Earth & Environmental Science 2019 v1.3

IA2 mid-level annotated sample response

August 2018

Student experiment (20%)

This sample has been compiled by the QCAA to assist and support teachers to match evidence in student responses to the characteristics described in the instrument-specific marking guide (ISMG).

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of the use of renewable or non-renewable resources to modify experimental methodologies and process primary data
3. analyse experimental evidence about the use of renewable or non-renewable resources
4. interpret experimental evidence about the use of renewable or non-renewable resources
5. investigate phenomena associated with the use of renewable or non-renewable resources through an experiment
6. evaluate experimental processes and conclusions about the use of renewable or non-renewable resources
7. communicate understandings and experimental findings, arguments and conclusions about the use of renewable or non-renewable resources.

Note: Objective 1 is not assessed in this instrument.

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Instrument-specific marking guide (ISMG)

Criterion: Research and planning

Assessment objectives

2. apply understanding of the use of renewable or non-renewable resources to modify experimental methodologies and process primary data
5. investigate phenomena associated with the use of renewable or non-renewable resources through an experiment

The student work has the following characteristics:	Marks
• informed application of understanding of the use of renewable or non-renewable resources to modify experimental methodologies demonstrated by – a considered rationale for the experiment – justified modifications to the methodology • effective and efficient investigation of phenomena associated with the use of renewable or non-renewable resources demonstrated by – a specific and relevant research question – a methodology that enables the collection of sufficient, relevant data – considered management of risks and ethical or environmental issues.	5–6
• adequate application of understanding of the use of renewable or non-renewable resources to modify experimental methodologies demonstrated by – a reasonable rationale for the experiment – feasible modifications to the methodology • effective investigation of phenomena associated with the use of renewable or non-renewable resources demonstrated by – a relevant research question – a methodology that enables the collection of relevant data – management of risks and ethical or environmental issues.	3–4
• rudimentary application of understanding of the use of renewable or non-renewable resources to modify experimental methodologies demonstrated by – a vague or irrelevant rationale for the experiment – inappropriate modifications to the methodology • ineffective investigation of phenomena associated with the use of renewable or non-renewable resources demonstrated by – an inappropriate research question – a methodology that causes the collection of insufficient and irrelevant data – inadequate management of risks and ethical or environmental issues.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis of evidence

Assessment objectives

2. apply understanding of the use of renewable or non-renewable resources to modify experimental methodologies and process primary data
3. analyse experimental evidence about the use of renewable or non-renewable resources
5. investigate phenomena associated with the use of renewable or non-renewable resources through an experiment

The student work has the following characteristics:	Marks
• appropriate application of algorithms, visual and graphical representations of data about the use of renewable or non-renewable resources demonstrated by correct and relevant processing of data • systematic and effective analysis of experimental evidence about the use of renewable or non-renewable resources demonstrated by − thorough identification of relevant trends, patterns or relationships − thorough and appropriate identification of the uncertainty and limitations of evidence • effective and efficient investigation of phenomena associated with the use of renewable or non-renewable resources demonstrated by the collection of sufficient and relevant raw data.	5–6
• adequate application of algorithms, visual and graphical representations of data about the use of renewable or non-renewable resources demonstrated by basic processing of data • effective analysis of experimental evidence about the use of renewable or non-renewable resources demonstrated by − identification of obvious trends, patterns or relationships − basic identification of uncertainty and limitations of evidence • effective investigation of phenomena associated with the use of renewable or non-renewable demonstrated by the collection of relevant raw data.	3–4
• rudimentary application of algorithms, visual and graphical representations of data about the use of renewable or non-renewable resources demonstrated by incorrect or irrelevant processing of data • ineffective analysis of experimental evidence about the use of renewable or non-renewable resources demonstrated by − identification of incorrect or irrelevant trends, patterns or relationships − incorrect or insufficient identification of uncertainty and limitations of evidence • ineffective investigation of phenomena associated with the use of renewable or non-renewable resources demonstrated by the collection of insufficient and irrelevant raw data.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Interpretation and evaluation

Assessment objectives

4. interpret experimental evidence about the use of renewable or non-renewable resources
6. evaluate experimental processes and conclusions about the use of renewable or non-renewable resources

The student work has the following characteristics:	Marks
• insightful interpretation of experimental evidence about the use of renewable or non-renewable resources demonstrated by justified conclusion/s linked to the research question • critical evaluation of experimental processes about the use of renewable or non-renewable resources demonstrated by – justified discussion of the reliability and validity of the experimental process – suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence.	5–6
• adequate interpretation of experimental evidence about the use of renewable or non-renewable resources demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of experimental processes about the use of renewable or non-renewable resources demonstrated by – reasonable description of the reliability and validity of the experimental process – suggested improvements and extensions to the experiment that are related to the analysis of evidence.	3–4
• invalid interpretation of experimental evidence about the use of renewable or non-renewable resources demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of experimental processes about the use of renewable or non-renewable resources demonstrated by – cursory or simplistic statements about the reliability and validity of the experimental process – ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and experimental findings, arguments and conclusions about the use of renewable or non-renewable resources

The student work has the following characteristics:	Marks
• effective communication of understandings and experimental findings, arguments and conclusions about the use of renewable or non-renewable resources demonstrated by – fluent and concise use of scientific language and representations – appropriate use of genre conventions – acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and experimental findings, arguments and conclusions about the use of renewable or non-renewable resources demonstrated by – competent use of scientific language and representations – use of basic genre conventions – use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

Task

Context
You have completed the following practicals in class: • Model location, exploration and extraction of a metallic resource. Use a locality map to predict the location of a metallic resource (suggested practical). • Analyse and interpret geophysical and geochemical exploration datasets (mandatory practical). • Design and conduct experiments to model other separation or processing techniques (e.g. crushing, smelting and froth flotation, gravitational separation) (suggested practical). • Conduct an experiment to model turbidity management strategies, using settling ponds (mandatory practical). • Investigate the effect of slope/revegetation on the volume of water run-off and amount of topsoil lost through erosion (suggested practical).
Task
Modify (i.e. refine, extend or redirect) an experiment in order to address your own related hypothesis or question. You may use a practical performed in class, a related simulation or another practical related to Unit 3 (as negotiated with your teacher) as the basis for your methodology and research question.

Sample response

Criterion	Marks allocated	Result
Research and planning Assessment objectives 2, 5	6	5
Analysis of evidence Assessment objectives 2, 3, 5	6	4
Interpretation and evaluation Assessment objectives 4, 6	6	3
Communication Assessment objective 7	2	2
Total	**20**	**14**

The annotations show the match to the instrument-specific marking guide (ISMG) performance-level descriptors.

Key: Research and planning | Analysis of evidence | Interpretation and evaluation | Communication

Note: Colour shadings show the characteristics evident in the response for each criterion.

Research and planning [5–6]

a considered rationale for the experiment

The rationale contains evidence of a logical, scientifically informed basis for the experiment.

Student experiment

How does the slope of the ground affect erosion?

Rationale

The relationship between runoff, soil erosion and the gradient of land surface is not well understood (Fang, Sun and Tang, 2014). Runoff is defined as water that flows over land rather than infiltrating into it (Tarbuck, Lutgens, and Tasa, 2016). Soil erosion is defined as the movement of particles of soil, surface sediments and rocks by the action of water and or wind. The rate of soil erosion can be affected by:

- size and velocity of raindrops
- permeability of the soil
- soil particle size and shape
- slope angle
- exposure and vegetative cover.

(Hubble, Huxley, Imlay-Gillespie, 2011), (Moore and Burch, 1986).

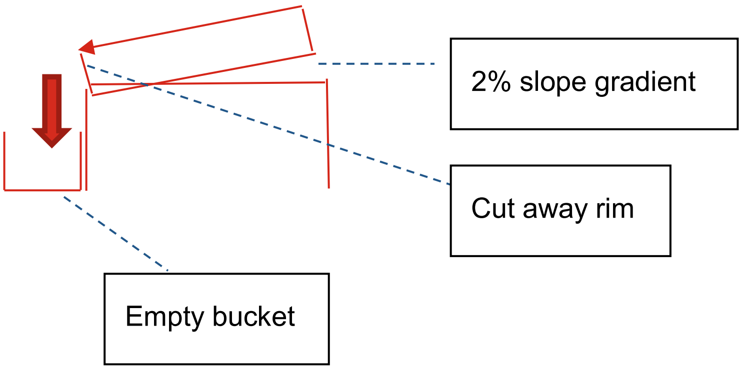
Rainfall erosivity is a term that is used to describe the potential for soil to be washed off from disturbed, de-vegetated areas and move with surface waters during storms (Soil and Water Conservation Engg, 2013). Rainfall erosivity and subsequent runoff are highly related to soil loss. Soil erosion by running water occurs where the intensity and duration of rainstorms exceeds the capacity of the soil to allow the rainfall to infiltrate the soil (Murty and Jha,1985).

Provides a reason for conducting the experiment. Provides reasons for modifying the original experiment. **Research and planning [3–4]** **a relevant research question** The research question is connected to the rationale and allows the effective investigation of Unit 3 Topic 1. However, the response does not specifically identify the independent variable or the dependent variable. **Research and planning [5–6]** **justified modifications to the methodology** The response gives sound reasons for how the modifications to the methodology will refine, extend or redirect the original experiment.	Rehman et.al (2015) conducted an experiment to assess runoff and sediment losses under different slope gradients (1,5 and 10%). They found that there was a positive correlation between increasing the slope and the volume of water runoff and soil eroded from the slope. The purpose of conducting this experiment is to refine Rehman's experiment by investigating the effect of slope gradients (2, 4, 6, 10, and 12%) on the amount of soil loss. It is expected that modifying Rehman's experiment by increasing the number of slope gradients investigated will provide information that can be used to refine Rehman's results to determine a specific mathematical model for the positive correlation established by the original experiment. Mathematical models demonstrate greater validity when more accurate data is available to verify the model (Robinson,1997). This experiment will also extend Rehman's experiment by investigating a larger range of slopes than Rehman. It is expected that by increasing the range of slope gradients to be investigated (2-12%), the positive correlation established by Rehman will be tested beyond the parameters of the original experiment (1-10%). This will help broaden the possible application of this model to environments with greater than 10% slope gradients. **As such, the research question to be investigated is:** How does the slope of the ground affect erosion? **Modification to experiment methodology** The specific modifications to Rehman's original experiment are as follows:

Modification to experiment methodology

Table 1: Modification to experiment methodology

Modification* to Rehman's experiment	Reason why this modification will refine or extend the original experiment
Double the number of slope gradients investigated from 3 to 6 (e.g. Diagram 1)	Mathematical models demonstrate greater validity when more accurate data is available to verify the model (Robinson,1997). By using 6 points of data rather than 3, a more valid mathematical model will be able to be generated.
Extend the range of slope gradients investigated up to 12%	Rehman's experiment found that a proportional relationship existed between the slope gradient and the mass of soil collected. By extending the range of slope gradients, this experiment will establish whether or not the proportional relationship is maintained on steeper slopes.

	Diagram 1: Experimental set up for a 2% slope gradient 
Research and planning [5–6] **considered management of risks and ethical or environmental issues** The response shows careful and deliberate identification and planning to handle risks and ethical or environmental issues in the experiment.	

Management of risks

During the planning of the methodology for this experiment, some risks were identified. The risks and their associated management strategies are outlined below:

Table 2: Management of risks

Risk identified	Management strategy
The bags of soil are heavy and need to be lifted	The correct lifting technique must be used to minimise stress on the lower part of the back.
Particles of soil may be flicked into a person's eye	Safety glasses must be worn at all times
Water spills on the floor	A visual check must be made after each trial to ensure that the floor is dry. Rubber soled footwear will also prevent any slip

Raw data

Qualitative Data

Table 3: Observations of water runoff and soil erosion.

Trial	Observations
1.	There was an obvious difference in the time the water took to first reach the bottom of the tray for each of the different slopes. The water trickled down the 2% slope compared to the 12% slope where it seemed to almost run straight along the slope with very little water infiltrating into the soil. There appeared to be some initial crusting starting to form on the lower 2 slopes (i.e. 2 & 4%) after the first 5 minutes. Soil was washed off all trays but there appeared to be a greater mass of sediment in the buckets for the 10 and 12% slopes compared to the rest.
2.	Initial results were similar to the first repetition, but with the addition of small rills occurring in the trays with the higher slopes. There appeared to be a greater crusting effect for the 2-6% slopes with the area increasing for each tray compared to the first repetition. Trays with larger slopes again appeared to have greater soil sediment in the bottom of the collecting bucket after deposition.
3.	Very similar observations to trials 1 and 2

Research and planning [5–6]

a methodology that enables the collection of sufficient, relevant data

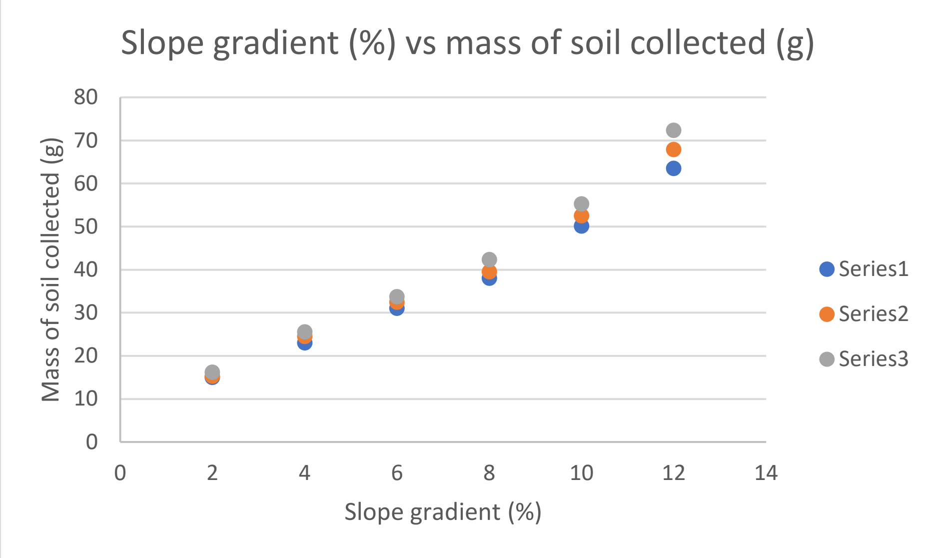
The methodology shows careful and deliberate thought. It enables collection of adequate data so an informed conclusion to the research question can be drawn.

Quantitative Data (Raw data)

Table 4: Mass of soil collected across three separate trials with respects to slope gradient

Slope gradient (%)	Mass (g) of Soil collected in runoff (±0.1g)		
	Trial 1	Trial 2	Trial 3
2	15.0	15.3	16.2
4	23.0	24.5	25.5
6	31.0	32.4	33.7
8	38.0	39.5	42.3
10	50.1	52.5	55.2
12	63.5	67.9	72.3

Annotations	Response
Analysis of evidence [5–6] **collection of sufficient and relevant raw data** The raw data is adequate for forming a conclusion and has direct bearing upon the research question. Five variations of the independent variable and three repetitions of each measurement are adequate.	**Graph 1:** Raw data of mass of soil collected across three separate trials with respects to slope gradient.



Processed data

Communication [2]

appropriate use of genre conventions

The response follows scientific conventions of units and significant figures.

Quantitative Data (Processed data)

Table 5: Mass (g) of soil in runoff water for different slope gradient (cm)

Slope gradient (%)	Mass of Soil collected in runoff (± 0.1g)			Average mass of soil (g)
	Trial 1	Trial 2	Trial 3	
2	15.0	15.3	16.2	15.5
4	23.0	24.5	25.5	24.3
6	31.0	32.4	33.7	32.4
8	38.0	39.5	42.3	39.9
10	50.1	52.5	55.2	52.6
12	63.5	67.9	72.3	67.9

Analysis of evidence [3–4]

basic processing of data

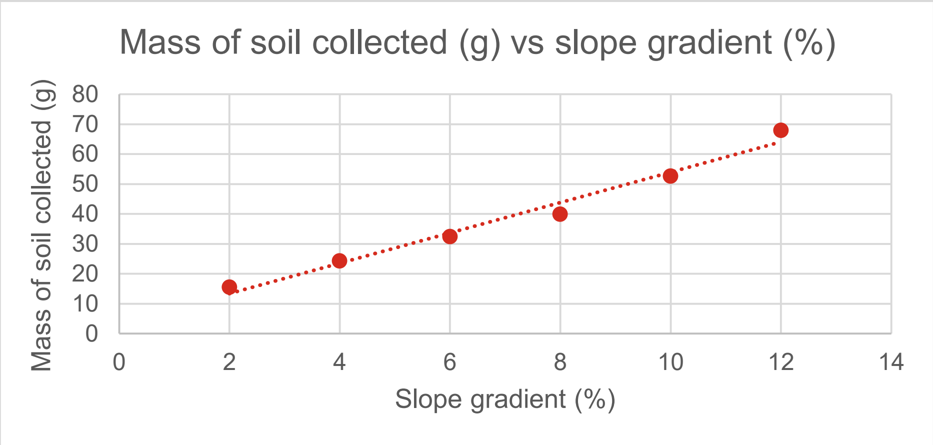
The mean of each set of trials has been calculated. However, the uncertainties associated with these means have not been calculated.

Processed data: sample calculations

Average values in **Table 3**.

Average soil mass for the 2% slope: $\frac{(15.0+15.3+16.2)}{3}$ g

= 15.5 g

Communication [2] **appropriate use of genre conventions** The response follows scientific conventions of the construction of graphs. **Analysis of evidence [3–4]** **identification of obvious trends, patterns or relationships** The response recognises a clearly evident pattern. However, this analysis is not thorough, as some relationships that are applicable to the research question (e.g. the equation of the line) have not been recognised. **basic identification of uncertainty and limitations of evidence** The response shows fundamental consideration of the impact of measurement uncertainty. However, measurement uncertainty has not been appropriately quantified. The response shows fundamental consideration of the experiment's limitations.	# Analysis of data Graph 2: Mass of soil collected with respects to slope gradient.  Graph 2 suggests a linear relationship between the slope gradient and the mass of soil collected. This suggests that as the gradient of the slope increases, there is a directly proportional increase in the amount of soil that is eroded from the surface due to runoff. Graph 1 shows that there was a small amount of variation in results between trials. Graph 2 shows that line of best fit does not fall on all of the data points. This means that there is some uncertainty and limitations to the data. It should be noted that this model is limited to exposed slopes where there is no ground cover, and a single rain event occurs. The limitation of the model is due to the limitations of the data collected. Data was not collected on slopes with rocks, roots, grass or trees present. Further, data was collected on a slope that was uncompacted and dry before a 'rain' like event.

Interpretation and evaluation [3–4]		Interpretation and evaluation [1–2]
reasonable conclusion/s relevant to the research question The conclusion is based on sound judgment and stated in terms of the research question, but does not directly refer to evidence. **suggested improvements and extensions to the experiment that are related to the analysis of evidence** The suggested improvements would improve the validity and reliability of the experiment. However, the response does not use evidence to inform the modifications. The suggested extensions address the limitations of the experiment. However, the response does not address the limitations identified in the analysis.	**Interpretation and evaluation** The evidence suggests a direct relationship between erosion and slope. This experiment has number of sources of random error that caused the results to vary from one trial to another. A number of steps could be taken to improve the experiment: • The initial soil level should be below the level of the rim of the tray. • The process of separating all the soil washed into the container from the runoff water could be refined. • Set up a raindrop shower over the top of the tray with the correct volume. The experimental method is valid because it answered the research question. Further investigation could look at: • extending the range of the experiment to look at soil loss at higher slopes • extending the length of slope in a controlled environmental setting. In conclusion, the results from this experiment help to conditionally answer the research question and support earlier work by Rehman (2015). It would appear that areas with bare soil on steeper slopes will result in greater amount of soil erosion due to greater runoff during rainfall events. This will have implications for managing areas devoid of vegetation in urban and agricultural settings. Word count: 1639	**cursory or simplistic statements about the reliability and validity of the experimental process** The statement about reliability gives little attention to the details of the experiment. The statement about validity is oversimplified. **Communication [2]** **fluent and concise use of scientific language and representations** Throughout the response, any errors in the use of scientific language do not hamper the reader from easily understanding the intended meaning. The response avoids unnecessary repetition of information and is within the prescribed length, i.e. 1500–2000 words.

Communication [2] **acknowledgment of sources of information through appropriate use of referencing conventions** The sources of information are acknowledged using a referencing style that is suitable for the purpose of the scientific report.	

References

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