2025 ASSESSMENT REPORT
ESS315118 ENVIRONMENTAL SCIENCE

General Comments

The written examination was well received by candidates and teachers. Most candidates felt the examination paper was accessible and allowed ample scope for them to demonstrate their knowledge. Teachers appreciated the varying range of complexity in questions from those that assessed basic understanding through to questions that required greater analysis of interrelated concepts, as is the nature of Environmental Science.

In most cases, candidates provided very good answers. Where candidates performed poorly, it was mostly due to inadequate or incorrect detail in their response. Candidates are advised to carefully read the questions, seek out exactly what is being asked of them and make connections to the course content they have covered during the year. This should provide scope for all candidates to attempt all questions.

Candidates are reminded to consider the command words (i.e. list, describe, explain) and highlight them during the reading time. Generally, answer ‘explain’ with the most amount of detail and write in all the space provided.

Candidates can expect questions that have non-routine contexts – these are questions that use geographic areas or scenarios that are not covered in the course content. Candidates should read these questions carefully and identify exactly what is being asked and align this with content they have been taught and construct their response accordingly.

Candidates are reminded that the Information Sheet be used as a reference to assist them in constructing their responses. Responses that are written word-for-word from the sheet reveal little understanding of the required knowledge and often yield little if any credit. Candidates should use the information and apply it to the question. It is also advisable for future candidates to equip themselves with an approved English dictionary, which may prove to be an invaluable asset if terms used in the question challenge their understanding of what is being asked.

The following section specifically comments on candidates’ performance. Markers have offered suggested answers to each question, followed by specific comment on aspects such as how the question was assessed, where candidates gained or lost marks, where they had difficulty in interpreting the question, or where candidates failed to comprehend what was required to successfully answer the question. The suggested answers are by no means prescriptive. Candidates providing different but valid answers were rewarded accordingly as noted by the examiners.

Section A – Criterion 2

Question 1

a.

i. Independent variable: Rainfall or amount of water (½)
ii. Dependent variable: Survival of eucalyptus seedlings (½) OR survival rate of eucalyptus seedling (½).

b. The control group should receive water that models the typical rainfall that the region receives (600 mm/yr) (1). The group should be somewhere between 20 to 100 eucalyptus seedlings, and all seedlings should receive the equivalent of between 10 and 12 mm of rainfall (600mm ÷ 52 weeks) (1), with watering conducted weekly.

Some quantitative data required for full marks, ½ lost if none. Reference to why a control group was necessary was awarded partial marks (½) if mentioned it was needed as a comparison.

c. Four variables required (½ mark per variable)

Possible answers include temperature, type of soil, amount/type of fertiliser, initial soil moisture content, size of pot, humidity, species of seedlings, age of seedlings, initial health of seedlings, exposure to direct sunlight, soil nutrients, seedling size, watering method, position in laboratory, number of seedlings/treatment or type of seedling.

d. 2 marks per controlled variable, one limitation needed for each. Many possible answers, examples include:

Controlled Variable 1: Temperature

Seedlings may be sensitive to temperature extremes which often occur at times of low rainfall, particularly if water stressed (1). Generally, temperature fluctuations are not represented in a laboratory experiment (1).

Controlled Variable 2: Type of soil

In a natural environment the soil characteristics can vary within a small area. There are likely to be different levels of organic matter both within and on the surface of the soil and these will alter the moisture retention of the soil (1). These variations are generally not able to be represented in laboratory conditions (1).

Also: artificial lighting in a laboratory lacks the diurnal variation of outside. Natural sunlight can be intense during the middle of the day (1). This can impact rate of photosynthesis and hence growth (1).

Comments:

a. Candidates generally performed well in this question. Some incorrectly stated “drought conditions” or “lower rainfall” for the IV as written in the hypothesis. Simply stating “growth/height of seedlings” for the DV was not awarded the half mark as “eucalyptus” was needed as part of the DV. Some candidates got the IV and DV the wrong way around.

b. Many candidates interpreted this question to describe why a control group was needed rather than describe what the control group would be. Candidates needed to include some quantitative data to help describe the size of the control group and how much water the

plants would be given. Very few used any data at all. Half a mark was awarded if candidates referenced the group should represent the 'typical or average' amount of water received in their natural habitat.

c. Most candidates performed well in this question. They were able to list four variables that should be controlled. Some answers such as "the weather", "water/air quality" or "wind" were not awarded the half mark as they were not specific enough nor relevant in a laboratory situation.

d. Many candidates struggled with this question, discussing why the variable needed to be controlled in general and not how this variable can have limitations when carrying out a laboratory experiment as opposed to field trials. Some responses were too vague such as "lack of light can alter results" and were not credited any marks.

Question 2

a. Independent variable: Type of fertiliser (½)

b. Dependent variable: Height/growth of barley (seedlings) (½). The word 'barley' was needed for the ½ mark.

c. Many possible answers for two marks (½ for correct IV and ½ for correct DV, 1 mark for clear causal relationship with direction between IV and DV)

d. Use of fertiliser (½) increases (1) the growth of barley seedlings (½)

OR

Barley seedlings given fertiliser (½) will show an increased (1) rate of growth compared to those given no fertiliser (½).

The full two marks were only awarded if a causal relationship was stated between the IV and the DV or a clear direction (IV increases the DV).

e. 1 mark for describing each feature (two required)

Possible features include:

- variables such as amount of sunlight and water given were controlled
- control group given no fertilisers used for comparison
- more than one fertiliser type used
- sample sizes in each group are the same
- it was a field experiment so more realistic
- duration of experiment was adequate to show barley growth
- regular data collection on a weekly basis.

f. 2 marks per valid improvement, total 4 marks. Many possible answers, including:

Use different amounts of one type of fertiliser rather than using two different fertilisers (½). This allows the effect of amount of fertiliser on plant growth to be assessed (½). If two different fertilisers are used, it is harder to tell whether results are due to the type or the amount (½). Different fertilisers may contain different nutrients, release rates or chemical compositions (½).

OR

Extend the experiment to measure yield instead of just seedling height (½). Height alone doesn't always correlate with productivity (½). Fertiliser might affect early growth (height) (½), but its true impact may be seen later in flowering, grain development, and final harvest (½).

Comments:

a. Most candidates performed well in this question. The most common errors were writing just "fertiliser" for the IV and not including "barley" for the DV.

b. Many candidates struggled to achieve full marks for this part mainly due to vague hypotheses (such as "If the different fertilisers are used, the plants will grow better") or their hypothesis was written incorrectly with two DV's (plants will grow higher and faster). If no causal relationship was stated, ½ mark was deducted.

c. Most candidates performed well in this question. However, some failed to describe how the feature could provide valid results. For example, "there is a control group" or "there is a large sample size" but did not state why a control or why a large sample size gives valid results. Without this information, only ½ mark was awarded for each feature.

d. Many candidates did not achieve full marks on this question. They did not provide sufficient detail in their response. The question asked for an explanation on two improvements to the experimental design in question. Some explained how experimental design in general can be improved and were awarded part marks but only if they referred to the barley experiment.

Question 3

a.
   i. With *S. molesta*: Site 3 (½)
   ii. Without *S. molesta*: Site 8 (½)

b. Abiotic factors likely to have been measured (four needed for ½ mark each):

   Dissolved oxygen, water and air temperature, turbidity, level of nitrates, phosphates, salinity, pH, wind speed, light levels, size of the site, water flow, water depth, humidity, rainfall.

c. 1 mark per valid reason for using quadrats (two reasons required). Examples could include:

   - Biodiversity and population density can be estimated without surveying the entire area (impractical, time-consuming and expensive).
   - Using quadrats of the same size and shape provides a consistent, repeatable method for sampling vegetation across different parts of the estuary.
   - Simple and cost effective for non-mobile organisms as it can be conducted without expensive equipment.
   - Quadrats good for immobile organisms such as plants in this case, so counts and abundance within each quadrat reliably represents the population in that set area.

d. The study indicates that there are fewer native aquatic species in the wetland sites that have *S. molesta* present, 2 to 4 species with *S. molesta* present and 6 to 8 without S. molesta. However, there are limitations that prevent a conclusion of cause and effect (1). Other biotic and abiotic factors at the sites with less native aquatic species may have led to reduced diversity. No baseline data for the sites that now have *S. molesta* is included so there may be other reasons why there are fewer native aquatic species in these areas (1). Therefore, results are inconclusive. Further studies would be required before a conclusion could be made (1).

For the full 3 marks, an evaluation was needed; one supporting statement, one non-supporting statement and a concluding statement.

e. Given the size of the area, a remote sensing study using drone footage or satellite imagery could be utilised to map a larger extent of the estuary area containing *S. molesta*, giving more reliable data (1). Researchers would probably need to develop a sampling program to ensure adequate coverage of the entire area. Once areas of infestation were determined using aerial techniques, water-based surveys could be undertaken to determine the depth and density of *S. molesta* (1).

Other possible answers could include:

- Increased sites could be surveyed, to 10 with *S. molesta* and 10 without *S. molesta* to increase amount of data to improve reliability.
- Sample at various times of the year (the time of year was not mentioned). This would provide information if water temperature or longer daylight hours increase *S. molesta* growth.
- A survey on wildlife could be useful to see if birds may be impacted or aid in the spread of the invasive plant.
- Speak with locals about changes in *S. molesta* distribution or examine historical aerial photographs to show changes over time.

Comments:

a. Most candidates performed well in this question. A few listed more than one site that had the highest number of native species. This could have been due to the word “sites” in the question. Half marks were awarded if the sites listed were the highest from each column.

b. Mostly done well. Answers such as pollution, pressure, weather conditions and water quality were not awarded marks as they were too general in nature.

c. Many candidates described what quadrat sampling entailed rather than responding to the question and explaining why quadrat sampling was used in this investigation. Half marks were awarded accordingly.

d. Very few candidates received the full 3 marks for this question as responses were not an evaluation of the data provided. Most lacked a non-supporting statement and/or an overall concluding remark.

e. Most candidates performed well in this question and were able to outline some form of further investigation to provide increased information on the spread of *S. molesta*. Most common answers were to complete further sampling at different sites and use of drones or aerial surveying. Some mentioned belt/line transects which received half a mark.

Question 4

a. Baseline data or baseline survey (1)

b. Establishing the size of the wallaby population before the fox control program provides baseline data (1) that can be used to assess change in population numbers (½) that can be attributed to the control program (½).

c. At least one statement outlining a positive, negative and ethical consideration was needed (1 mark each), and two marks were given for linking these considerations to multiple

recaptures. The ethical consideration should include information that was not already mentioned in the negative discussion. Possible answers include:

A positive effect is that multiple recapture sessions increase the accuracy of population size estimates by providing more data points (1). Recapture can be affected by many variables (e.g. weather or moon phase or levels of hunger) so conducting multiple recapture sessions increases the chances of recapturing tagged animals (1).

A negative is that multiple recapture sessions require more funding for equipment, travel, data management, labour etc., so can become expensive (1). Repeated recapturing can cause wallabies to become trap shy and avoid the area (1).

Ethically, repeated handling of wallabies can cause physical stress, injury, or behavioural changes (1). Researchers must follow guidelines for humane treatment, including proper handling techniques, checking trap daily and limiting animal interactions (1).

Other possible considerations included: multiple recaptures enabled increased data on health and demographics of the population; handlers must minimise stress by using appropriate traps, be trained animal handlers and avoid extreme weather conditions.

Comments:

a. Most candidates performed well in this question.

b. Many candidates misinterpreted this question and discussed that preliminary data was needed to record the decrease in wallaby population after the foxes were introduced into the area. It was obvious the many did not understand what the term ‘fox control program’ meant (1 mark was awarded in this case). Answer needed to refer to the use of the baseline data to compare to changes occurring due to the fox removal.

c. Overall, most candidates received at least 3 marks for this question. Marks were commonly lost due to lack of detail or repeating points in the ethical and negative considerations or not relating their answer to multiple recapture sessions specifically.

Section B – Criterion 5

Question 5

a. Competition (½)

Parasitism (½)

b.

i. The rabbit and the possum both compete (½) for some of the same food resources such as grasses and low vegetation so reducing the amount of food available to the other (½).

ii. The tapeworm is a parasite and absorbs nutrients from the dingo (½) to sustain its own growth causing the dingo (the host) to be harmed (½).

c. Answer needed to clearly outline the interaction between two species. Possible answers include:

- Cows and egrets. Cattle disturb insects when they graze which provides food for the cattle egret. The cattle are not affected by the egrets in any way.
- Remora fish and reef shark. Remora fish attach to shark and benefit from ease of transport, protection from predators and food scraps from the shark when feeding. The shark is generally unaffected.
- Staghorn fern in native fig tree. Staghorn ferns use native fig trees for support and access to better sunlight but do not harm the tree.
- Barnacles on whales. Barnacles adhere to whale skin where they can filter feed on passing nutrients. Whale not affected

Comments:

a. Most candidates performed well in this question.

b. For both i and ii candidates were able to correctly identify why the interaction was competitive or parasitism but often did not describe the effect on each species.

c. A large number of candidates incorrectly gave examples of mutualistic or predatory relationships and did not give a species that was unaffected.

Question 6

a.

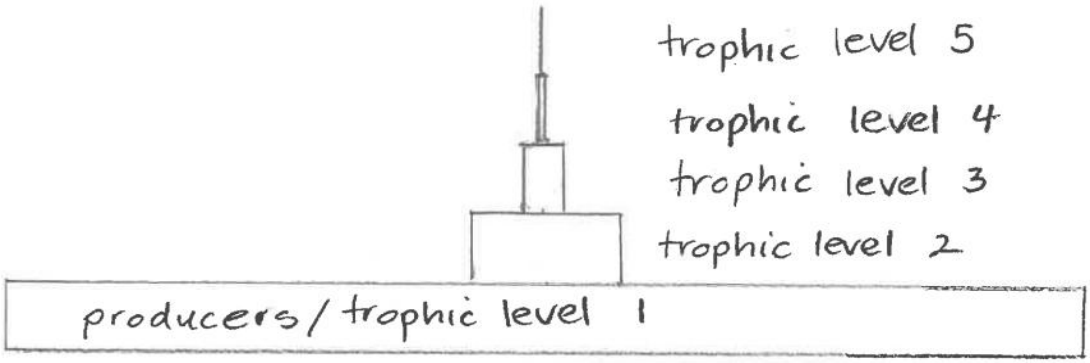
i. algae or phytoplankton
ii. zooplankton, tadpoles, insect larvae or water fleas (only one needed)
iii. Lake Eyre Hardyhead, Bony Herring, Desert Frog or Banded Stilt (only one needed)
iv. Five tropic levels

b. Detritivores or decomposers

c. Many possible answers. Examples include:

- Phytoplankton (P) → Zooplankton (C1) → Bony Herring (C2) → Silver Gull (C3)
- Algae (P) → Water flea (C1) → Desert Frog (C2) → Whistling Kite (C4)
- Phytoplankton (P) → Green Frog (C1) → Bony Herring (C2) → Golden Perch (C3) → Whistling Kite (C4)
- Algae (P) → Insect larvae (C1) → Lake Eyre Hardy Head (C2) → Pelican (C4)
- Algae (P) → Insect larvae (C1) → Bony Herring (C2) → Golden Perch (C3) → Whistling Kite (C4)
- Phytoplankton (P) → Green Striped Frog (C1) → Golden Perch (C3) → Whistling Kite (C4)

d. Labelled pyramid of energy. 1 mark for correct proportions, ½ mark for correctly labelled trophic levels, ½ mark for showing 5 trophic levels.



e. Unlike the pyramid of energy, a pyramid of biomass does not necessarily follow the 10% rule (½). In this case it may be inverted (½) as the producers (e.g. phytoplankton) may be more productive and have a lower biomass than the first order consumers feeding on them (½). This is because the phytoplankton reproduce quickly and are consumed quickly (½).

f. The inland saltwater ecosystem has lower availability of resources (½) and has a lower overall plant productivity (½). This results in lower availability of energy to provide the food web and fewer trophic levels can exist (½) due to energy loss between each trophic level transfer (½).

   Marks were also awarded for other relevant answers such as: inland ecosystem is short-lived and dry for long periods of time, low in nutrients and lacks a physical reef structure (therefore less niches). Tropical reefs are stable and nutrient-rich, allowing for more complex food webs with many trophic levels. Inland ecosystems present a challenging environment and requires species that are suitably adapted to the harsh conditions which limits number of available niches and species. Marine reef ecosystems are much larger and are connected to the entire ocean region which allows for migratory species, influx of nutrients, and higher productivity.

Comments:

a. Most candidates answered this question correctly and gained full marks.

b. Most candidates answered this question correctly and gained full marks.

c. Most candidates answered this question correctly and gained full marks.

d. Candidates were typically awarded at least one mark; however, many answers were missing labels or five trophic levels, and a number of candidates did not show a significant decrease from one level to the next.

e. The majority of candidates identified that the biomass pyramid could be inverted but did not discuss reasons why.

f. Most candidates were able to gain at least part marks for this question; however, responses often lacked a true discussion with sufficient detail for full marks.

Question 7

a. ½ mark for each input, two required. Examples include: weathering of rocks, animal urine, decomposition of plants and animals by fungi and bacteria, incorporation into sedimentary rock from phosphates in solution, bird guano or influx of fertiliser.

b. ½ mark for each output, two required. Examples include: loss in drainage/runoff and leeching from rocks or assimilation by plant cells which absorb phosphates.

c.

i. One of the following (½ mark): Use of fertilisers, runoff from other agriculture areas, sewage, stormwater or guano.

ii. One of the following (½ mark): Removal of plants (harvests) and animals (for meat or dairy production), removal of dead organic matter prior to decomposition or excess irrigation causing runoff.

d. Candidates needed to give two similarities and two differences for full marks. 1 mark allocated for each similarity and difference. Possible answers include:

Similarities:

- Both are essential nutrient cycles that support life by providing elements needed for biological molecules.
- Both can be present in the soil at some point in their cycle.
- Both can enter the soil by the breakdown of animal and plant matter.
- In natural ecosystems, both cycles involve bacteria.
- Plants can absorb both nutrients through root systems.

Differences:

- The nitrogen cycle includes an atmospheric phase, unlike the phosphorus cycle.
- Nitrogen moves relatively quickly through ecosystems, whereas phosphorus moves more slowly if locked up in sedimentary rock.
- Nitrogen cycle can involve lightning.
- Nitrogen requires more bacteria species to convert it before plant absorption.
- Total amount of nitrogen on earth is greater than phosphorous.

Comments:

a. Most candidates answered this question correctly and gained full marks.

b. Most candidates answered this question correctly and gained full marks.

c. Most candidates answered this question correctly and gained full marks.

d. Most candidates were able to gain at least part marks for this question; however, there were many responses that did not include two similarities and two differences required for full marks.

Question 8

a. Green carpenter bee

b. European honeybee

c. The extent of competition between green carpenter bees and European honeybees on Kangaroo Island is limited (1). There is some competition for food foraging (European bee can use native plants) but they do not compete extensively for resources (1). While both species forage for nectar and pollen, they often target different plant species (1), reducing direct competition. There is no direct competition for nesting sites (1).

d. The European honeybee does exert some pressure on the green carpenter bee through partial niche overlap (1) especially with respect to plant preferences. However, due to differences in nesting behaviour and foraging, the green carpenter bee maintains a distinct ecological niche (1). No two species share the same niche without one outcompeting the other. Therefore, while there is some overlap with resources, the effect of the European honeybee on the Green Carpenter bee is minimal. (1)

Comments:

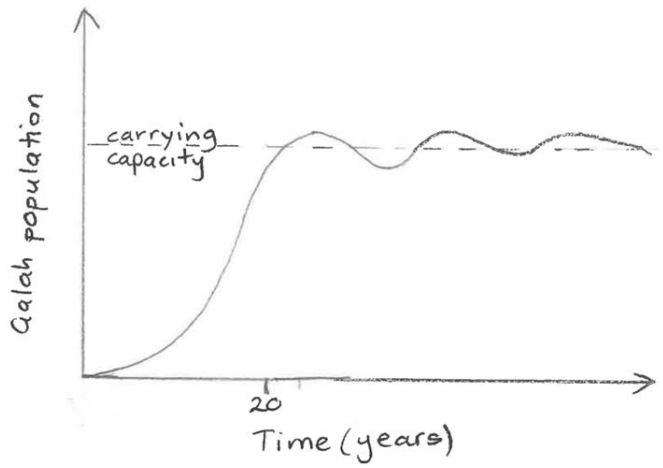
a. Most candidates answered this question correctly and gained full marks.

b. Very few candidates gained full marks for this question. There was confusion about the amount of competition between the two species with many candidates stating that there was significant competition and the green carpenter bee would be outcompeted and go extinct. A number of candidates addressed part c) of the question in their response and repeated themself in the follow up question.

c. Very few candidates gained full marks for this question. There was confusion about the amount of niche overlap between the two species with many candidates stating that there was significant competition and the green carpenter bee would be outcompeted and go extinct.

Question 9

a. Mark allocation for drawing and labelling graph: overall shape (1), indication of 20-year time interval on scale before carrying capacity reached (1), labelling carrying capacity (½), and labelling axes (½).



b. S-shaped curve/logistic curve.

c. Raptors are apex predators that rely on abundant prey at lower trophic levels (1). If ecosystems are healthy there will be enough primary production to support higher trophic levels including apex predators regardless of the 10 percent energy rule (1).

Comments:

a. The majority of candidates received at least 1-2 marks on this question. Very few included all required information with many forgetting to label the axes.

b. Most candidates answered this question correctly and gained full marks.

c. Only a small number of candidates gained the full 2 marks which required an explanation rather than just stating facts. Several candidates were awarded part marks if they referred to the raptors being able to reduce numbers of individuals in lowered levels to avoid trophic cascade.

Section C – Criterion 6

Question 10

a.

i. Any two of the following points: Less than average rain (½) and higher than average temperatures (½) in eastern Australia leading to increased droughts (½) or bushfires (½), cooler sea surface temperatures (SST) (½) and weaker westerly winds (½).

ii. Any two of the following points: Increased rainfall in eastern and northern Australia (½) and lower daytime temperatures (½), increased risk of flooding (½), warmer SST (½), stronger westerly winds (½).

b. During an El Niño event, westerly trade winds weaken or reverse (½), which shifts the main area of convection (Walker circulation) away from Australia toward the central Pacific (½) and leads to a build-up of warmer SST in the central and eastern Pacific Ocean (½). This reduces the upwelling of cold, nutrient-rich water along the South American coast (½).

Comments:

a. Most candidates did well in identifying weather conditions in Australia that indicated an El Niño or La Niña year and obtained full marks. However, many were not specific about the geographic location within Australia (east coast, north).

b. Few candidates obtained full marks on this question, mainly due to a lack of geographic specificity in their answers. The question asked about conditions in the Pacific and many answers did not address the location of winds, SST or atmospheric circulation but talked in generalities which could not be rewarded.

Question 11

a. Any two of the following list (1 mark per valid reason):

- There is a permanent supply of water to the roots of the Huon pines even during reduced rainfall or drought conditions.
- Bushfires are less likely to occur because it is difficult for them to 'jump' rivers.
- Dense rainforest along riverbanks therefore Huon pines are more protected from bushfire.
- Good growing conditions for Huon pines along riverbanks (acid, free-draining soil, protection from drying winds and strong afternoon sun).

b. 3 valid points including quantitative data related to at least 3 forest types.

Distribution of different forest types in the Tarkine are closely related to the frequency of fire. Where fire frequency is highest (every 10-25 years), areas of sedgeland may occur. If fire frequency is lower (every 50-100 years), wet sclerophyll will develop. Mixed forests have a fire frequency between 90 and 300 years. As the fire frequency reduces a rainforest understory develops and rainforest is likely to occur when there is more than 400 years since the last fire.

c. Rainforests are not adapted to bushfires (½) and once burned will take at least 400 years to regenerate (½), not necessarily to their original state if unsuitable conditions prevail. Huon pines, endemic to Tasmania (½) can be thousands of years old (½), generally not producing seed until they are at least 600-800 years old (½), thus they need protection to propagate new individuals (½).

Comments:

a. Most candidates identified at least one reason for the distribution of Huon pines along riverbanks and many provided two valid reasons. Where candidates lost marks, it was usually because they did not provide detail in their description.

b. Given that the stem of the question described the different forest types found in the Tarkine, candidates' responses were expected to include these types. Responses also needed to include some quantitative data about fire frequency (given in the Information Sheet) to obtain full marks. In general, most candidates provided some information, but few gained full marks.

c. Identifying the longevity of the Huon pine was key to answering this question – many candidates did state that Huon pine was a very long-lived species. Few candidates discussed forest regeneration in terms of sources of propagules (seeds) and therefore lost marks. No candidate stated that Huon pines only become reproductively mature at more than 600 years old.

Question 12

a.

i. 406.5 ppm (acceptable range 406.5-407.5 ppm) (½ mark for number, ½ mark for units).

Due to the nature of the graph, if a candidate marked on Figure 9 the value at the start of the year and then stated this in the answer (405 ppm), ½ mark was given.

ii. 414 ppm (acceptable range 413 to 415 ppm) (½ mark for number, ½ mark for unit).

b. Monthly mean CO_2 levels show an annual cycle (½) with higher levels early in the year and lower levels later in the year (½) on an underlying trend (½) of a linear increase (½) of about 2.5 ppm/year (½).

c. CO_2 levels vary cyclically each year (½), comparisons can only be made validly between the same times of year (½), not between spring and winter for example. However, the trend line indicates the size and direction of overall change (1).

d. Any of the following, provided sufficient detail was given. No marks were given for discussion of seasonality in temperature unless related to plant or human activity:

   Annual fluctuations are due to the greater land mass of the northern hemisphere than the southern hemisphere (1). The decay of plant material in the northern autumn / winter releases CO_2 (½) which is then reabsorbed by plants in the northern spring / summer (½). Likelihood of widespread bushfires which release CO_2 (½) is dependent on season – more likely in summer (½).

   Distribution of human population is not even between hemispheres (½). Production of CO_2 from fossil fuels (½) used in heating (½) or transportation or manufacturing (½) may vary seasonally (½).

e. 2 marks for each of many possible environmental consequences – response needed to address two different environmental consequences for full marks. Examples include:

   Increased levels of CO_2 lead to increases in absorption of CO_2 in water and this reduces the pH making it more difficult for marine organisms to make calcium carbonate and form structures potentially leading to loss of coral and other marine organisms.

   Higher CO_2 levels enhance the greenhouse effect, trapping more heat in the atmosphere. This can cause more frequent and intense heatwaves and changes in precipitation patterns, leading to droughts or floods.

Comments:

a. Most candidates correctly identified the value from the graph in (i) and extrapolated the expected value in (ii).

b. This question was generally well answered but some candidates did not provide information on both the annual fluctuations and the overall trend.

c. Most candidates identified that the overall trend was best represented by the smoothed mean, but many did not provide valid reasons for considering the individual monthly values.

d. About half of the candidates identified seasonal fluctuations in the release or absorption of CO_2 but most attributed the fluctuations as anthropogenic rather than the much larger effect of seasonal changes in photosynthesis between the northern and southern hemisphere.

e. This question was generally poorly answered. Many candidates confused effects of loss of stratospheric ozone or photochemical smog rather than increases in CO_2 and many responses were very vague rather than addressing specific effects such as ocean acidification.

Question 13

a. Any one of January, February, March, April, November, or December (1 mark). Full credit was also given for the answer November – April.

b. Any two of the following (1 mark for stating the method and 1 mark for description of that method):

   - Physical removal of the mats of *S. molesta*. This could be done for example using a combination of rakes or grabs from the shoreline or from boats or barges and lifting equipment. Material composted or disposed of away from waterways.
   - Use of species-specific herbicides by spraying in-situ at specific dosages.
   - Use of a named herbivore (e.g. duck, cow) which can consume *S. molesta*
   - Introduction of a species-specific pathogen (e.g. virus) after suitable testing on native species.

   Partial credit was given for answers which suggested modifying conditions so that the Salvinia weevil would be active all year round as these methods were generally highly impractical.

c. Response had to address one of the methods described in part b) and required sufficient detail for full marks. Possible answers included:

   - Physical removal may leave behind or spread pieces of *S. molesta* that can infest new areas.
   - Machinery and personnel conducting removal may damage areas of native vegetation.
   - Production of pollution from machinery.
   - Herbicides could adversely affect native species in situ or be transported through waterway to other aquatic systems. Herbicide may bioaccumulate in organisms in the food chain up to and including humans.
   - Introduced herbivores or pathogens may remove or kill native species of vegetation or have unpredicted food web consequences.

Comments:

a. Very well answered – most candidates provided a valid response, the few who didn't had probably misread the question.

b. Well answered for at least one appropriate method, candidates who lost marks did not provide sufficient detail.

c. Well answered with most candidates identifying at least some negative consequences of their chosen method.

Question 14

½ mark was given if the candidate provided a definition of the type of biodiversity. Partial credit was given if candidates provided explanation under the wrong category of biodiversity.

a. Genetic biodiversity is likely to reduce (½). Mass bleaching reduces coral populations and therefore reduces the genetic variants (½) either randomly or systematically if certain variants have a sensitivity to higher temperatures (½). Loss of other species dependent on coral (½) will reduce their populations and thus genetic biodiversity (½).

b. Species biodiversity is likely to reduce (½). Many species depend on coral for survival (½). Death of coral means that different species lose a source of food or shelter (½). Some corals are more impacted by coral bleaching than others (½).

c. Ecosystem biodiversity is likely to reduce (½). Within the reef system there are a variety of habitats and communities (½). Coral is central to these habitats. Fewer or dead coral reduces the number and diversity (½) of these habitats and communities (½).

Comments:

This question was not particularly well-answered. Candidates generally achieved some marks, but few provided enough detail in all three parts to achieve full marks.

Section D – Criterion 7

Question 15

a. It is a measure of the environmental impact of an individual and refers to the amount of productive land appropriated on average by an individual to meet their needs (food, water, transport, housing and energy).

b. 2 marks per appropriate strategy. Many possible answers, exampled include:

- The government could expand its investment in renewable energy such as solar and wind energy which reduces reliance on fossil fuels for Australia's electricity needs.
- Individuals, to reduce fuel use and greenhouse gas emissions, could reduce the distance that they drive alone by walking, cycling, using public transport like buses and trains, or carpooling.

Comments:

Generally well done, a) was better than b). Candidates overlooked referring to the ecological footprint.

Question 16

a.

i. Ecosystem service: Food production

Ecosystem category: Provisioning services (Supporting Services)

ii. ½ mark for naming, 1 ½ marks for discussion

Nutrient cycling is reduced since intensive farming depletes organic matter and reduces biodiversity in the soil. If soil organisms like microbes, fungi, and earthworms cannot function effectively the result is poor soil structure, reduced water retention and lower availability of essential nutrients for crops.

b. The restoration enhances cultural services by improving recreational opportunities, promoting physical and mental wellbeing. It also allows for connection to nature and heritage as healthy riverbanks support native species and landscapes, fostering a sense of place and cultural identity.

Comments:

This question was well-answered by most candidates.

Question 17

a. Low level ozone can damage tissues of the respiratory tract, cause inflammation and worsen asthma.

b. Ground level ozone develops when nitrogen oxides react with volatile organic compounds in the presence of sunlight. These substances are emitted by vehicles and power plants.

c. ½ mark for each, many possible answers. Examples include: particulates (PM10 and PM2.5), smoke, and SO_2.

d. Stratospheric ozone absorbs ultraviolet radiation. The reduction of ozone due to reactions with substances such as CFCs allows increased ultraviolet radiation to reach the earth's surface causing sunburn and other UV related plant tissue damage.

Comments:

a. This question was not particularly well-answered, despite details being available on the Information Sheet.

b. Mostly well done. Although only a few candidates received full marks as many omitted sunlight in their response.

c. Well done.

d. Generally, well done. Although, many candidates overlooked including health implications.

Question 18

a. Bioaccumulation (½ mark for biomagnification)

b. 1 mark for each valid reason/statement, examples include:

- Some individuals may have consumed more fish than other individuals potentially due to age of the individual.
- Individuals who consume fish from higher trophic levels will potentially be exposed to greater levels of mercury.
- Some individuals will be eating fish with higher concentrations of mercury because of the closeness to areas affected by gold mining.

c. Name (1 mark): Biomagnification

Explain (2 marks): Mercury is a persistent pollutant and will not biodegrade. It is taken up by primary producers which are eaten by primary consumers which are then consumed by secondary consumers and so on. It is biomagnified up the food chain.

Comments:

a. Very well done.

b. Poorly done. Most candidates covered only one aspect of different mercury levels, therefore not achieving full marks. Many candidates explained biomagnification.

c. Generally, well done. Few candidates received full marks because persistence was not mentioned.

Question 19

a. An algal bloom is the rapid increase in biomass due to favourable conditions. When the short-lived algae die, they are decomposed by aerobic decomposers (e.g. bacteria) which rapidly consume O_2 in their respiratory processes.

b. Increased temperatures lead to increased growth as photosynthesis and respiration speed up. Calm weather means that the algae and decomposing bacteria are not dispersed. Favourable conditions are maintained.

c. Sewage contains large amounts of organic matter. Microorganisms in the water break down this organic material, and in doing so, they consume oxygen leading to BOD.

Comments:

a. Generally, well done. A few candidates mentioned that the algae are taking up the oxygen.

b. Poorly done.

c. Generally, well done. Candidates did not notice that the question is now a freshwater example.

Question 20

a. Description of how clearing native vegetation (1½) and poor irrigation practices (1½) increase soil salinity required.

   Clearing native vegetation removes adapted and deep-rooted species which reduces water uptake and leads to rising water table (*i.e.* bringing salts to the surface). Excessive irrigation causes a rise in the water table bringing dissolved salts to the surface, or use of poor-quality irrigation water adds salts to the soil.

b. 2 marks per each well discussed agricultural practice. Many possible answers, examples include:

   - Water management – use appropriate amounts of good quality water, install subsurface drainage to drain excess irrigation water and salts, and use of drip irrigation to minimise salt accumulation.
   - Soil health and structure – add organic matter to improve water infiltration, apply gypsum to replace sodium ions with calcium ions.
   - Vegetation and plant selection – use of salt tolerant species, use of crop rotation to improve soil structure and nutrient uptake, use of cover crop to reduce evaporation and erosion.

Comments:

a. Overall, well done. Some candidates misinterpreted the question and mentioned fertiliser.

b. Overall, well done. Some candidates mentioned generic agricultural practices that did not answer the question.

Section E – Criterion 8

Question 21

a. 2 marks for each description of sustainable development approach. Many possible answers, examples include:

- Economic – increase the cost of single use plastic and at the same time make available paper or cardboard bags or food containers.
- Legislation – ban on production or use of plastics for certain purposes, require producers to collect waste plastic for recycling, fine those who dump plastic.
- Technology – reduce or limit plastic and provide alternative material such as plant starch which is biodegradable to reduce the amount of non-biodegradable plastic in the ocean.
- Science – research new methods to remove plastics from oceans and deploy at scale with the captured plastic to be sorted and recycled where possible.

b. Plastic pollution in the oceans could be considered a tragedy of the commons because the oceans (½) is a shared global resource with limited regulation (½). Individuals and industries benefit (½) by using plastic and disposing of it irresponsibly, causing harm to marine ecosystems (½). Since no single group owns the oceans (½), there is little incentive to protect (½) this resource leading to collective environmental harm and damage (½).

Comments:

a. This question was very approachable, and most candidates performed well. The name of an approach (e.g. Legislation) was not required for full marks but was rewarded with ½ mark if included. Stronger candidates included examples such as the Ocean Clean-up or Seabin.

b. This question was more challenging, and few candidates achieved full marks. A clear understanding that the ocean is the commons and individuals (and industries) benefit by polluting to the detriment of all, was needed for full marks.

Question 22

a. Scenario 1 – Full cost pricing (1)

   Scenario 2 – Efficient use of resources (1)

   Scenario 3 – Precautionary and anticipatory principle (1)

b. 2 marks for each principle of sustainability, ½ mark for name and 1½ mark for each explanation.

   - Scenario 1: Intragenerational Equity (½)

     Explanation: Co-management ensures that Indigenous communities have equal access (½) to decision-making and use of the national parks. It respects cultural knowledge, promotes social equity (½) and supports fair use (½) of resources among the current generation (½).

   - Scenario 2: Intergenerational Equity (½)

     Explanation: Protecting (½) the region ensures that its natural and cultural values are preserved for future generations (½). By restricting damaging activities, the environment is safeguarded so that future generations do not have to clean-up (½) environmental degradation from mining and forestry. This leaves the environment in the same condition (½) for the future.

   - Scenario 3: Ecological Integrity (½)

     Explanation: Restricting activities like tourism, fishing and development (½) helps maintain the function (½) of ecosystems. Conservation areas such as this World Heritage Area (½) protect biodiversity (½) for long-term sustainability.

Comments:

a. Most candidates successfully achieved 3 marks. A surprising number of students did not read ‘state’ in the question and wasted time explaining the sustainability principle and achieved 0 marks.

b. Different answers for each scenario were able to achieve full marks depending on the detail in the candidate’s explanation. Ecological integrity and intergenerational equity were often, and successfully, swapped.

Question 23

a. An environment management plan aims to identify, minimise and manage potential environmental impacts (½) from development or ongoing activities (½) and meet legal requirements (½) of the world heritage listing. World heritage listing requires no further environmental degradation (½) of the site thus managing and monitoring (½) for this potential damage requires a management plan.

b. Two stakeholders required: First nations people (½), conservation groups (½), government (local, state, federal) (½) or recreational users (½).

c. Environmental Protection and Biodiversity Conservation Act (1).

d. Education provides information to landholders and the communities (½) about how to best manage private land (½) to maintain the OBP population with respect to issues such as land clearing, predator management and type of vegetation needed (½). They may become active in preventing development/land clearing of forests (½) that are critical food sources of the OBP. Other actions may be planting food-bushes and trees (½) or restoring of degraded areas (½) or trapping feral animals (½) in OBP habitats.

e. The CAR framework is considered for conservation within the National Reserve System. As the OBPs migrate between three states (½), to be comprehensive, the reserves should be on a regional-scale (½), including each bioregion (½) that is important for OBPs. The TWWHA in Tasmania follows this framework (½) but not OBP habitats in Victoria and SA (½). On the mainland, wintering habitat include some conservation reserves (½), but it is not entirely protected (½). Adequate refers to the size (½) of a reserve to maintain ecological viability (½) and as the population of OBP is critically endangered this has not occurred (½). The TWWHA is representative as it includes areas of finer-scale habitats (½) within ecosystems e.g. saltmarshes for feeding (½) and eucalyptus hollows for nesting (½).

f. Overall, moderately successful (½) since the decline in 1980s numbers are now back to approximately 150 (½) but with genetic loss (½) as there were less than 20 individuals in 2010s (½) and the species has not gone extinct in the wild (½). But in the 45 years since 1980s the numbers have not increased (½). With the OBP breeding habitat protected (½), future OBP breeding potential is safe (½) but could be still considered uncertain (½) due to climate change and other threats as numbers are still low and captive breeding and predator control (½) will still likely be needed (½) in the immediate future.

Comments:

a. Very few candidates realised that an environmental management plan is a legal requirement and did not achieve full marks.

b. All candidates achieved full marks.

c. The following were also accepted (1 mark each): Threatened Species Protection Act (Tasmania), National Parks and Reserve Management Act (Tasmania), Flora and Fauna Guarantee Act (Victoria), CITES, RAMSAR, and the World Heritage Convention.

d. Responses to this question were often vague and without a clear on-the-ground action, full marks were not achieved.

e. Candidates found this question very challenging and often left it blank. Each term (comprehensive, adequate and representative) needed to be discussed, as well as both the Mainland and Tasmania, for full marks. A maximum of 1 mark was achieved if the Information Sheet was copied with no relevance to the question.

f. Most candidates did very well in this question as the information was available in an accessible form. Arguments for either successful or not successful achieved full marks if the discussion was relevant. Data from the question as well as some reference to conservation efforts was required for full marks.

Question 24

Positive impacts: The Tasmanian salmon industry is a major contributor to the state's economy (½), especially in regional areas. It provides high-paying employment (½) and supports other local businesses and services (½). The industry also invests in scientific research (½) and aquaculture innovation (½). A large amount of healthy protein (½) with omega fatty acids (½) supports our growing population.

Negative impacts: There are environmental concerns like water pollution and damage to marine habitats (½), which threaten species (e.g. Maugean skate) (½). Issues like mass fish deaths (½), wildlife entanglements (½), and antibiotic use has raised animal welfare problems (½). Communities also deal with noise and light pollution (½), and Indigenous groups are worried about impacts on culturally important marine areas.

Evaluation: Overall, the industry's SLO is weak and contested (½) as there have been a great deal of rallies and protests in recent years (½). Even though in rural areas the economics and employment that salmon aquaculture offer is valued by many (½), better adherence to regulations (½), reconsideration of industry expansion (½) and more honest communication with the public is required (½).

Comments:

Candidates performed well in this question; however, the evaluation part was poorly done. Many candidates did not know the term SLO. For full marks the evaluation had to clearly show that a SLO is an informal social licence to operate where the public agrees with a development / industry. Without a SLO there is much public outrage. In the evaluation, both the positive and negative impacts needed to be considered for full marks.