2023 VCE Environmental Science external assessment report

General comments

The Environmental Science examination includes a variety of questions that require students to have a clear understanding of key terms and concepts, to be able to state these correctly, and to apply them to a specific issue. Other questions in this paper ask students to apply their environmental science knowledge to particular scenarios. In both cases, students needed to make sure they responded to the specific question and answered the question directly. For example, in Section B, Question 3c. students were required to state, within the table provided, two economic costs and two benefits related to the environmental water allocations to the billabong. The term 'economic' is in both the question stem and the title of the table; however, many of the answers given were not specifically economic benefits or costs (many incorrect answers were environment-based). Therefore, students need to carefully read the stem of the question and respond with issue asked for.

Some questions require one example (such as Questions 7a. or 8b.), and with these types of questions students should give a clear single idea rather than provide a few possible options or points. For example, some students wrote 'thermal and potential' in the box labelled 'steam' in Question 7a. about geothermal energy production. When multiple answers are given, assessors are not permitted to try to sort through a list of points or ideas and find one that is correct. Therefore, students need to consider their response and focus on what they consider to be the best single answer.

Although not common, some students provided incorrect ideas about the hole in the ozone layer and ultraviolet radiation causing global warming, or simplistic explanations around greenhouse gases being a blanket that keeps Earth warm, or simply said that heat can't escape Earth. Understanding the specific scientific role that greenhouse gases have in the atmosphere, including the interactions involving different forms of solar energy, is key knowledge (as listed on page 38 of the study design). It is expected that students have a correct understanding of the role re-radiated infrared radiation plays in global warming and how greenhouse gases, particularly carbon dioxide, absorb and re-emit shorter infrared wavelengths. This includes the knowledge that it is visible light being absorbed by Earth's surface and re-radiated as infrared radiation that mainly interacts with these greenhouse gas molecules in the atmosphere.

Students' understanding of key terms related to scientific data and measurement (page 16 of the study design) varied greatly across the responses to this examination. Precision, accuracy and validity were often confused, and Question 8f. about reproducibility was not well answered. Not only are students expected to be able to explain these terms, but they also need to be able to apply them correctly to different scientific experiments and investigations. Students should try to study examples of different scientific investigations and fieldwork. By considering how these key terms relate to different examples, they could improve their use and understanding of these terms.

Specific information

This report provides sample answers, or an indication of what answers may have been included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

The statistics in this report may be subject to rounding, resulting in a total of more or less than 100 per cent.

Section A

The table below indicates the percentage of students who chose each option. Grey shading and bold text indicate the correct answer.

Question	Correct answer	% A	% B	% C	% D	% No answer	Comments
1	D	4	1	22	**73**	0	The difference between bioaccumulation (which occurs as toxin levels accumulate within the bodies of organisms within one trophic level) and biomagnification (which occurs as toxin levels increase in higher trophic levels of the food chain) is correctly outlined in option D. Given that both involve toxin levels, some students incorrectly chose option C.
2	C	6	7	**86**	1	0	
3	B	12	**68**	9	11	0	Students who did not have a clear understanding of the meaning of 'background extinction rate' chose one of the three incorrect options rather than the correct answer, option B. To fully understand changes in the rate of extinction and mass extinctions, students must be aware that not all extinctions are due to human causes and that there is a 'normal' or background extinction rate. This refers to the number of species that would be expected to become extinct over a period of time, based on non-anthropogenic factors.
4	C	3	4	**80**	13	0	
5	A	**91**	3	4	2	0	
6	C	3	26	**67**	4	0	A correct understanding of the conservation category 'near threatened' and how it is placed within the classification hierarchy enabled students to correctly select option C. Some students incorrectly chose option B even though there is no indication in the information provided that the eel will become endangered in the near future. If population numbers did reduce, it would be firstly classified as vulnerable (the next category level).
7	A	**95**	1	1	3	0	
8	C	13	4	**62**	20	0	Cement production is a major emitter of the greenhouse gas carbon dioxide. The graph shows that carbon dioxide levels from cement production were relatively low and stable from around 1930 to 1945. When World War II finished in 1945, there was a rapid increase in population and construction that required cement to be manufactured (option C). Some students incorrectly

Question	Correct answer	% A	% B	% C	% D	% No answer	Comments
							chose option D, thinking that the basic process of making cement has changed. The basic process of heating crushed limestone rock in a high-temperature kiln to produce the 'clinker' material used in cement hasn't changed, but it is this heating that produces large quantities of carbon dioxide.
9	A	**87**	6	3	4	0	
10	D	16	4	7	**73**	0	Most students correctly understood the concept of 'greenhouse gas warming potential' and the use of carbon dioxide as a reference point to enable a comparison of the impact of different greenhouse gases in the atmosphere (by comparing how much energy one tonne of a gas will absorb compared to one tonne of carbon dioxide), as described in option D. The most common incorrect answer was option A – the amount of energy absorbed and stored by a carbon dioxide molecule is not quantified by a warming potential value, which is a relative measure.
11	D	3	20	3	**74**	0	
12	C	0	59	**38**	1	0	Students had difficulty in answering this question correctly. The focus of the question was on interpreting the graph between 1980 and 1990, which showed that while there was some relationship between precipitation and tree ring growth (particularly between 1981 and 1983), it was not the only variable affecting ring width (option C). Many students incorrectly chose option B, but the graph does not indicate that tree ring width always increases with precipitation (as shown between 1983 and 1985).
13	D	20	6	9	**65**	0	As stated in the general comments section of this report, there is a difference in the clarity of understanding around the interactions of solar energy, the atmosphere and the surface of Earth. Students should understand that visible light is absorbed by Earth's surface and re-emitted as infrared radiation (option D). It is not 'reflected' as infrared (option A), which many students incorrectly chose.
14	A	**69**	7	10	13	0	Students either understood the meaning of the albedo effect and how it is scored and chose option A correctly or did not understand the way it is scored and picked one of the other three incorrect options. Students should be aware that albedo is scored between zero and one. A perfectly reflective surface would get an albedo score of 1, while a completely dark object (which absorbs radiation) would have an albedo score of 0. If a surface has a high albedo score (i.e., closer to 1) then it would reflect more energy and lead to cooling (and vice versa).
15	C	12	4	**31**	52	1	The generation, use and limitations of climate models were not well understood. Climate scientists continue to develop their models in the desire to help make more accurate projections of future climates, but are limited by the power of computers to process all the data and simulate climate complexities. Many

Question	Correct answer	% A	% B	% C	% D	% No answer	Comments
							students incorrectly chose option D. Climate models try to consider atmospheric patterns and systems as well as variables related to ocean patterns and land cover changes. These factors are all interrelated.
16	B	3	**90**	1	7	0	
17	D	0	11	12	**77**	0	
18	D	15	1	35	**47**	1	The distinction between explanations of the principle of 'conservation of biodiversity and ecological integrity' in the four options needed to be considered. This principle considers the protection of species and ecosystems, but also requires consideration of the need to enhance the quality of ecosystems to provide for the needs of future generations (option D). The sustainability principle requires us to do more than simply protect what we have or maintain species diversity at current levels (given that the rate of species extinction and ecosystem disturbance due to human causes is increasing).
19	C	21	8	**67**	3	1	The calculation of population size using the mark-recapture technique required students to use the formula 'N (estimated number of individuals) = M × C / R', where M is the number of individuals first caught and marked, C is the number of individuals caught the second time and R is the number recaptured with the mark. Therefore, the size of the skink population would be calculated by multiplying 32 by 52 then dividing by 16, which is 104 (option C). Students who did not correctly apply the formula seemed to pick option A (obtained by adding 32 and 52).
20	A	**97**	2	1	1	0	
21	C	20	16	**61**	2	1	Some students had difficulty with this energy calculation. The final energy consumption from black and brown coal was 1661 petajoules in 2020–2021. Because the efficiency was only 30%, the amount of energy required as an input was 5537 petajoules (option C). To get this figure, 1661 was multiplied by 100 and then divided by 30.
22	B	14	**71**	3	12	0	
23	C	9	22	**59**	9	1	Since the first law of thermodynamics states that energy cannot be created or destroyed, and can only be converted from one form to another, option C is the correct answer. Due to the differential heating of Earth's surface by solar radiation, differences in air pressure are created. The movement of this air due to the imbalance of air pressure creates wind.
24	A	**84**	9	6	1	0	
25	D	2	6	11	**81**	0	

Question	Correct answer	% A	% B	% C	% D	% No answer	Comments
26	C	6	5	**79**	8	1	.
27	A	**75**	3	15	5	1	
28	B	4	**62**	9	24	1	The concept of 'uncertainty' is the reason for the scientific use of the ± (plus or minus) symbol that follows the reported value of a measurement and the numerical quantity that follows this symbol. It allows a scientist to indicate the range of values in which the true value is expected to lie (option B). It is not used to eliminate systematic errors (option D), which some students incorrectly chose.
29	B	1	**93**	4	2	1	
30	B	19	**66**	8	7	1	The data generated by the students was primary data that they collected firsthand (option B) but was not qualitative (option A). Understanding and using terms relevant to scientific data, including its measurement, collection and analysis, is important for students studying VCE Environmental Science.

Section B

Question 1

The focus of the first question was on biodiversity issues in a small area near the Daintree Rainforest and the use of Simpson's Index of Diversity (SID). Rather than a specific SID calculation using data, the question required an understanding of how the index is calculated and what the index indicates about species diversity.

Question 1a.

Mark	0	1	2	Average
%	14	26	60	1.5

Correct answers listed the two pieces of data needed to calculate SID – the number of different species (species richness) and the number of individual organisms (species abundance). Students generally correctly identified both measurements.

Question 1b.

Mark	0	1	Average
%	61	39	0.4

Students who had an understanding of how the index is calculated were able to state that 'N' in the formula represents 'the total number of individuals or organisms'. The question was not well answered, and many students incorrectly stated 'the total number of species'.

Question 1c.

Mark	0	1	Average
%	45	55	0.6

A clear understanding of what the index value means allowed many students to correctly circle 'Lower'. If there is dominance of one particular species rather than a wider variety of species, there will be less diversity at the site. The final calculated SID value will be a figure between 0 and 1. A figure that is closer to zero (i.e., lower) indicates a lower species diversity.

Question 1d.

Mark	0	1	2	3	4	Average
%	23	23	25	22	7	1.7

The question asked about a practical technique for assessing species diversity, specifically the edge effect in relation to quadrat sampling, based on a key knowledge point on page 32 of the study design. The more common approach discussed the implications related to deciding whether or not a species on the edge or border of a quadrat should be included in that sample. A broader approach related to quadrats placed on or near the boundary of one habitat and another. This 'edge effect' relates to the changes in population characteristics or community structures that occur at the boundary of two habitats.

Either approach required an explanation of how this may specifically impact the accuracy of the quadrat sampling, and what accuracy means (i.e., how close the diversity calculation generated by this quadrat data is to the 'true value' of species diversity). Better answers defined both terms clearly and discussed the impact of counting all species that cross the boundary of the quadrat in the sampling (i.e., the species diversity calculated from this data might be higher than the actual value). To overcome this issue, students identified methods that could be used to address this in sampling, such as using larger circular quadrats (which reduces the edge-to-volume ratio) or having a clear criterion to follow when sampling (e.g., only count the plant if more than half is within the quadrat).

Question 1e.

Mark	0	1	2	Average
%	42	15	43	1

In this question fundamental mathematical concepts were required to carry out basic calculations involved in the use and understanding of scientific data. The change in the percentage of plant coverage is calculated by subtracting the initial number of hectares from the final, dividing this number by the initial number of hectares, and then multiplying this quotient by 100. To show working, correct answers were:

$$27 - 19 = 8 \text{ hectares} \qquad 8/19 \times 100 = 42.1\%$$

Question 1f.

Mark	0	1	2	Average
%	16	25	59	1.5

Most students were able to explain a plant restoration strategy that may have been used to increase the vegetation coverage on the Kurranji Babu. Better answers described replanting strategies that involved removing invasive weed species or using controlled burning to encourage the regrowth of endemic plants. Other clear answers described developing wildlife corridors to join the isolated patches of remnant vegetation. The focus of answers needed to be on explaining one plant restoration strategy; simple answers that identified 'protecting or conserving the area' did not meet this requirement.

Question 2a.

Mark	0	1	2	3	Average
%	7	28	50	15	1.8

Many students found it difficult to fully answer this question. Complete answers identified the specific issues related to fragmentation and considered this in relation to the specific behaviour of the female mice. They explained why the erosion of hills and vegetation had fragmented suitable areas of pebbles and was therefore a risk to the population of eastern pebble-mound mice. Lower-scoring answers did not focus on the loss of pebble mounds (due to the spread of sandy areas) or did not consider the fact that female offspring only travel short distances and therefore would not be able to disperse to mounds further away. If female mice cannot find suitable areas with pebbles and mounds in which to breed, there is likely to be a reduction in population size.

Question 2b.

Mark	0	1	2	Average
%	47	28	25	0.8

This question was based on a specific key knowledge point on page 32 of the study design and was one of the least successfully answered questions on this year's examination paper. Three factors should be considered when qualitative assessment of conservation status is being undertaken to identify species in need of conservation action: changes in (1) availability of suitable habitat; (2) geographic distribution; and/or (3) population size. Students needed to identify one of these indicators and give a relevant description of how it relates to the eastern pebble-mound mouse situation. Many of the stronger answers described the change (decrease) in suitable habitat availability, with the loss of suitable vegetation and pebble mounds as an indicator that the need to conserve the population was increasing.

Question 2c.

Strategy 1

Mark	0	1	2	Average
%	21	24	54	1.3

Strategy 2

Mark	0	1	2	Average
%	31	22	48	1.2

Most students were able to develop at least one suitable strategy to reduce the risk of extinction for the pebble-mound mouse. Two ideas were required, and the concept of captive breeding was not accepted given the statement in the question stem. The better answers focused on the specific threat to this particular species, which was clearly the loss of suitable habitat and breeding sites. Management strategies that addressed habitat loss included: erosion prevention and control by stabilising sand and revegetation; the creation of pebble mounds to allow for litters to be raised; translocation to a suitable habitat with similar hills and vegetation with access to pebbles; or the establishment of wildlife corridors (including pebble mounds) to allow females to travel and breed, increasing genetic diversity. Answers that focused on other potential threats that weren't specified (such as food loss and predators) were less successful in obtaining marks.

Question 3a.

Mark	0	1	2	3	Average
%	19	28	37	15	1.5

Having considered the information provided in the question stem, students needed to apply their knowledge of the two sustainability principles listed to the issues raised in the scenario. Less successful answers stated straightforward definitions of 'efficiency of resource use' and 'intergenerational equity'. Better answers were able to discuss them in context and apply them to the environmental water allocations, billabong and river. For instance, they explained the concept of efficiency of resource use with the example of using suitable amounts of water (not wasting it) to maintain the long-term ecological health of the billabong ecosystem while minimising any impact on the Wimmera River of removing this water. The concept of intergenerational equity was discussed in context. For example, they highlighted the need to preserve the natural resources of the 'Ranch and Billabong' site, including the river red gums, fish and sneezeweed, and maintain this environment

for the benefit of the current generation of users while also making sure it stays in a suitable state for future generations, including the Wotjobaluk peoples. The most successful answers also considered the use of the Wimmera River (not just the billabong) in providing for current and future generations to access the water sustainably for drinking, farming and so on, as well as for recreation.

Question 3b.

Mark	0	1	2	3	Average
%	18	14	51	17	1.7

Most students were able to identify separate ecological and sociocultural dimensions included in the management plan for the 'Ranch and Billabong' site. Few students were able to provide a complete response, which included a description of the relationship between these two dimensions. The management plan considered the link between these two factors – restoring and supporting the health of the ecosystem would improve sociocultural aspects for the community.

Question 3c.

Mark	0	1	2	3	4	Average
%	15	24	32	15	14	1.9

Many students were able to provide two clear economic costs (such as the cost involved in providing the infrastructure for moving water to the billabong), but less successful responses gave a variety of non-economic benefits. Relevant economic benefits included the potential jobs for the Indigenous community working in education at the site or the boost to the local economy from tourists visiting the restored site.

Question 3d.

Mark	0	1	2	Average
%	8	52	40	1.3

Acceptable answers focused on the fact that, as the traditional owners, the Wotjobaluk peoples hold native title to this area and also have a longstanding connection to, and understanding of, these lands. This deep knowledge and understanding of the environment should form part of the management process, and as key stakeholders they have an important voice in the decision-making process. Responsible decision-making requires the consideration of different perspectives from a variety of key stakeholders and the incorporation of these views into an effective, balanced management plan.

Question 4a.

Mark	0	1	2	Average
%	10	20	70	1.6

Most students were able to identify and correctly describe one of the reasons that climate change is causing sea levels to rise globally. Some students mentioned both reasons, but a clear explanation of only one was required. They either correctly explained that as ocean temperatures have increased due to global warming, sea levels have risen due to thermal expansion, or that the melting of land-based ice (i.e., glaciers, ice caps and ice sheets) has added more water to the oceans. Incorrect answers did not specifically mention land-based ice and only mentioned sea ice or icebergs melting (which does not add significantly to the sea level

because they are already in the water, and the volume of water they displace as ice is about the same as the volume they displace when melted).

Question 4b.

Mark	0	1	2	Average
%	9	41	50	1.4

Students varied in their understanding of how sea level data could be used to assist management. Better answers were able to clearly make the link between using data to assess the rate of sea level changes (based on comparisons with past data) and using this to plan for effective management decisions or implement actions to address future impacts.

Question 4c.

Mark	0	1	2	Average
%	19	55	26	1.1

Many students did not clearly understand the process of determining climate projections (and what climate projections are). To develop climate projections, scientists collect multiple sources of current and historical climate data, which are then used in computer models to generate predictions of climate patterns or to determine the likelihood of various climate events occurring in the future.

Question 4d.

Mark	0	1	2	Average
%	8	15	77	1.7

Most students answered this question well. Clear responses identified that the council would likely prioritise a combination of economic and social needs, including tourism, infrastructure, insurance, and health and safety, while aiming to protect the environment as much as possible, whereas the local environmental group would prioritise protecting the local species and habitats.

Question 5a.

Mark	0	1	Average
%	37	63	0.7

Most students were able to provide a clear, simple statement that highlighted that the natural greenhouse effect maintains a habitable temperature which allows life to exist on Earth.

Question 5bi.

Mark	0	1	2	3	4	Average
%	2	4	46	17	32	2.8

Most students were able to place their answers in the table and correctly identify that the amount of carbon dioxide in the atmosphere has increased, and that this is due to the growth of industrialisation and the

burning of fossil fuels as an energy source. However, many students had difficulty with the first row of the table, incorrectly stating that the amount of water vapour had stayed the same due to the natural water cycle not changing. Levels of water vapour have increased in the atmosphere since industrialisation began due to increasing temperatures causing greater evaporation.

Question 5bii.

Mark	0	1	2	Average
%	13	77	10	1.0

The increase in carbon dioxide concentration results in a higher average global temperature. Most students were able to correctly make this connection. The 'how' part was less well understood, and many students had difficulty in explaining how carbon dioxide absorbs and then re-emits infrared radiation in the atmosphere.

Question 5c.

Mark	0	1	2	3	Average
%	16	34	40	11	1.5

It was acceptable to present a case for either of the options based on explanations related to their effectiveness in reducing net carbon dioxide. Understanding the carbon cycle was a key basis for good answers. Students could argue that protecting the old growth forest and not developing it for housing (option two) would allow photosynthesis to continue, thereby absorbing carbon dioxide from the atmosphere and not producing carbon dioxide during the building phase. The forest acts as a carbon store and clearing it would release this. Others argued that establishing a plantation forest in a previously unforested area (option one) would increase carbon dioxide absorption, as the new, young plants growing in a new area would add to the carbon levels being stored. Clearly justifying why their option was likely to be more effective in meeting the government's targets than the other option was important in receiving full marks.

Question 5d.

Mark	0	1	2	Average
%	19	45	35	1.2

Most students were able to identify at least one technology (other than the use of forests) to reduce atmospheric carbon dioxide levels. Two were required. Suitable responses included: carbon capture and storage in oceans or underground; the creation of artificial sinks in wetlands or water bodies (focused on algae); and changes based on using non-fossil energy sources such as electric vehicles and more efficient electrical appliances.

Question 6a.

Mark	0	1	2	Average
%	7	18	75	1.7

In general, students completed the table correctly, circling non-fossil/renewable for biofuel and fossil/non-renewable for petrol.

Question 6b.

Mark	0	1	2	3	Average
%	39	36	12	13	1.0

Students had difficulty in describing the impact of the production and use of bioethanol on the carbon cycle. Many did not understand that the combustion of bioethanol does produce carbon dioxide (as does the fermentation process). Not many students made the connection that growing sugarcane (the source of bioethanol in this scenario) undergoes photosynthesis, which removes carbon from the atmosphere. A few students were able to explain that as biofuel replaces fossil fuels, more carbon remains stored, or that biofuels are more carbon neutral.

Question 6c.

Mark	0	1	2	Average
%	37	32	31	1.0

A circular economy is one that focuses on achieving sustainable consumption and production, as well as nature-positive outcomes. It refers to the outputs of one process becoming the useful inputs of another (recycling). By keeping materials in use, in this case sugarcane waste, the material becomes an input into the making of bioethanol, thereby reducing waste and reducing reliance on other non-renewable fuels.

Question 6d.

Mark	0	1	2	3	Average
%	30	22	23	25	1.4

Answers to this question varied considerably in quality. The question required a logical response in describing the environmental impacts of accessing/extracting conventional diesel compared to producing biodiesel. Many students understood that diesel is sourced from crude oil that requires drilling/mining to extract it. Drilling can damage natural habitats for wildlife and can lead to oil spills, with major environmental consequences. In contrast, biodiesel is extracted from plant materials (in this case sawmill waste). Therefore, there is a greater level of negative environmental impacts from conventional diesel compared to biodiesel. Students who discussed the use (rather than the extraction or production) of the fuels did not receive marks for this question.

Question 6e.

Mark	0	1	2	Average
%	28	26	46	1.2

Technocentrism is the value system that places importance on technology and industry and supports the idea that humans have control over nature. Environmental problems may exist, but they are seen as problems to be solved using science and technological development. Biofuels were developed scientifically, and this use of technology is combating environmental problems related to waste and energy issues. Students varied in their ability to clearly explain technocentrism and how the development of biofuels aligns with this value system.

Question 7a.

Mark	0	1	2	Average
%	12	45	42	1.3

A variety of energy forms were accepted at the four stages of geothermal energy production shown in the diagram. Answers were potential or thermal (for Earth's core), heat or kinetic (for steam), mechanical or kinetic (for turbine), and electrical (for generator). Common incorrect answers identified steam or geothermal as 'chemical' (whereas most of the heat in the latter comes from the radioactive decay of elements in Earth's core).

Question 7b.

Mark	0	1	2	Average
%	42	40	18	0.8

This question was not well answered, as many students did not correctly address the question. Some incorrect answers did not respond to the focus on 'the amount of energy that leaves the geothermal power plant' and that which 'reaches homes for use'. They incorrectly discussed energy loss during steps from accessing heat energy under the ground and converting it in the power plant. Many other low-scoring answers just stated that the loss of energy was due to the second law of thermodynamics, without explanation. The energy that comes out of the power plant is electricity and this is what reaches the home – it is not converted to another form, although the voltage is changed by transformers in the electrical grid. Better answers explained that as the energy is transported a distance along the power lines in the electrical grid (from the power plant to houses), energy is lost or degraded in the form of heat and sound.

Question 7c.

Mark	0	1	2	Average
%	45	42	13	0.7

The concept of base load was poorly understood by many students. Often, they did not link the idea of base load to a specific time period (i.e. the minimum energy usually required by a community in a 24-hour period). Better answers did this and explained that geothermal energy could provide a constant or reliable energy supply to meet this steady, more predictable energy requirement for the community.

Question 7d.

Mark	0	1	2	Average
%	32	36	31	1.0

Most students understood that the concept of intragenerational equity refers to notions of fairness and justice across the communities and states within the present generation. Answers did not always highlight how the establishment of a new geothermal power plant might impact this principle. Better answers explained how the building of the power plant might result in land being cleared and a loss of natural habitat (including the lagoon), which would negatively impact current generations living in that area. Others explained how using this renewable energy source rather than fossil fuel would have a positive impact on current generations by reducing their carbon footprint, which is a sustainability focus within the broader community.

Question 7e.

Mark	0	1	2	Average
%	9	8	83	1.8

Students were able to identify one relevant stakeholder group and explain why consultation with them would be important. Correct answers often focused on local resident groups, environmental groups, Indigenous communities or energy companies.

Question 8a.

Mark	0	1	2	Average
%	11	13	76	1.7

A hypothesis should be a prediction or proposed explanation of the results expected from the investigation. It should link the two variables: in this case, the level of salinity and the growth of the eucalypts. Better responses clearly stated that if the eucalypt seedlings were watered with high concentrations of saline solution they would not grow as much as those watered with pure water.

Question 8b.

Mark	0	1	2	3	Average
%	8	15	19	59	2.3

Most students were able to correctly identify the dependent variable as the growth of the eucalypt seedlings and the independent variable as the level of salinity in the watering solutions. Some students had difficulty in identifying the controlled variables. Acceptable answers included a constant temperature of 25 °C, a humidity of 55%, or the controlled light levels with a 14-hour day and 10-hour night cycle.

Question 8c.

Mark	0	1	Average
%	36	64	0.7

Most students knew that the incorrectly calibrated ruler was an example of a systematic error. Incorrect answers often suggested it was either a random or human error.

Question 8d.

Mark	0	1	2	Average
%	41	32	26	0.9

Many students confused the concepts of accuracy, validity and precision. They were asked to explain if the student's viewpoint was correct or not, and to clarify the term 'validity'. Validity refers to the experiment still investigating what it set out to (i.e. how the growth rate of eucalypts is affected by watering with different saline solutions). The results are therefore valid (and the student is incorrect) because they still recorded growth, but the measurements were inaccurate.

Question 8e.

Mark	0	1	2	3	Average
%	13	4	31	52	2.2

Using the data from the graphs, most students identified that species B grew better than species A when watered with higher concentrations of salt solution. They compared growth figures taken from the graph and explained that because the farmer's soil had a salinity level equivalent to '9 g/L of NaCl, this would most closely correspond with the results of the eucalypts watered with the 10 g/L solution shown in the graph.

Question 8f.

Mark	0	1	2	3	4	Average
%	42	24	16	11	7	1.2

Students found this question one of the most difficult on the examination paper. This seems to be mainly due to a misunderstanding of the concept of 'reproducibility' and an inability to apply the concept to the scenario presented. Reproducibility as defined in the study design is 'the closeness of the agreement between the results of successive measurements of the same quantity being measured, carried out under different conditions of measurement. These conditions include a different measurement procedure, a different observer, a different measuring instrument, a different location, and a different time period.' It was important to make this meaning clear in discussing issues around the farmer's original measurement of salinity on her property (rather than the student's greenhouse results). Only a few complete answers were able to discuss how the group of students could measure salinity levels again at the farmer's property using 'changed conditions' and get readings to compare with the original measurement of 9 g/L. Two general examples of changed conditions of measurement were required, and could have included using a different method of measurement (e.g. measuring the electrical conductivity of soil); using a different measuring instrument or different testing equipment for salinity; using a different observer (i.e. not the farmer) to record results; testing at a number of different soil locations around the farm; or using a different time scale (e.g. measuring soil salinity every second day). If they used different measurement methods and produced results similar to the farmer's, then they could be said to have shown reproducibility.

Lower-scoring answers wrote about just repeating measurements (i.e. simply doing the same test again and getting the same results, which relates to the concept of 'repeatability') or wrote about eucalypt plants reproducing. Some students incorrectly confused testing for pH with salinity. A detailed knowledge of how to specifically test for salinity was not required as part of the answer.