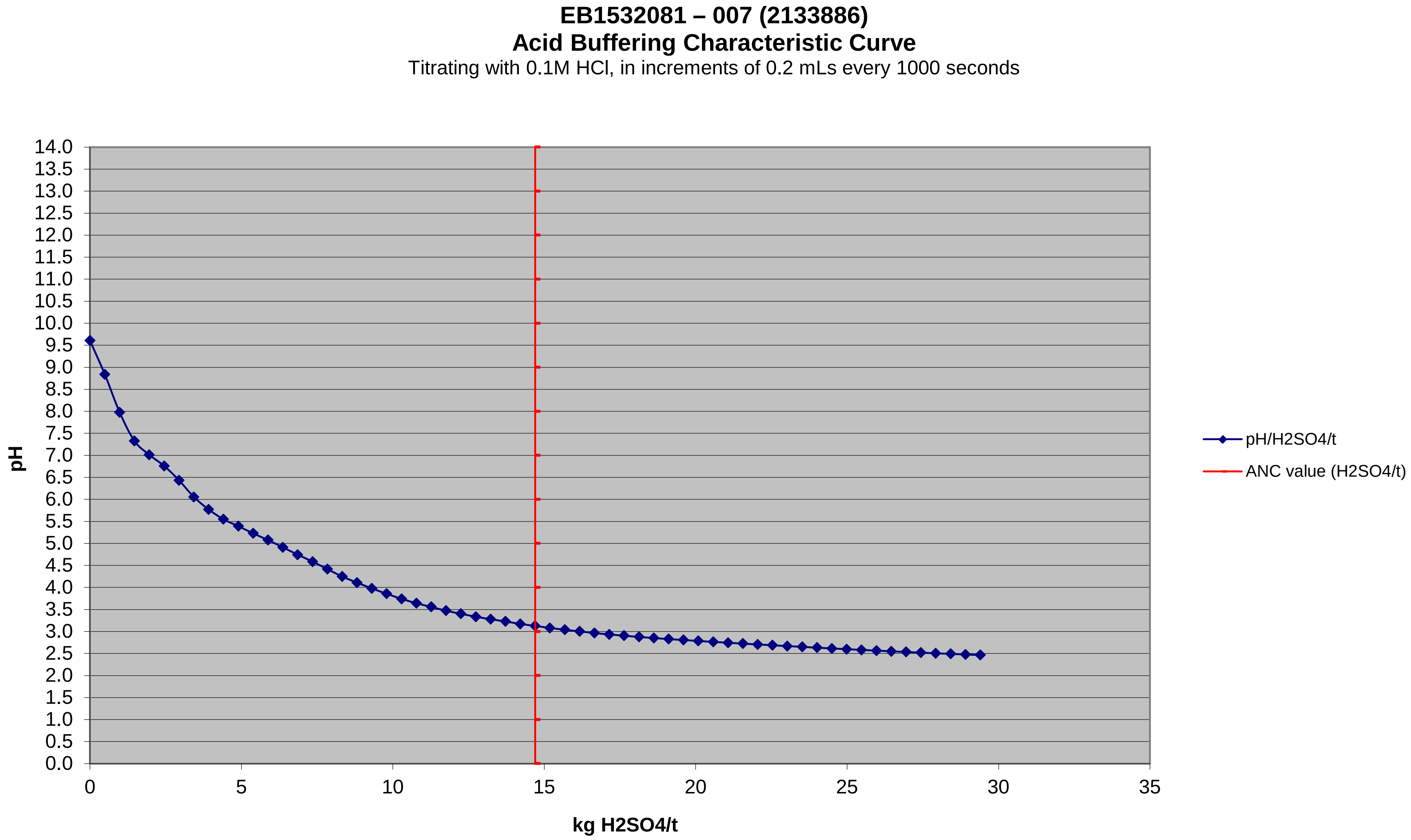



EB1532081 – 004 (2133257)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds
pH
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70

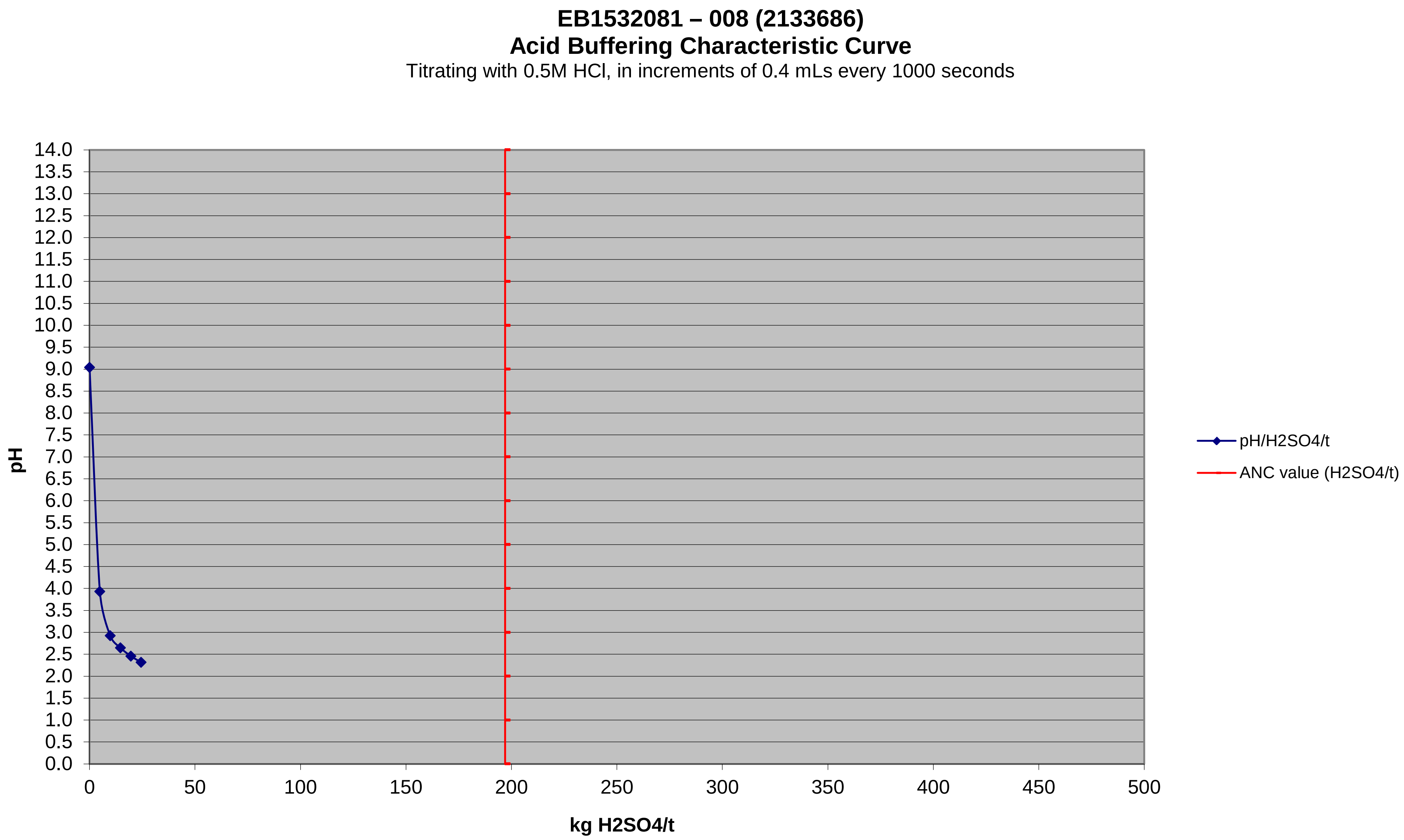
EB1532081 – 005 (2133528)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds



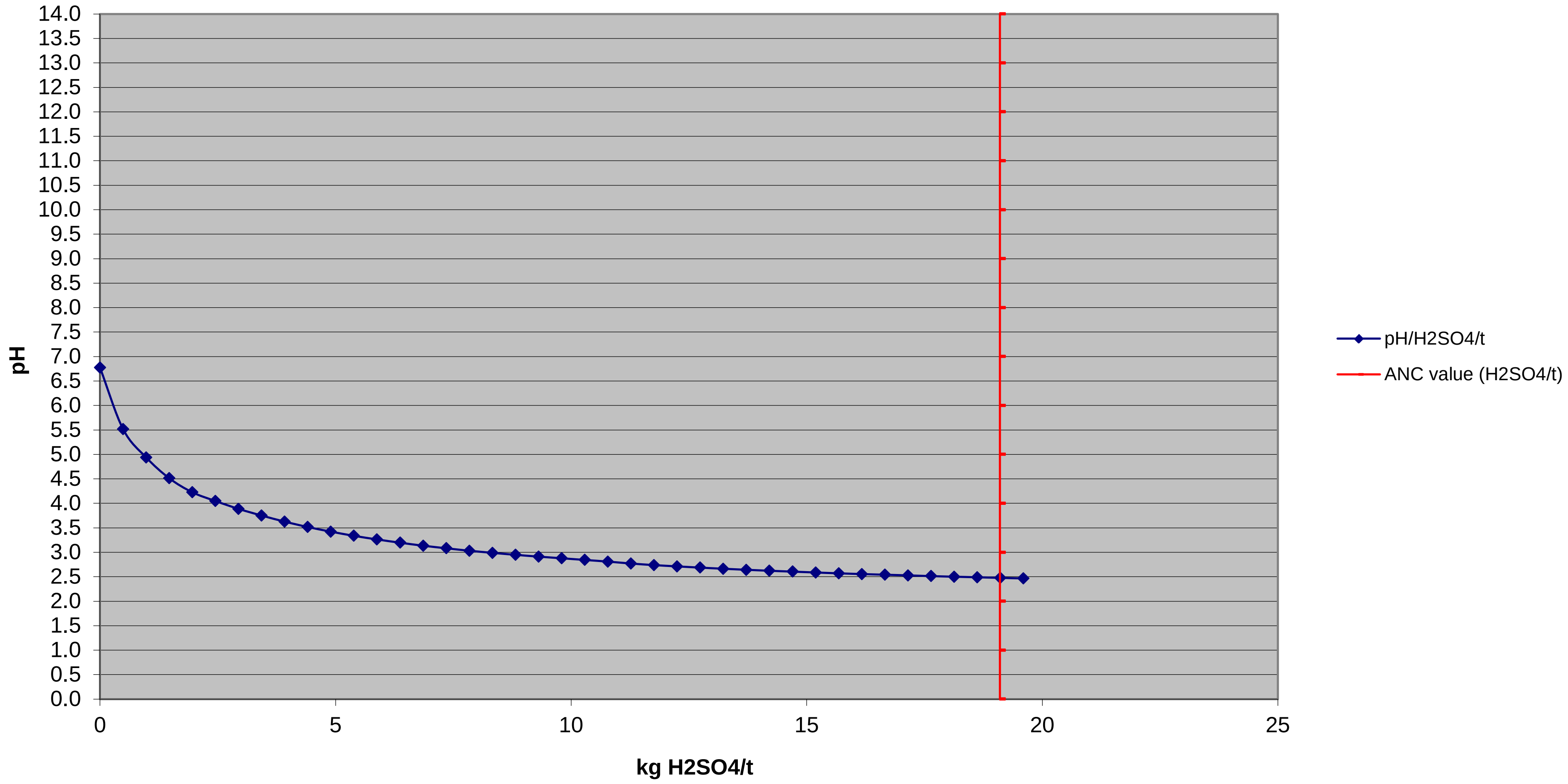

EB1532081 – 006 (2133148)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds
pH
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)



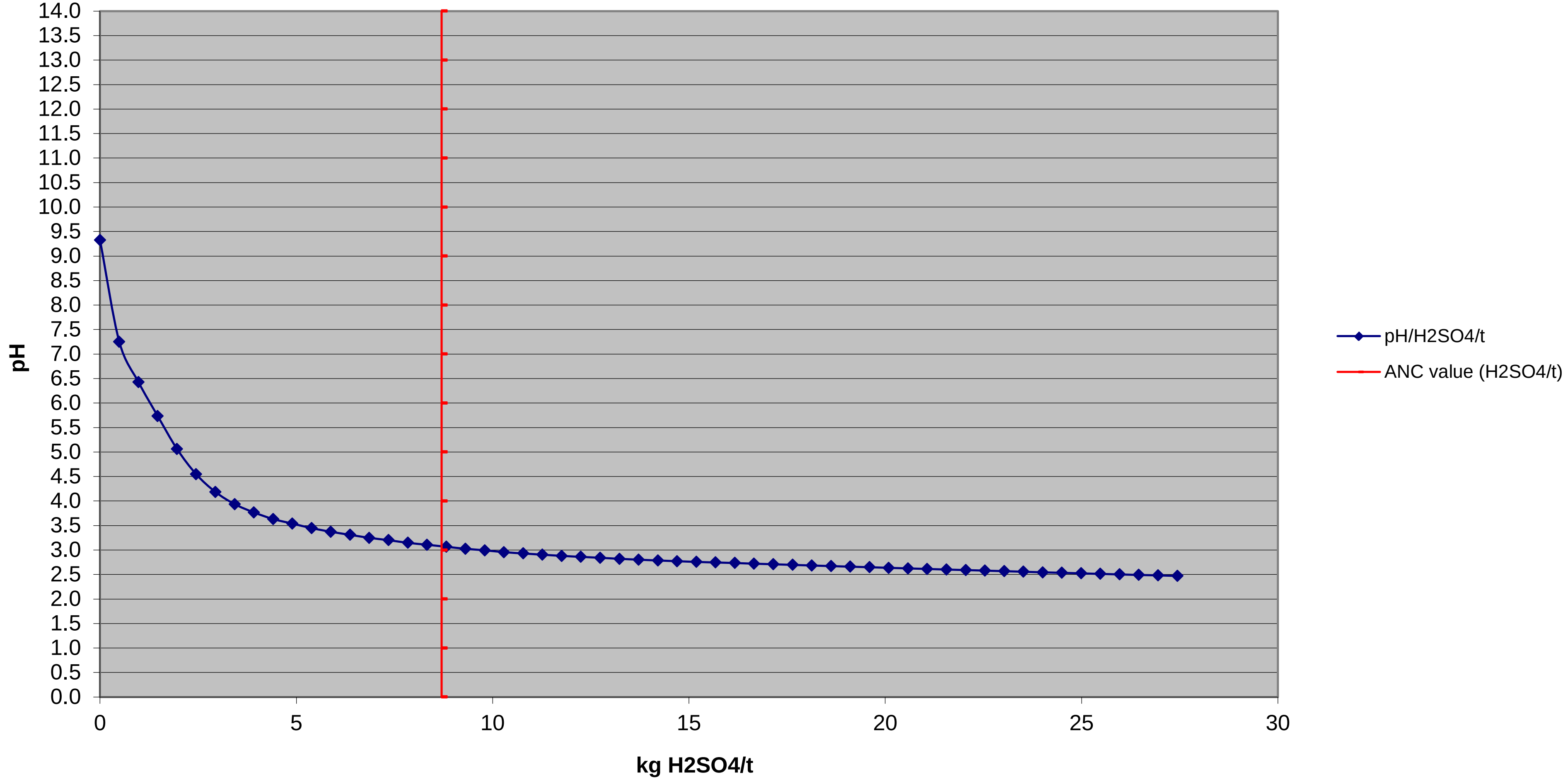
EB1532081 – 007 (2133886)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds
pH
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)


EB1532081 – 008 (2133686)
Acid Buffering Characteristic Curve
Titrating with 0.5M HCl, in increments of 0.4 mLs every 1000 seconds
pH
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
50
100
150
200
250
300
350
400
450
500
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)

EB1532081 – 009 (2133329)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds

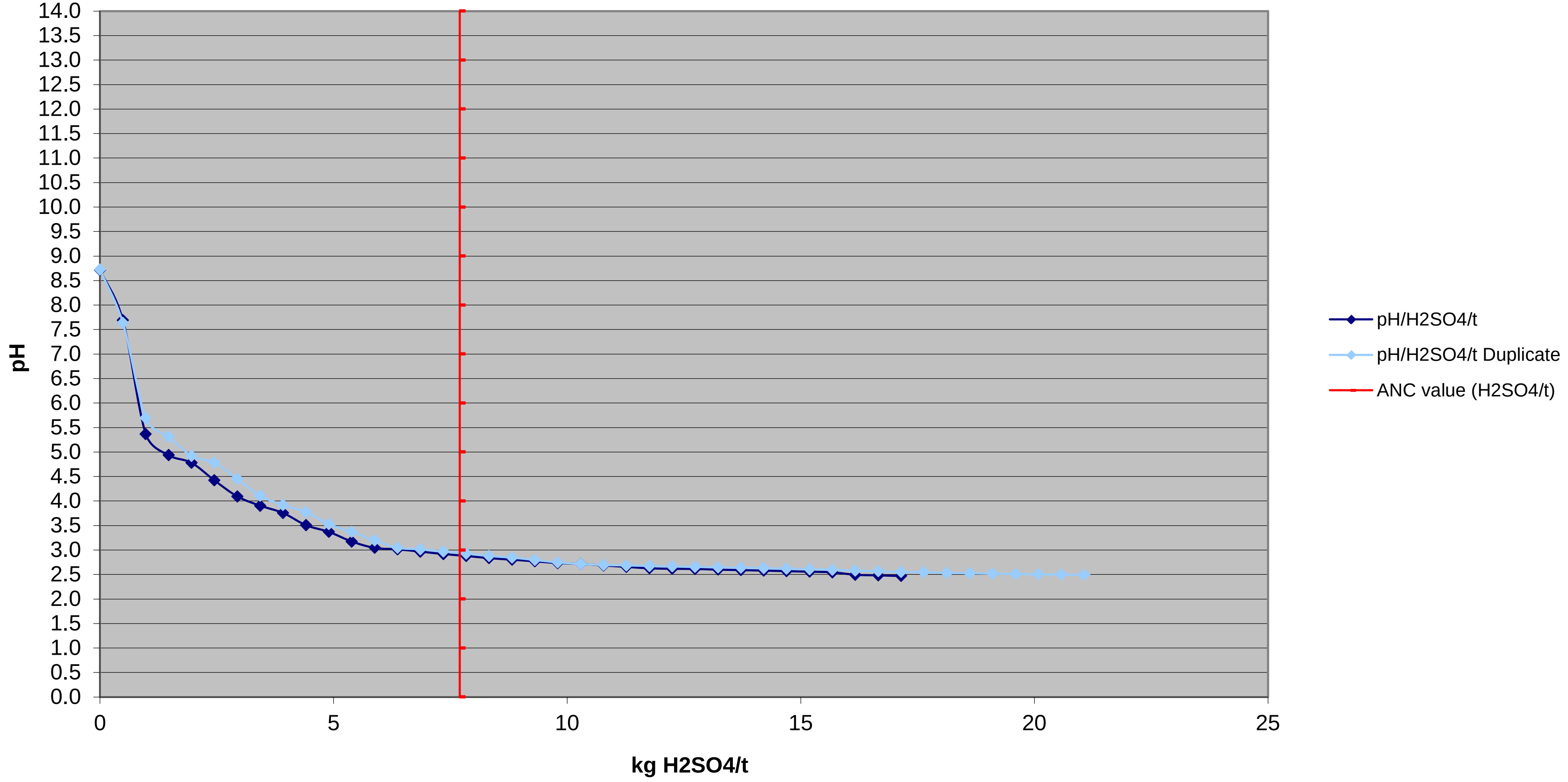


EB1532081 – 010 (2130893)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds

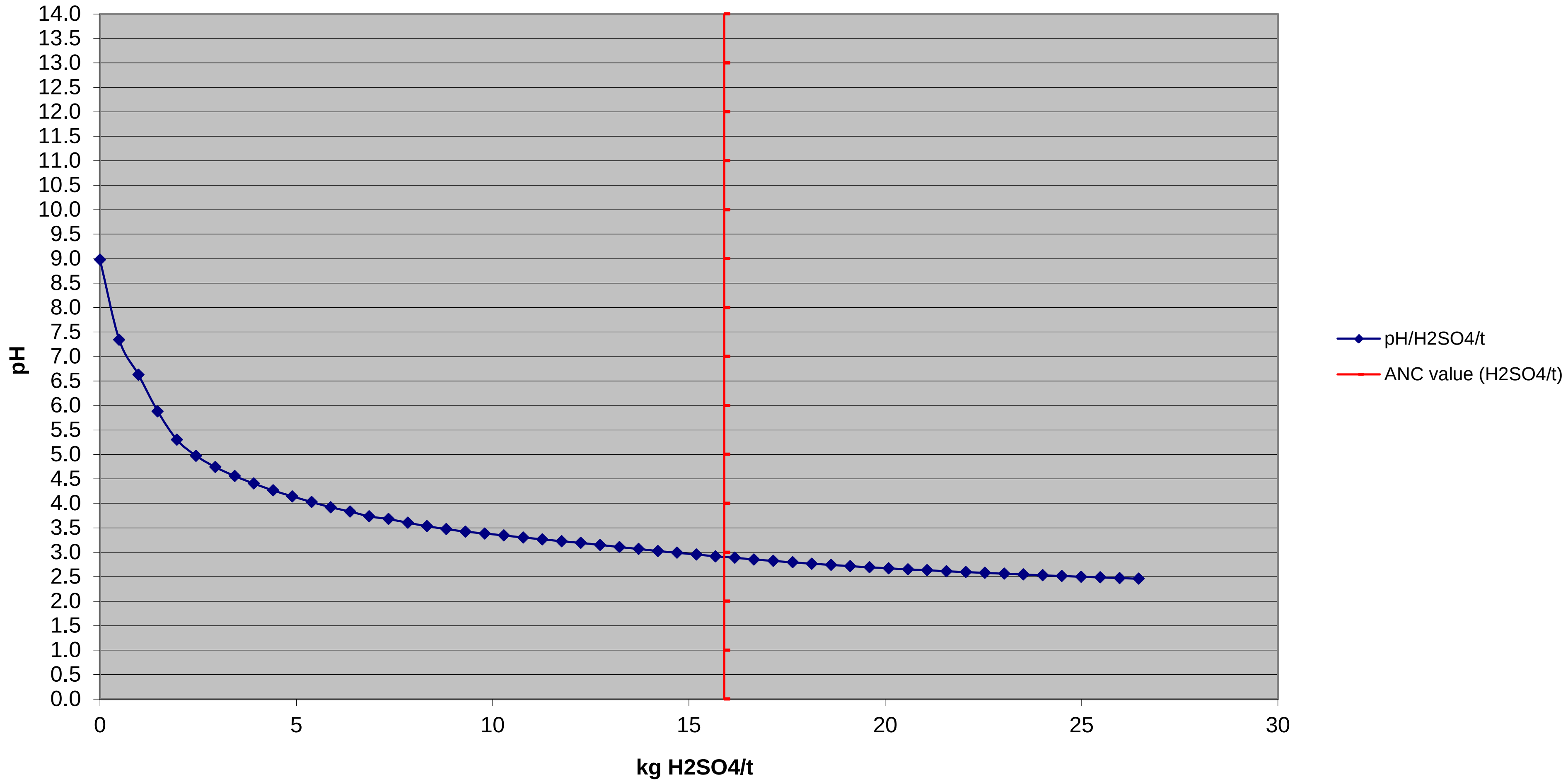


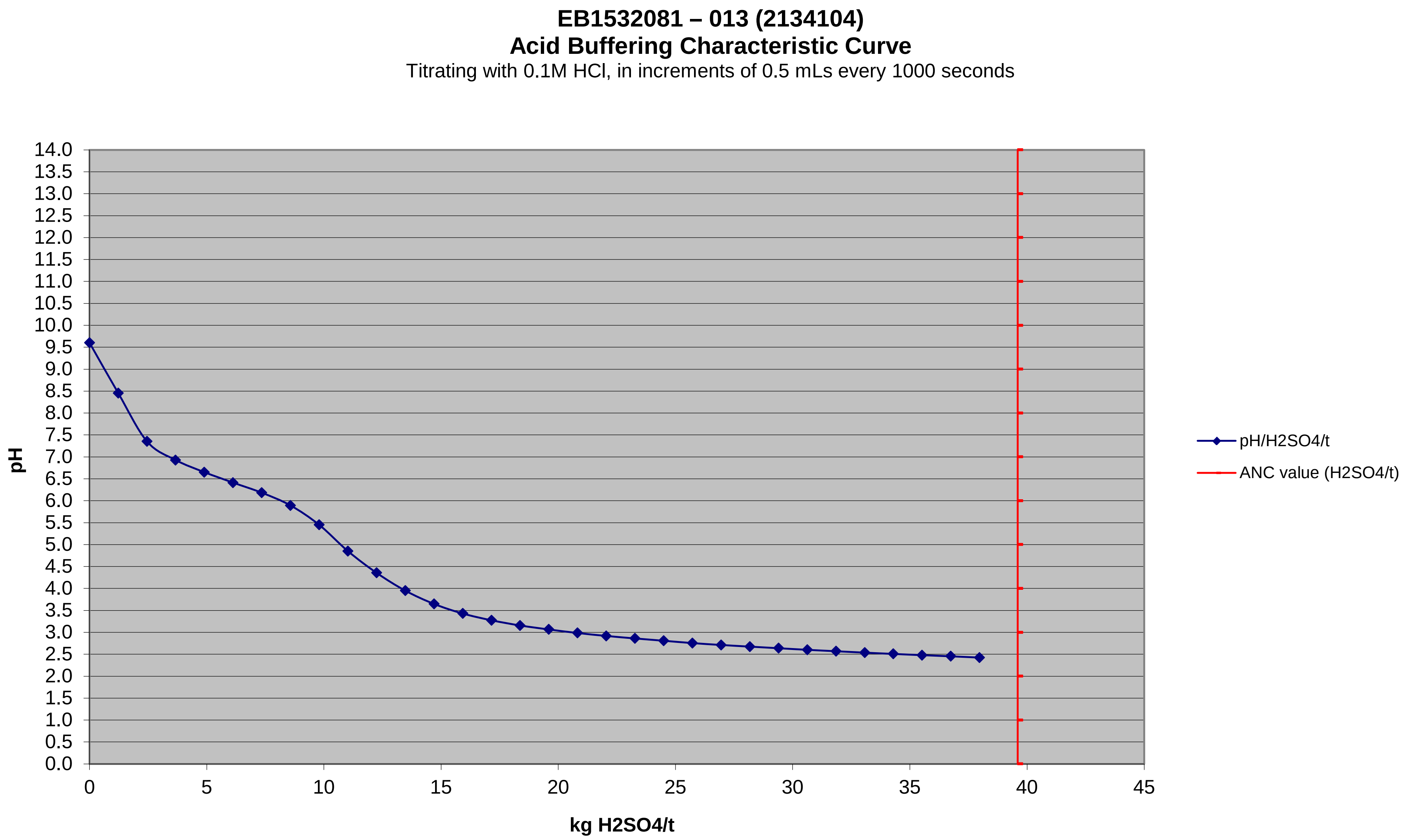
EB1532081 – 011 and Check 011 (2118644_2118645)
Acid Buffering Characteristic Curve

Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds

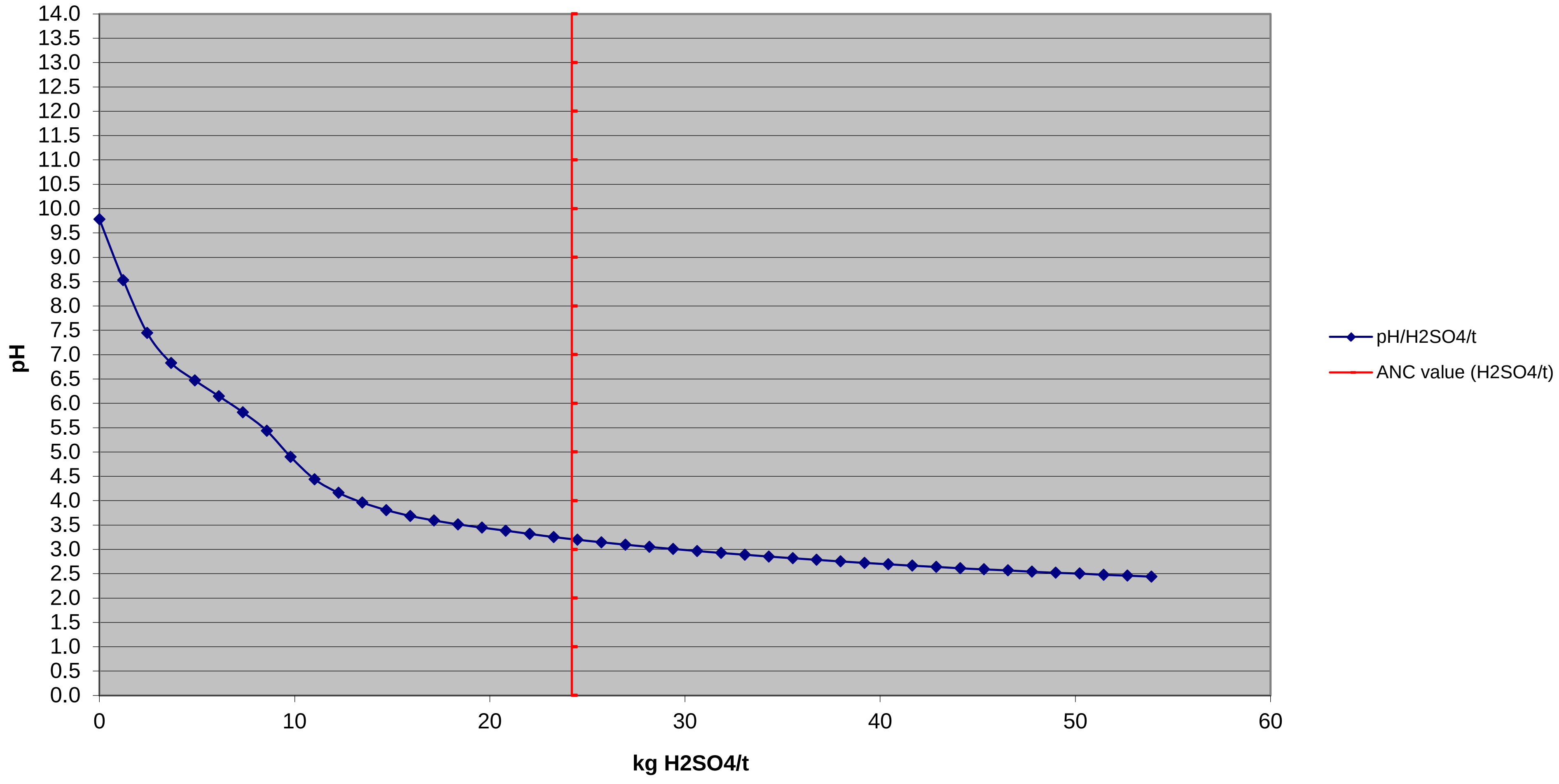


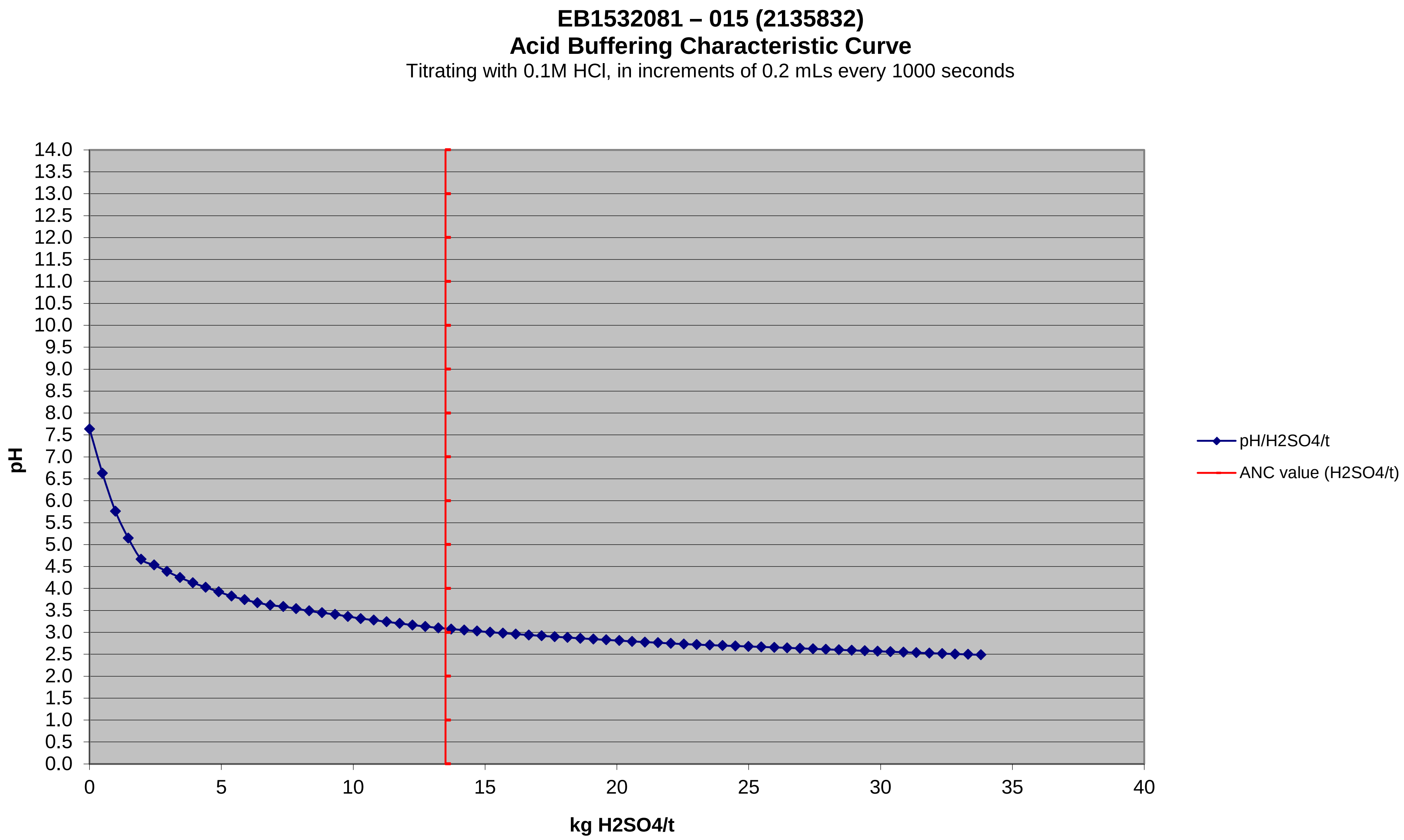
EB1532081 – 012 (2113728_2113729)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds




EB1532081 – 013 (2134104)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds
pH
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
40
45

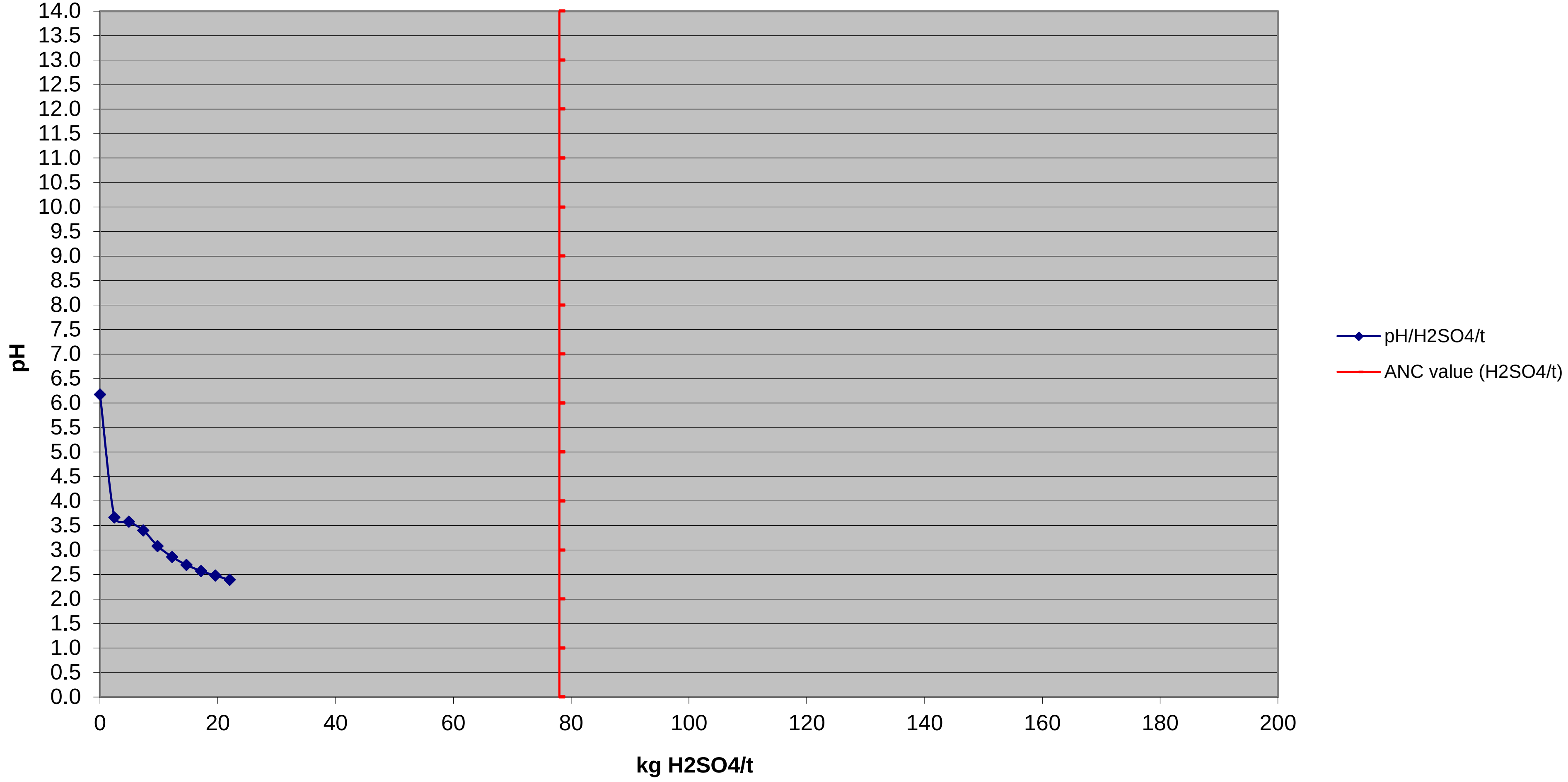
EB1532081 – 014 (2134341)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds

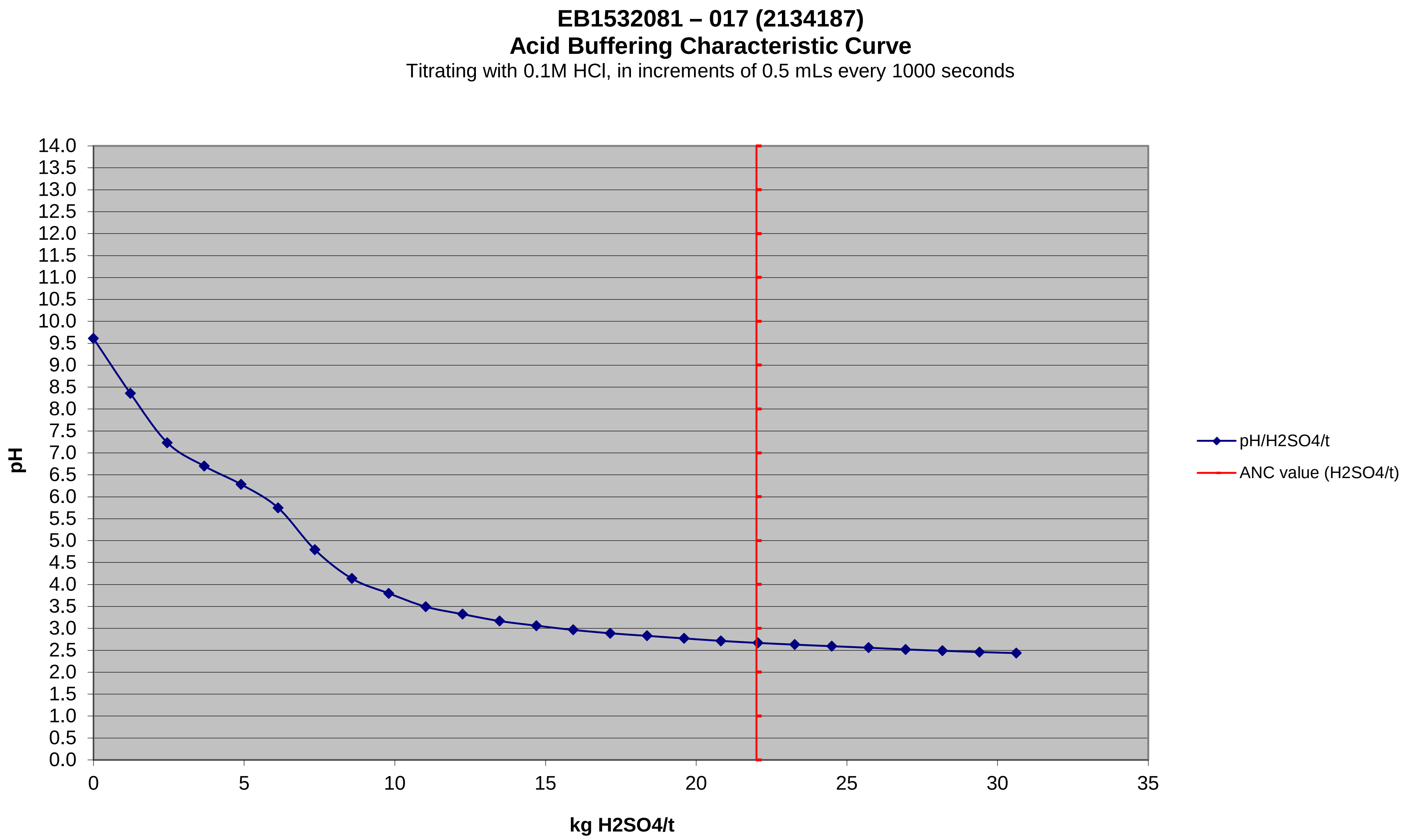




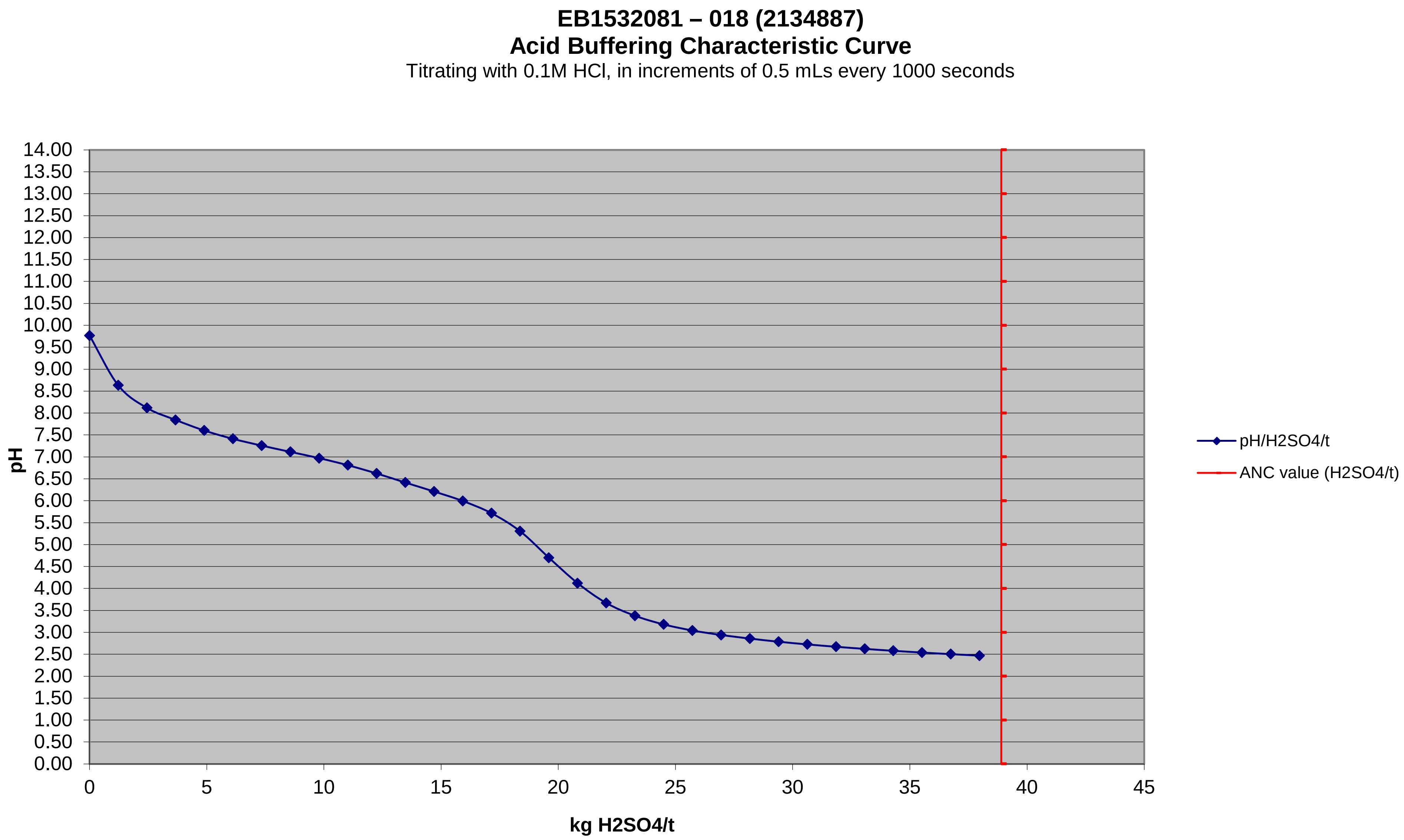
EB1532081 – 015 (2135832)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds
pH
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
40
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)

EB1532081 – 016 (2133727)
Acid Buffering Characteristic Curve
Titrating with 0.5M HCl, in increments of 0.2 mLs every 1000 seconds



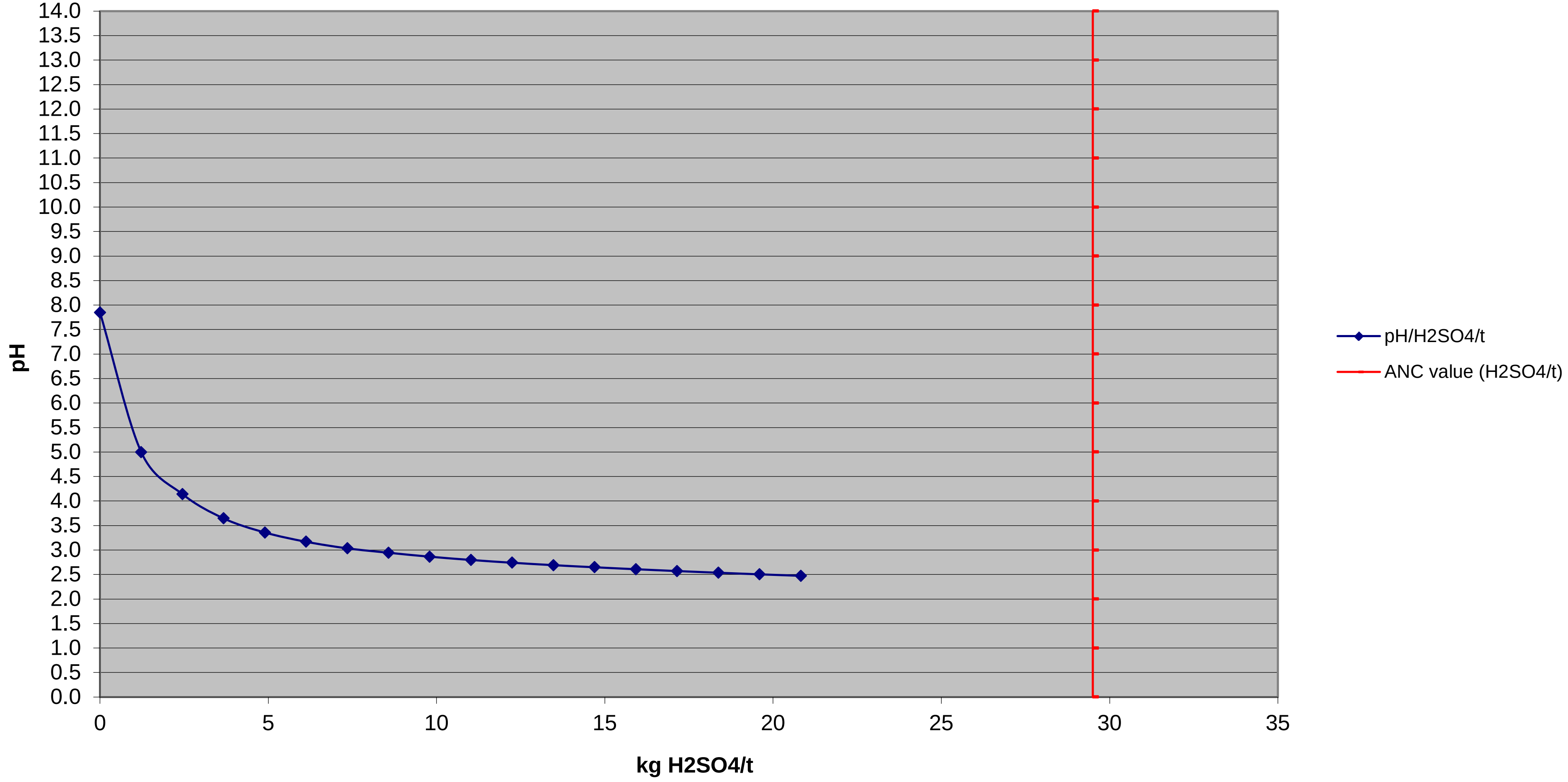


EB1532081 – 017 (2134187)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds
pH
kg H2SO4/t
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
35
pH/H2SO4/t
ANC value (H2SO4/t)

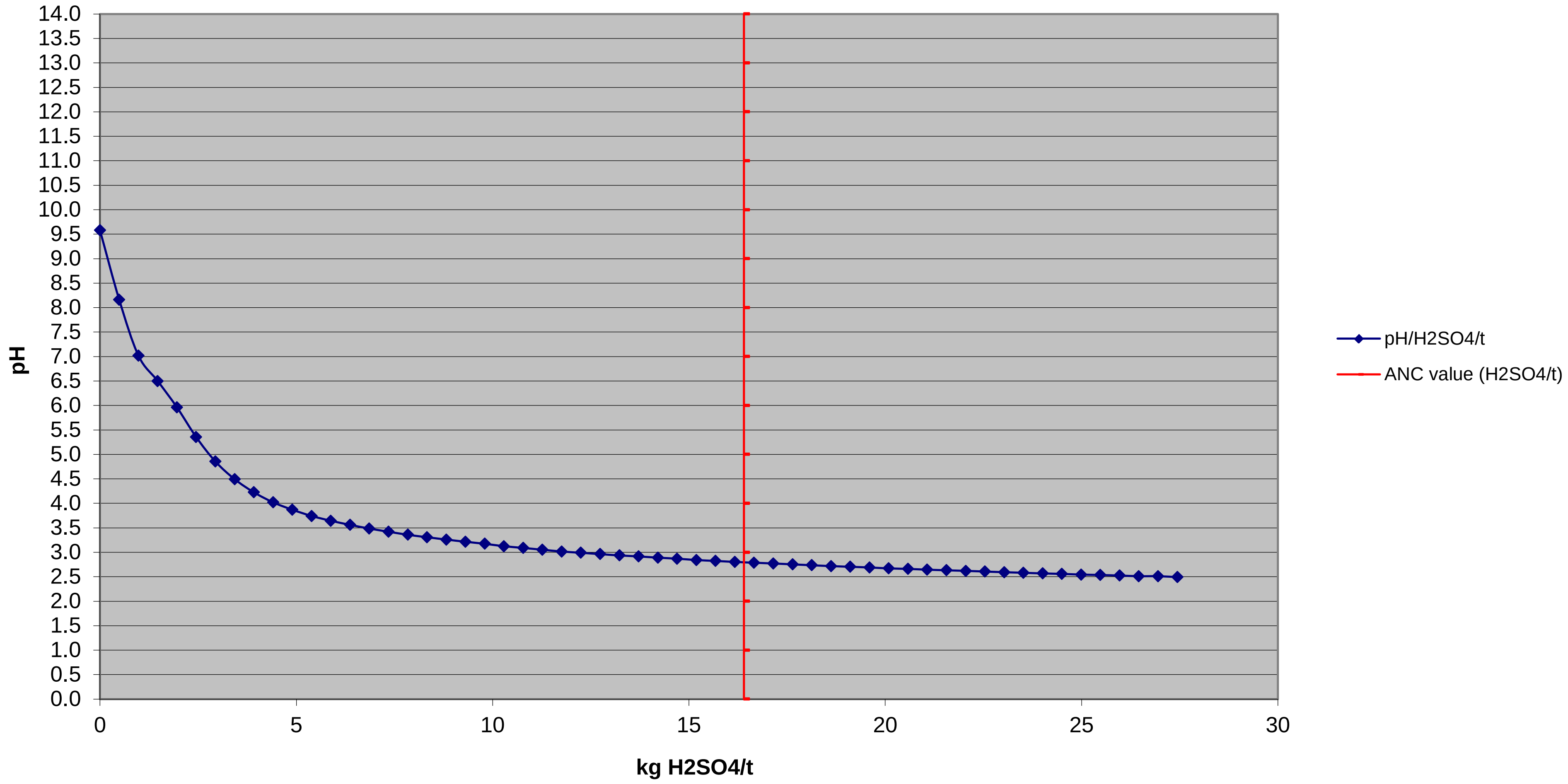

EB1532081 – 018 (2134887)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds
pH
14.00
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
5
10
15
20
25
30
35
40
45
kg H2SO4/t
pH/H2SO4/t
ANC value (H2SO4/t)

EB1532081 – 020 (2130745)
Acid Buffering Characteristic Curve

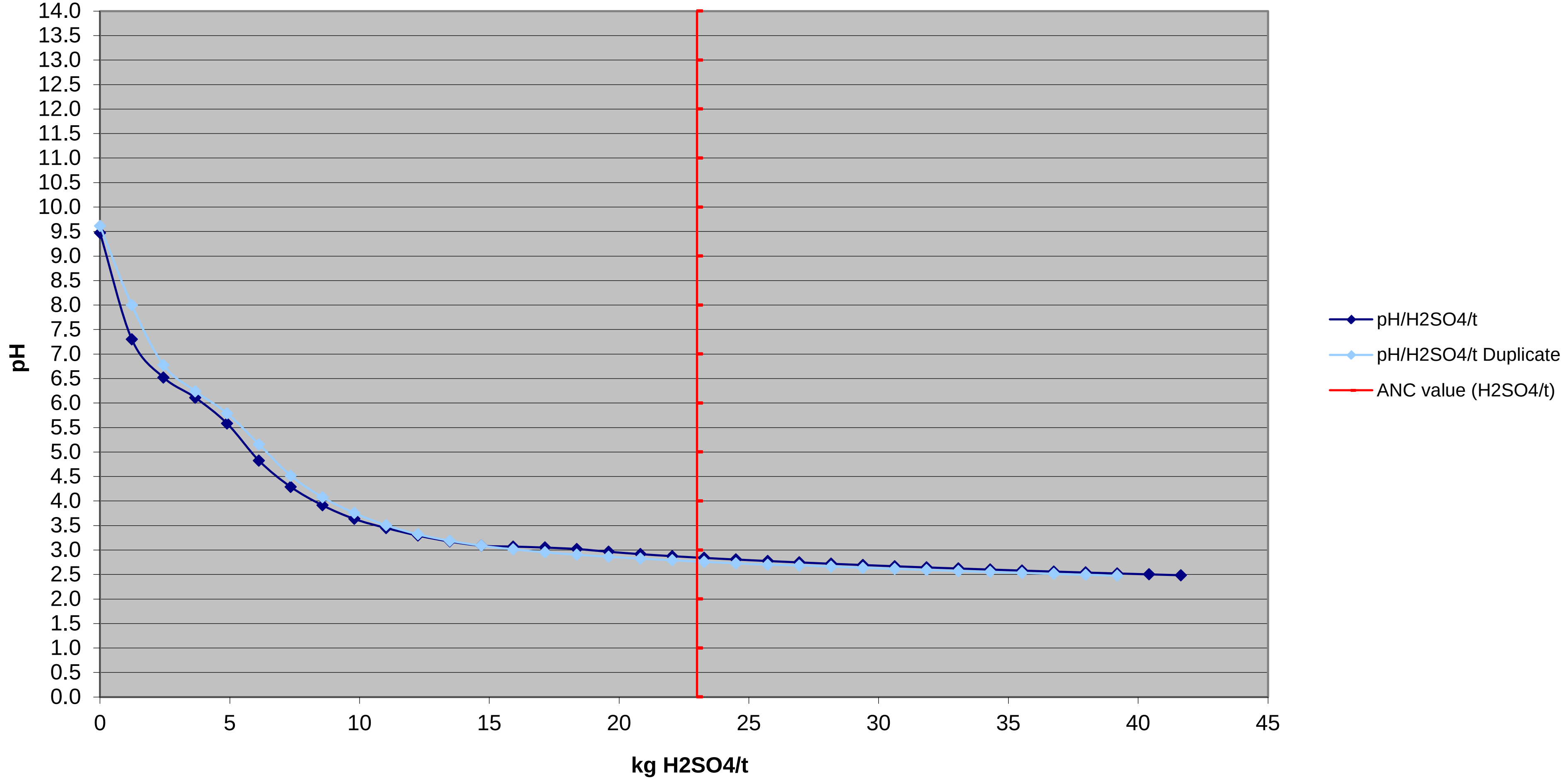
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds



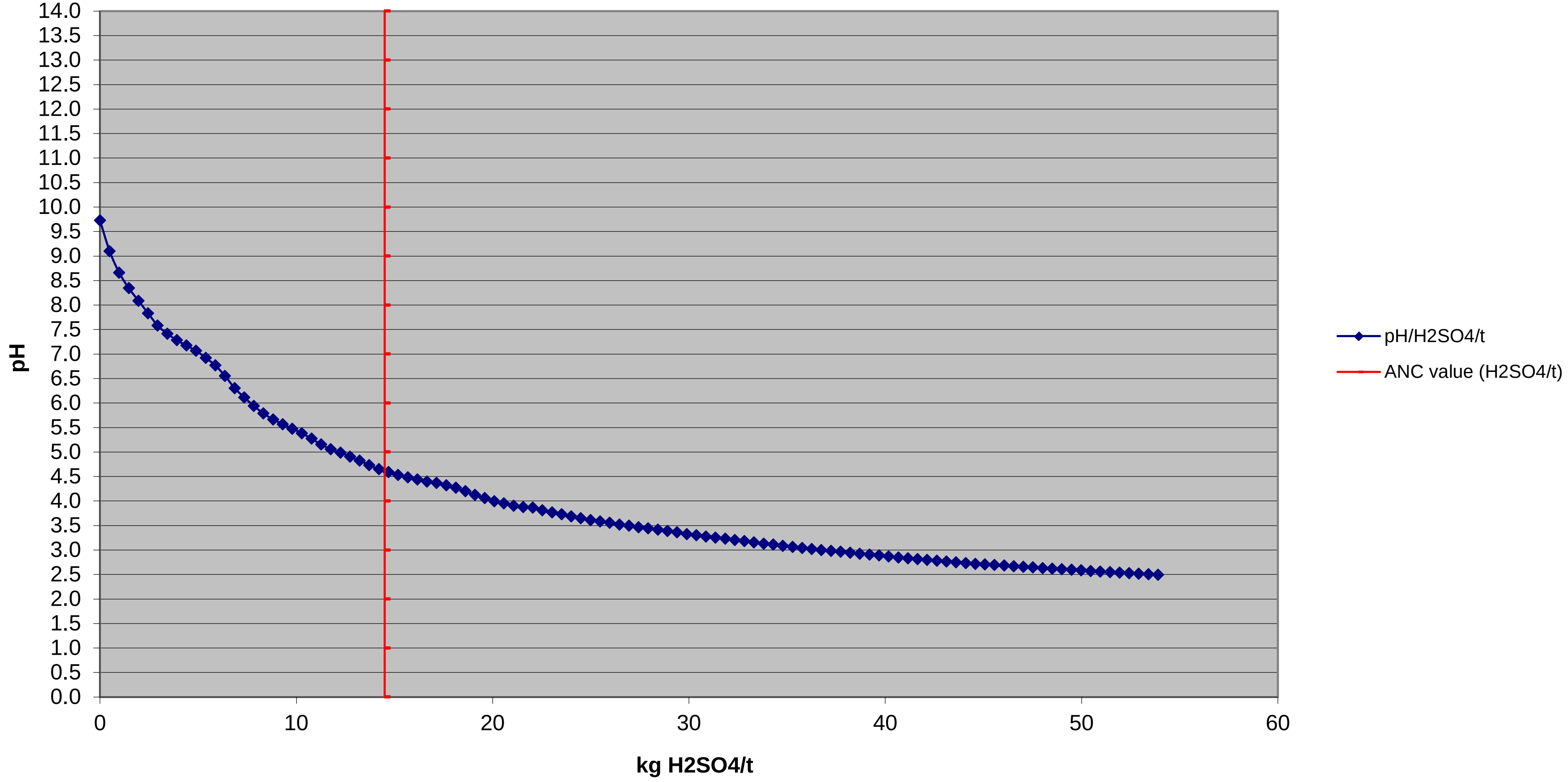
EB15320812 – 021 (2136002)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds



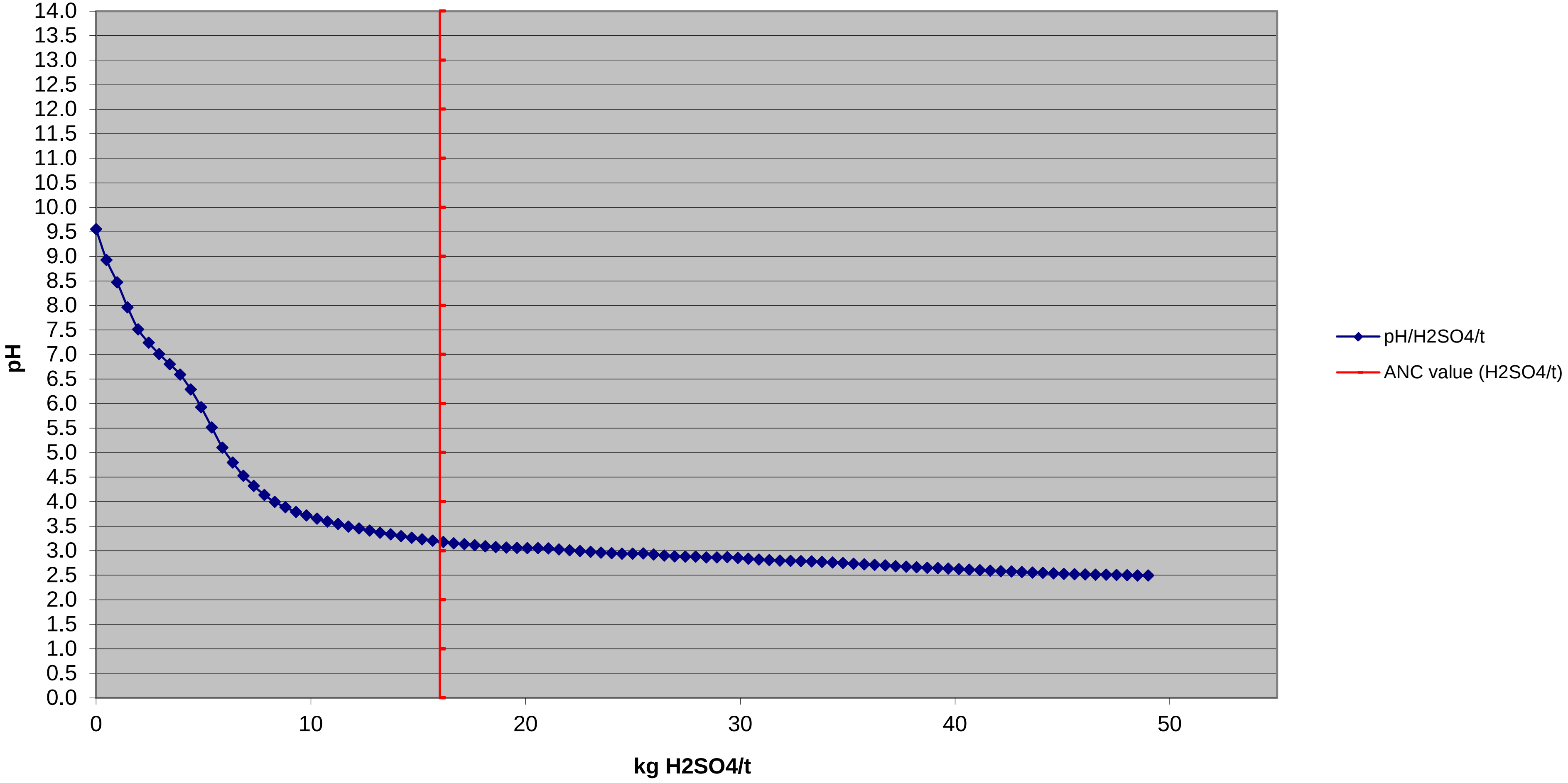
EB1532081 – 022 and Check 022 (2132125)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.5 mLs every 1000 seconds



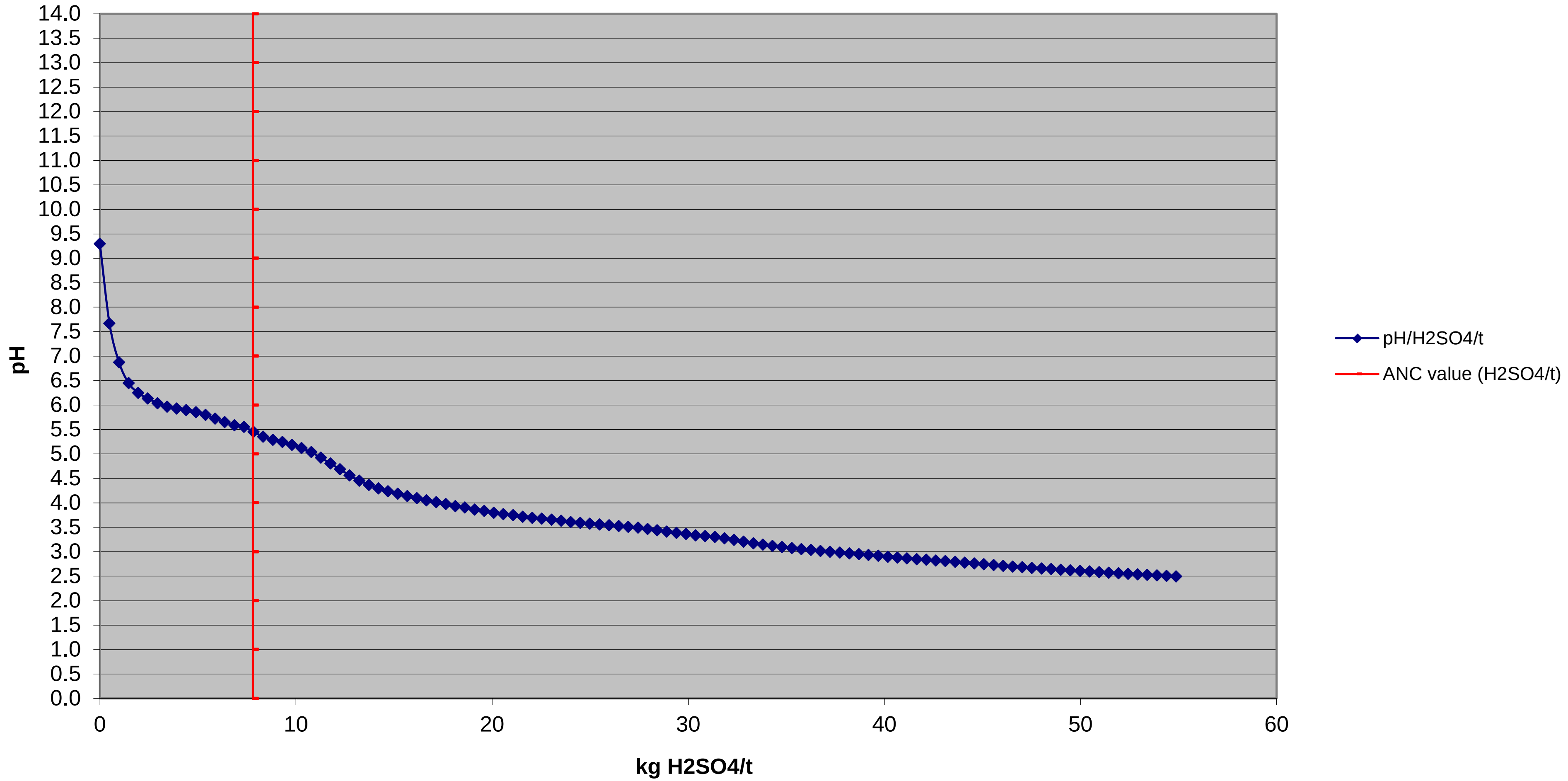
EB1532081 – 023 (2134597)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds



EB1532081 – 024 (2134886)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds



EB1532081 – 025 (2131103)
Acid Buffering Characteristic Curve
Titrating with 0.1M HCl, in increments of 0.2 mLs every 1000 seconds



Appendix C – Leachate Analysis Results

Sample ID	Sample Lithology	Al			Sb			As			Ba			Be			B			Bi		
	Units	(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)		
	ANZECC (2000) FAE 99%	0.027			-			0.0008			-			-			0.09			-		
	ADWG (2011) Health	-			0.003			0.01			2			0.06			4			-		
	ADWG (2011) Aesthetic	0.2			-			-			-			-			-			-		
			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed	
Sample ID	Sample Lithology	Results	FAE99%	ADWG (A)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)
2133119	Mineralisation	0.07	2.59	0.35	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.39	No FAE99%	0.20	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG
2134651	Mineralisation	0.10	3.70	0.50	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.52	No FAE99%	0.26	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG
2130694	Mineralisation	0.01	0.37	0.05	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.12	No FAE99%	0.06	<0.001	No FAE99%	<LOR	<0.05	<LOR	<LOR	<0.001	No FAE99%	No ADWG
2133257	Mineralisation	0.05	1.85	0.25	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.30	No FAE99%	0.15	<0.001	No FAE99%	<LOR	<0.05	<LOR	<LOR	<0.001	No FAE99%	No ADWG
2133528	Mineralisation	0.06	2.22	0.30	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.16	No FAE99%	0.08	<0.001	No FAE99%	<LOR	<0.05	<LOR	<LOR	<0.001	No FAE99%	No ADWG
2133148	Pegmatite	0.73	27.04	3.65	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.47	No FAE99%	0.23	<0.001	No FAE99%	<LOR	0.16	0.43	0.04	<0.001	No FAE99%	No ADWG
2133886	Pegmatite	0.87	32.22	4.35	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.60	No FAE99%	0.30	<0.001	No FAE99%	<LOR	0.14	0.38	0.04	<0.001	No FAE99%	No ADWG
2133686	Pegmatite	1.00	37.04	5.00	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.46	No FAE99%	0.23	<0.001	No FAE99%	<LOR	0.16	0.43	0.04	<0.001	No FAE99%	No ADWG
2133329	Pegmatite	0.92	34.07	4.60	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.33	No FAE99%	0.17	<0.001	No FAE99%	<LOR	0.19	0.51	0.05	<0.001	No FAE99%	No ADWG
2130893	Pegmatite	0.72	26.67	3.60	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.43	No FAE99%	0.21	<0.001	No FAE99%	<LOR	0.13	0.35	0.03	<0.001	No FAE99%	No ADWG
2118644_2118645	Schist	0.82	30.37	4.10	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.44	No FAE99%	0.22	<0.001	No FAE99%	<LOR	0.14	0.38	0.04	<0.001	No FAE99%	No ADWG
2113728_2113729	Schist	0.95	35.19	4.75	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.40	No FAE99%	0.20	<0.001	No FAE99%	<LOR	0.17	0.46	0.04	<0.001	No FAE99%	No ADWG
2134104	Schist	0.34	12.59	1.70	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.48	No FAE99%	0.24	<0.001	No FAE99%	<LOR	0.16	0.43	0.04	<0.001	No FAE99%	No ADWG
2134341	Schist	0.54	20.00	2.70	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.53	No FAE99%	0.26	<0.001	No FAE99%	<LOR	0.14	0.38	0.04	<0.001	No FAE99%	No ADWG
2135832	Schist	1.57	58.15	7.85	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.37	No FAE99%	0.19	<0.001	No FAE99%	<LOR	0.23	0.62	0.06	<0.001	No FAE99%	No ADWG
2133727	Gneiss	1.98	73.33	9.90	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.40	No FAE99%	0.20	<0.001	No FAE99%	<LOR	0.19	0.51	0.05	<0.001	No FAE99%	No ADWG
2134187	Gneiss	0.52	19.26	2.60	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.50	No FAE99%	0.25	<0.001	No FAE99%	<LOR	0.13	0.35	0.03	<0.001	No FAE99%	No ADWG
2134887	Gneiss	0.24	8.89	1.20	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.50	No FAE99%	0.25	<0.001	No FAE99%	<LOR	0.16	0.43	0.04	<0.001	No FAE99%	No ADWG
2130745	Gneiss	0.91	33.70	4.55	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.33	No FAE99%	0.17	<0.001	No FAE99%	<LOR	0.19	0.51	0.05	<0.001	No FAE99%	No ADWG
2136002	Gneiss	1.06	39.26	5.30	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.50	No FAE99%	0.25	<0.001	No FAE99%	<LOR	0.10	0.27	0.03	<0.001	No FAE99%	No ADWG
2132125	Gneiss	0.87	32.22	4.35	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.43	No FAE99%	0.22	<0.001	No FAE99%	<LOR	0.19	0.51	0.05	<0.001	No FAE99%	No ADWG
2134597	Gneiss	0.37	13.70	1.85	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.50	No FAE99%	0.25	<0.001	No FAE99%	<LOR	0.15	0.41	0.04	<0.001	No FAE99%	No ADWG
2134886	Gneiss	0.53	19.63	2.65	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.49	No FAE99%	0.24	<0.001	No FAE99%	<LOR	0.15	0.41	0.04	<0.001	No FAE99%	No ADWG
2131103	Gneiss	0.93	34.44	4.65	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.47	No FAE99%	0.24	<0.001	No FAE99%	<LOR	0.15	0.41	0.04	<0.001	No FAE99%	No ADWG

Exceeds FAE95	
Exceeds ADWG (Health)	
Exceeds ADWG (Aesthetic)	

Sample ID	Sample Lithology	Cd			Cr			Co			Cu			Fe Dissolved			Pb			Mn		
	Units	(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)		
	ANZECC (2000) FAE 99%	0.00006			0.00001			-			0.001			-			0.001			1.2		
	ADWG (2011) Health	0.002			0.05			-			2			-			0.01			0.5		
	ADWG (2011) Aesthetic	-			-			-			1			0.3			-			0.1		
			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed	
Sample ID	Sample Lithology	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (A)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)
2133119	Mineralisation	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	<0.05	No FAE99%	<LOR	<0.001	<LOR	<LOR	0.00	0.00	0.00
2134651	Mineralisation	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	<0.05	No FAE99%	<LOR	0.002	0.59	0.20	<0.001	<LOR	<LOR
2130694	Mineralisation	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	<0.05	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.001	<LOR	<LOR
2133257	Mineralisation	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	<0.05	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.001	<LOR	<LOR
2133528	Mineralisation	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	<0.05	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.001	<LOR	<LOR
2133148	Pegmatite	<0.0001	<LOR	<LOR	0.002	2.00	0.04	<0.001	No FAE99%	No ADWG	0.002	1.43	0.00	0.09	No FAE99%	0.30	0.004	1.18	0.40	<0.001	<LOR	<LOR
2133886	Pegmatite	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.001	0.71	0.00	0.13	No FAE99%	0.43	0.003	0.88	0.30	0.00	0.00	0.00
2133686	Pegmatite	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	0.21	No FAE99%	0.70	0.008	2.35	0.80	0.00	0.00	0.00
2133329	Pegmatite	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.001	0.71	0.00	0.46	No FAE99%	1.53	**0.058**	17.06	5.80	0.00	0.00	0.00
2130893	Pegmatite	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.003	2.14	0.00	0.08	No FAE99%	0.27	0.005	1.47	0.50	<0.001	<LOR	<LOR
2118644_2118645	Schist	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.002	1.43	0.00	0.27	No FAE99%	0.90	<0.001	<LOR	<LOR	0.00	0.00	0.00
2113728_2113729	Schist	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.002	1.43	0.00	0.76	No FAE99%	2.53	<0.001	<LOR	<LOR	0.00	0.00	0.01
2134104	Schist	<0.0001	<LOR	<LOR	0.002	2.00	0.04	<0.001	No FAE99%	No ADWG	0.001	0.71	0.00	0.11	No FAE99%	0.37	0.002	0.59	0.20	0.00	0.00	0.01
2134341	Schist	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.002	1.43	0.00	0.20	No FAE99%	0.67	0.002	0.59	0.20	0.00	0.00	0.00
2135832	Schist	<0.0001	<LOR	<LOR	0.002	2.00	0.04	<0.001	No FAE99%	No ADWG	0.001	0.71	0.00	1.22	No FAE99%	4.07	0.006	1.76	0.60	0.01	0.00	0.01
2133727	Gneiss	<0.0001	<LOR	<LOR	0.002	2.00	0.04	<0.001	No FAE99%	No ADWG	0.012	8.57	0.01	1.94	No FAE99%	6.47	0.005	1.47	0.50	0.01	0.01	0.02
2134187	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.008	5.71	0.00	0.06	No FAE99%	0.20	0.003	0.88	0.30	0.00	0.00	0.00
2134887	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.001	0.71	0.00	0.07	No FAE99%	0.23	0.002	0.59	0.20	0.00	0.00	0.00
2130745	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	0.68	No FAE99%	2.27	0.004	1.18	0.40	0.02	0.01	0.05
2136002	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.003	2.14	0.00	0.19	No FAE99%	0.63	0.004	1.18	0.40	<0.001	<LOR	<LOR
2132125	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.004	2.86	0.00	0.17	No FAE99%	0.57	0.004	1.18	0.40	0.00	0.00	0.00
2134597	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	0.07	No FAE99%	0.23	0.002	0.59	0.20	<0.001	<LOR	<LOR
2134886	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	<0.001	<LOR	<LOR	0.15	No FAE99%	0.50	0.002	0.59	0.20	0.00	0.00	0.00
2131103	Gneiss	<0.0001	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.010	7.14	0.01	0.19	No FAE99%	0.63	0.003	0.88	0.30	0.00	0.00	0.00

Exceeds FAE95	
Exceeds ADWG (Health)	
Exceeds ADWG (Aesthetic)	

Parameters		Mo			Ni			Se			Ag			Tl			Th		
Units		(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)			(mg/L)		
ANZECC (2000) FAE 99%		-			0.008			0.005			0.00002			-			-		
ADWG (2011) Health		0.05			0.02			0.01			0.1			-			-		
ADWG (2011) Aesthetic		-			-			-			-			-			-		
			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed			Times exceed	
Sample ID	Sample Lithology	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)
2133119	Mineralisation	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.007	No FAE99%	No ADWG
2134651	Mineralisation	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.0005	No FAE99%	No ADWG
2130694	Mineralisation	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.004	No FAE99%	No ADWG
2133257	Mineralisation	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.004	No FAE99%	No ADWG
2133528	Mineralisation	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.004	No FAE99%	No ADWG
2133148	Pegmatite	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.004	No FAE99%	No ADWG
2133886	Pegmatite	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.014	No FAE99%	No ADWG
2133686	Pegmatite	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.013	No FAE99%	No ADWG
2133329	Pegmatite	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.019	No FAE99%	No ADWG
2130893	Pegmatite	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.012	No FAE99%	No ADWG
2118644_2118645	Schist	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.002	No FAE99%	No ADWG
2113728_2113729	Schist	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.007	No FAE99%	No ADWG
2134104	Schist	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.002	No FAE99%	No ADWG
2134341	Schist	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.005	No FAE99%	No ADWG
2135832	Schist	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.002	No FAE99%	No ADWG
2133727	Gneiss	<0.001	No FAE99%	<LOR	0.001	0.09	0.05	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.01	No FAE99%	No ADWG
2134187	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.0005	No FAE99%	No ADWG
2134887	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.001	No FAE99%	No ADWG
2130745	Gneiss	0.003	No FAE99%	0.06	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.018	No FAE99%	No ADWG
2136002	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.025	No FAE99%	No ADWG
2132125	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.004	No FAE99%	No ADWG
2134597	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.0005	No FAE99%	No ADWG
2134886	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.001	No FAE99%	No ADWG
2131103	Gneiss	<0.001	No FAE99%	<LOR	<0.001	<LOR	<LOR	<0.01	<LOR	<LOR	<0.001	<LOR	<LOR	<0.001	No FAE99%	No ADWG	0.005	No FAE99%	No ADWG

Exceeds FAE95
Exceeds ADWG (Health)
Exceeds ADWG (Aesthetic)

Parameters		Sn			Sr			U			V			Zn			F			
Units		(mg/L)						mg/L			(mg/L)			(mg/L)			(mg/L)			
ANZECC (2000) FAE 99%		-			-			-			-			0.0024			-			
ADWG (2011) Health		-			-			0.017			-			-			1.5			
ADWG (2011) Aesthetic		-			-			-			-			3			-			
			Times exceed						Times exceed			Times exceed						Times exceed		
Sample ID	Sample Lithology	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Results	FAE99%	ADWG (H)	Dutch Guidelines
2133119	Mineralisation	<0.001	No FAE99%	No ADWG	0.09	No FAE99%	No ADWG	0.004	No FAE99%	0.24	0.03	No FAE99%	No ADWG	0.02	2.75	No ADWG	0.80	No FAE99%	0.53	0.23
2134651	Mineralisation	<0.001	No FAE99%	No ADWG	0.54	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.01	1.63	No ADWG	0.20	No FAE99%	0.13	0.06
2130694	Mineralisation	<0.001	No FAE99%	No ADWG	0.14	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.01	1.00	No ADWG	0.60	No FAE99%	0.40	0.17
2133257	Mineralisation	<0.001	No FAE99%	No ADWG	0.18	No FAE99%	No ADWG	0.006	No FAE99%	0.35	<0.01	No FAE99%	No ADWG	0.01	1.63	No ADWG	0.30	No FAE99%	0.20	0.09
2133528	Mineralisation	<0.001	No FAE99%	No ADWG	0.10	No FAE99%	No ADWG	0.012	No FAE99%	0.71	<0.01	No FAE99%	No ADWG	0.01	1.63	No ADWG	0.90	No FAE99%	0.60	0.26
2133148	Pegmatite	<0.001	No FAE99%	No ADWG	0.18	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	3.13	No ADWG	0.70	No FAE99%	0.47	0.20
2133886	Pegmatite	<0.001	No FAE99%	No ADWG	0.06	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.04	5.50	No ADWG	0.50	No FAE99%	0.33	0.14
2133686	Pegmatite	<0.001	No FAE99%	No ADWG	0.23	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	3.25	No ADWG	0.40	No FAE99%	0.27	0.12
2133329	Pegmatite	<0.001	No FAE99%	No ADWG	0.02	No FAE99%	No ADWG	0.001	No FAE99%	0.06	<0.01	No FAE99%	No ADWG	0.03	3.50	No ADWG	0.50	No FAE99%	0.33	0.14
2130893	Pegmatite	<0.001	No FAE99%	No ADWG	0.36	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	3.88	No ADWG	0.40	No FAE99%	0.27	0.12
2118644_2118645	Schist	<0.001	No FAE99%	No ADWG	0.09	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	4.13	No ADWG	0.50	No FAE99%	0.33	0.14
2113728_2113729	Schist	<0.001	No FAE99%	No ADWG	0.02	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	0.01	No FAE99%	No ADWG	0.04	4.50	No ADWG	**1.80**	No FAE99%	1.20	0.52
2134104	Schist	<0.001	No FAE99%	No ADWG	0.20	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	4.00	No ADWG	0.50	No FAE99%	0.33	0.14
2134341	Schist	<0.001	No FAE99%	No ADWG	0.12	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.04	5.38	No ADWG	0.60	No FAE99%	0.40	0.17
2135832	Schist	<0.001	No FAE99%	No ADWG	0.01	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.06	7.00	No ADWG	0.90	No FAE99%	0.60	0.26
2133727	Gneiss	<0.001	No FAE99%	No ADWG	0.02	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.04	4.38	No ADWG	0.60	No FAE99%	0.40	0.17
2134187	Gneiss	<0.001	No FAE99%	No ADWG	0.28	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.05	6.63	No ADWG	0.40	No FAE99%	0.27	0.12
2134887	Gneiss	<0.001	No FAE99%	No ADWG	0.13	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.04	4.88	No ADWG	0.40	No FAE99%	0.27	0.12
2130745	Gneiss	<0.001	No FAE99%	No ADWG	0.02	No FAE99%	No ADWG	0.001	No FAE99%	0.06	<0.01	No FAE99%	No ADWG	0.04	4.75	No ADWG	0.60	No FAE99%	0.40	0.17
2136002	Gneiss	<0.001	No FAE99%	No ADWG	0.07	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.02	3.00	No ADWG	0.50	No FAE99%	0.33	0.14
2132125	Gneiss	<0.001	No FAE99%	No ADWG	0.09	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	3.88	No ADWG	0.70	No FAE99%	0.47	0.20
2134597	Gneiss	<0.001	No FAE99%	No ADWG	0.17	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	3.50	No ADWG	0.30	No FAE99%	0.20	0.09
2134886	Gneiss	<0.001	No FAE99%	No ADWG	0.18	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.03	4.00	No ADWG	1.00	No FAE99%	0.67	0.29
2131103	Gneiss	<0.001	No FAE99%	No ADWG	0.18	No FAE99%	No ADWG	0.001	No FAE99%	<LOR	<0.01	No FAE99%	No ADWG	0.04	4.38	No ADWG	0.80	No FAE99%	0.53	0.23

Exceeds FAE99
Exceeds ADWG (Health)
Exceeds ADWG (Aesthetic)

	Parameters	SO_4	Al	As	B	Cd	Cr	Cu	Pb	Mn	Hg	Mo	Ni	Se	U	F
	Units	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L	(mg/L
	ANZECC (2000) Livestock	1000	5	1	5	0	1	1	0.1	0.1	0.002	0.05	1	0.02	0.2	2
Sample ID	Sample Lithology	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results	Results
2133119	Mineralisation	7	0.07	<0.001	0.15	<0.0001	<0.001	<0.001	<0.001	0.002	<0.0001	<0.001	<0.001	<0.01	0.004	0.8
2134651	Mineralisation	10	0.1	<0.001	<0.05	<0.0001	<0.001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.2
2130694	Mineralisation	3	0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.6
2133257	Mineralisation	7	0.05	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.01	0.006	0.3
2133528	Mineralisation	10	0.06	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.01	0.012	0.9
2133148	Pegmatite	6	0.73	<0.001	0.16	<0.0001	0.002	0.002	0.004	<0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.7
2133886	Pegmatite	4	0.87	<0.001	0.14	<0.0001	<0.001	0.001	0.003	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.5
2133686	Pegmatite	5	1	<0.001	0.16	<0.0001	<0.001	<0.001	0.008	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.4
2133329	Pegmatite	9	0.92	<0.001	0.19	<0.0001	<0.001	0.001	0.058	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.5
2130893	Pegmatite	7	0.72	<0.001	0.13	<0.0001	<0.001	0.003	0.005	<0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.4
2118644_2118645	Schist	8	0.82	<0.001	0.14	<0.0001	<0.001	0.002	<0.001	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.5
2113728_2113729	Schist	8	0.95	<0.001	0.17	<0.0001	<0.001	0.002	<0.001	0.004	<0.0001	<0.001	<0.001	<0.01	0.001	1.8
2134104	Schist	8	0.34	<0.001	0.16	<0.0001	0.002	0.001	0.002	0.004	<0.0001	<0.001	<0.001	<0.01	0.001	0.5
2134341	Schist	5	0.54	<0.001	0.14	<0.0001	<0.001	0.002	0.002	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.6
2135832	Schist	9	1.57	<0.001	0.23	<0.0001	0.002	0.001	0.006	0.007	<0.0001	<0.001	<0.001	<0.01	0.001	0.9
2133727	Gneiss	6	1.98	<0.001	0.19	<0.0001	0.002	0.012	0.005	0.012	<0.0001	<0.001	0.001	<0.01	0.001	0.6
2134187	Gneiss	11	0.52	<0.001	0.13	<0.0001	<0.001	0.008	0.003	0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.4
2134887	Gneiss	5	0.24	<0.001	0.16	<0.0001	<0.001	0.001	0.002	0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.4
2130745	Gneiss	8	0.91	<0.001	0.19	<0.0001	<0.001	<0.001	0.004	0.023	<0.0001	0.003	<0.001	<0.01	0.001	0.6
2136002	Gneiss	4	1.06	<0.001	0.1	<0.0001	<0.001	0.003	0.004	<0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.5
2132125	Gneiss	10	0.87	<0.001	0.19	<0.0001	<0.001	0.004	0.004	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.7
2134597	Gneiss	8	0.37	<0.001	0.15	<0.0001	<0.001	<0.001	0.002	<0.001	<0.0001	<0.001	<0.001	<0.01	0.001	0.3
2134886	Gneiss	6	0.53	<0.001	0.15	<0.0001	<0.001	<0.001	0.002	0.001	<0.0001	<0.001	<0.001	<0.01	0.001	1.0
2131103	Gneiss	6	0.93	<0.001	0.15	<0.0001	<0.001	0.01	0.003	0.002	<0.0001	<0.001	<0.001	<0.01	0.001	0.8

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