Higher
Course
Specification

Higher Environmental Science

Course code:	C826 76
Course assessment code:	X826 76
SCQF:	level 6 (24 SCQF credit points)
Valid from:	session 2020–21

This document provides detailed information about the course and course assessment to ensure consistent and transparent assessment year on year. It describes the structure of the course and the course assessment in terms of the skills, knowledge and understanding that are assessed.

This document is for teachers and lecturers and contains all the mandatory information you need to deliver the course.

This edition: June 2021 (version 3.1)

Contents

Course overview

The course consists of 24 SCQF credit points which includes time for preparation for course assessment. The notional length of time for candidates to complete the course is 160 hours.

The course assessment has three components.

Component	Marks	Scaled mark	Duration
Question paper 1	20	20	45 minutes
Question paper 2	100	100	2 hours and 30 minutes
Assignment	20	30	8 hours, of which a maximum of 2 hours is allowed for the report stage

Recommended entry	Progression
Entry to this course is at the discretion of the centre. Candidates should have achieved the National 5 Environmental Science course or equivalent qualifications and/or experience prior to starting this course.	♦ other qualifications in environmental science or related areas ♦ further study, employment and/or training

Conditions of award

The grade awarded is based on the total marks achieved across all course assessment components.

Course rationale

National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide time for learning, focus on skills and applying learning, and provide scope for personalisation and choice.

Every course provides opportunities for candidates to develop breadth, challenge and application. The focus and balance of assessment is tailored to each subject area.

Environmental science is an interdisciplinary subject which draws from the sciences and social sciences. Environmental scientists are involved in tackling issues such as global climate change, pollution, use of land and water resources, and changes in wildlife habitats. These issues require an understanding of scientific principles, economic influences, and political action.

The course is practical and experiential, and develops scientific awareness of environmental issues. The course allows candidates to understand and investigate the world in an engaging and enjoyable way. It develops candidates' ability to think analytically, creatively and independently, and to make reasoned evaluations. The course provides opportunities for candidates to acquire and apply knowledge, to evaluate environmental and scientific issues, to consider risk, and to make informed decisions. This can lead to candidates developing an informed and ethical view of topical issues. Candidates develop skills in communication, collaborative working, and leadership, and apply critical thinking in new and unfamiliar contexts to solve problems.

The course uses a field work and experimental approach to develop knowledge and understanding of concepts of environmental science.

Due to its interdisciplinary nature, candidates may benefit from studying environmental science along with other science subjects and geography, as this may enhance their skills, knowledge and understanding.

Purpose and aims

The course develops candidates' interest and enthusiasm for environmental science in a range of contexts, as well as their investigative and experimental skills. The course encourages candidates to take a problem-solving approach, develop solutions to prevent or reverse environmental deterioration, and develop an understanding of sustainable practices.

The course develops a scientific understanding of environmental issues. It provides a broad and up-to-date selection of ideas relevant to the central position of environmental science in society. This allows a deeper understanding of the environmental issues and possible solutions to these.

The course provides a range of opportunities for candidates to investigate key areas of the living environment such as biodiversity and interdependence. Through the Earth's systems, candidates will investigate resource issues in the geosphere, hydrosphere, biosphere and atmosphere. Sustainability and sustainable development are explored through food, water and energy security; as well as investigating issues relating to waste generation and its management.

The course has a strong interdisciplinary nature and aims to develop skills, knowledge and understanding in relevant areas of science and social science. It provides opportunities for candidates to develop scientific literacy skills. Candidates will recognise the impact environmental science makes on their lives, on the lives of others, on the environment, and on society.

The course allows flexibility and personalisation within each key area and within the course assignment by allowing choice in the topics studied.

The course enables candidates to make their own decisions on issues within a modern society where the body of scientific knowledge and its applications and implications are constantly developing.

The course aims to:

- develop and apply knowledge and understanding of environmental science to new situations
- develop an understanding of environmental science's role in scientific issues and relevant applications of environmental science, including the impact these could make in society and the environment
- develop scientific inquiry and investigative skills
- develop scientific analytical-thinking skills, including scientific analysis, in an environmental science context
- develop the skills to use technology, equipment and materials safely, in field work scientific procedures
- develop planning skills
- develop problem-solving skills in an environmental science context
- develop experimental and/or field work skills in an environmental science context
- use and understand scientific literacy, in everyday contexts, to communicate ideas and issues and to make scientifically informed choices
- develop the knowledge and skills for more advanced learning in environmental science
- develop skills of independent working

Who is this course for?

The course is suitable for candidates who are secure in their attainment of National 5 Environmental Science or an equivalent qualification. It may be suitable for those wishing to study environmental science for the first time.

The course emphasises field work and experiential learning opportunities, with a strong skills-based approach to learning. It takes account of the needs of all candidates, and provides sufficient flexibility to enable candidates to achieve in different ways.

Course content

The course content includes the following areas of environmental science:

Living environment

The topics covered are:

- investigating ecosystems and biodiversity
- interdependence
- human influences on biodiversity

Earth's resources

The topics covered are:

- the geosphere
- the hydrosphere
- the biosphere
- the atmosphere

Sustainability

The topics covered are:

- global challenges
- food
- water
- energy
- waste management
- anthropogenic climate change

Skills, knowledge and understanding

Skills, knowledge and understanding for the course

The following provides a broad overview of the subject skills, knowledge and understanding developed in the course:

- demonstrating knowledge and understanding of environmental science by making accurate statements
- describing information, providing explanations and integrating knowledge
- applying knowledge of environmental science to new situations, analysing information and solving problems
- planning and designing experimental/field work investigations to test given hypotheses or to illustrate particular effects
- carrying out experiments/field work investigations safely, recording detailed observations and collecting data
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experiments/field work investigations and suggesting improvements
- communicating findings/information effectively

Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment:

Living environment

1 Investigating ecosystems and biodiversity

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Abiotic, adaptation, biodiversity, biological oxygen demand, biotic, biotic index, capture-mark-recapture, density, dissolved oxygen concentration, distribution, diversity index, ecosystem, ecosystem diversity, frequency, genetic diversity, interquartile range, Lincoln index, percentage cover, quadrat, qualitative data, quantitative data, random sampling, relative abundance, reliability, simple random sampling, Simpson's biodiversity index, species, species diversity, species richness, standard deviation, stratified random sampling, systematic random sampling, transect, Trent biotic index, validity

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Assessing biodiversity**

- **Biodiversity classifications** — ecosystem diversity, species diversity, genetic diversity
- **Species richness and relative abundance**

b **Sampling plants and animals**

- **Qualitative techniques** — construction and use of paired statement keys
- **Quantitative techniques** — an understanding of the assessment of: density; relative abundance; percentage cover; frequency; distribution (biotic and biodiversity indices, to include Simpson's biodiversity index for terrestrial species, Trent biotic index for aquatic species, and Lincoln index for capture-mark-recapture). Candidates are not required to learn formulae.
- **Sampling techniques** — transect (point, line and belt); quadrat, including use for assessing density, percentage cover, frequency, and relative abundance; capture-mark-recapture; evaluation of invasive and non-invasive sampling techniques.
- **Randomisation and statistical analysis in sampling** — random sampling (simple, systematic and stratified); determination of mean, median and mode; determination of standard deviation and interquartile range; reliability and validity of results. Candidates are not required to learn formulae.

c **Measuring abiotic factors**

- **Aquatic** — temperature, water flow rate, dissolved oxygen content, biological oxygen demand (BOD), pH, salinity, tidal effects
- **Terrestrial** — temperature, light intensity, soil (moisture, pH and nutrients), wind velocity (speed and direction), precipitation, slope
- **Effects of abiotic factors on the frequency and distribution of organisms**

Living environment

2 Interdependence

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Assimilation, autotroph, biomass, carnivore, carrying capacity, climax community, community, competition, density-dependent, density-independent, ecological efficiency, ectotherm, edaphic, endotherm, exponential population growth model, grazing, gross primary productivity, herbivore, heterotroph, interdependence, inter-specific competition, intra-specific competition, logistic population growth model, net primary productivity, niche, omnivore, parasitism, population, population crash, population dynamics, population oscillation, population overshoot, predator-prey cycle, primary productivity, primary succession, respiration, secondary productivity, secondary succession, seral stages, succession, trophic, trophic level

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Succession**

- **Seral stages in primary and secondary succession**
- **Influence of climate, biotic, and edaphic factors on succession**
- **Characteristics of a climax community** — stable community, high biodiversity, complex food webs, high biomass

b **Energy conversion, transfer and loss in food chains and webs**

- **Primary productivity — gross and net**

  Gross primary productivity (GPP) is the rate at which autotrophs produce biomass in a given area and time period. Approximately half the GPP is used by plants for their own respiration. The remainder is either stored or utilised by the plants for new biomass production, and is available for consumption by heterotrophs.
  Net primary productivity (NPP) = GPP – respiration.

- **Secondary productivity and ecological efficiency**

  Secondary productivity is the assimilation of food into new biomass through the transfer of organic material between trophic levels.

  Ecological efficiency is the percentage of biomass produced by one trophic level that is transferred and incorporated into biomass at the next trophic level. On average, only 10% of the energy that enters a trophic level is passed on to the next trophic level. The remainder is used for respiration and movement, and is lost from the system as heat and indigestible waste. An ecological efficiency of 10% limits most food chains to four or five links, which explains why the volume of biomass typically reduces at each trophic level.

- **Impact of endotherms and ectotherms on energy transfer**

  Endotherms use internally-generated heat to maintain body temperature independent of external temperature change. A high metabolic demand to keep the body warm leaves a minimum of energy for biomass accumulation.

  Ectotherms rely on external environments for temperature control instead of generating their own body heat.

Ectotherms are more ecologically efficient than endotherms, passing on up to 15% of residual energy to the next trophic level in comparison to approximately 7% by endotherms. Therefore, food chains containing several ectotherm species, particularly marine food chains, are often longer in length.

c **Population dynamics**

- **The effects of density-dependent factors on the stability of ecosystems**

  Density-dependent factors reduce a population when numbers are high and allow the population to increase when numbers are low.

  Biotic interactions can act as density-dependent controls on the size of a population, including predator-prey cycles, grazing, competition (inter-specific and intra-specific), and parasitism.

- **Population growth — exponential and logistic population models**

  Population growth depends on the birth rate and death rate. As long as there are sufficient resources available, there will be an increase in the population over time.

  Changes in population growth in response to changes in limiting factors (such as resource availability and/or biotic factors) can be modelled.

  In the exponential growth model, a population increases over time regardless of resource limits or abiotic factors. A graph showing exponential population growth will have a characteristic J-shaped curve.

  In nature, exponential growth is not sustainable as eventually a population will exceed resource availability and/or be affected by density-dependent factors.

  In the logistic growth model, a population may grow exponentially until it reaches the carrying capacity of its environment, then will slow. A graph showing logistic population growth will have a characteristic S-shaped curve.

  In nature, logistic population growth is more sustainable than exponential population growth, as resource availability and biotic factors ensure that a population growth rate exceeding the carrying capacity can only ever be temporary. Scientists have observed that population oscillations mean that most populations seldom reach the carrying capacity and remain relatively stable overall.

- **Population oscillations — carrying capacity, population overshoot, population crash**

  As populations approach their carrying capacity, there will be insufficient resources to support more offspring. The population may temporarily exceed (overshoot) the carrying capacity and start to die off (crash) because of insufficient resources. The environment will then start to recover due to reduced population pressure, and after a period of time will be able to support increased population growth. This results in a series of population overshoots and crashes known as oscillations.

Living environment

- **The effects of density-independent factors on the stability of ecosystems**

  Density-independent factors affect the size of a population independent of the population density. These factors tend to be natural disasters.

3 Human influences on biodiversity

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Base flow, diffuse pollution, environmental assessment, environmental impact assessment (EIA), environmental monitoring, groundwater, habitat, habitat destruction, habitat fragmentation, hydrograph, initiative, invasive non-native species (INNS), keystone species, lag time, legislation, marine protected area (MPA), native species, non-native species, peak discharge, peak rainfall, plagioclimax, point pollution, policy, pollution, reforestation, rewilding, runoff, site of special scientific interest (SSSI), strategic environmental assessment (SEA), strategy

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Species reduction or increase through human activities and the influence on biodiversity**

- **Habitat fragmentation, destruction, rewilding**

  Habitat fragmentation results in the reduction of a large habitat area into smaller, scattered remnants and can have implications for biodiversity, including ecosystem diversity, species diversity, and genetic diversity. Loss of keystone species in particular can have a disproportionate impact on an ecosystem. Fragmentation impacts can include reduction in the total area of the habitat, reduction in the average size of each patch of habitat, and isolation of fragments.

  Habitat destruction leaves natural habitat unable to support species and communities within it. This reduces biodiversity, sometimes to the point of extinction.

  Rewilding involves activities that initiate or accelerate the recovery of habitats or ecosystems with respect to their health, integrity and sustainability. These activities can include erosion control, reforestation, use of local native species, removal of non-native species, removal of invasive plants, reintroduction of native species and keystone species, and creation of wildlife or habitat corridors to link habitat fragments.

- **Harvesting practices**

  Introduction of sustainable harvesting practices to limit over-exploitation of resources and reduce impacts on habitats, species, and biodiversity.

- **Reintroduction of nationally extinct species, both current and potential** — success, failure and conflict

- **Point and diffuse pollution of air, land and water**

  Point source pollution is discharged from a single location, usually from a pipe, chimney, or other outlet. Discharges are often individually minor but can combine to form diffuse pollution and have a significant environmental impact.

Living environment
Diffuse pollution arises from land use activities spread across large areas that have no specific point of discharge. This includes runoff from farmland, forestry activities, urban areas, roads and sealed surfaces, and industrial premises. ♦ **Plagioclimax** — moorland management for grouse, including muirburn and conservation grazing. ♦ **Conservation practices** — protecting wildlife sites; targeting action on priority species and habitats; embedding consideration of biodiversity in policy and decision-making; engaging people and encouraging behaviour change.
b **Environmental assessment and monitoring** ♦ **Purpose of environmental assessment and monitoring** Environmental impact assessment (EIA) aims to protect the environment by ensuring that a local planning authority has full knowledge of possible significant environmental effects of a proposed development, and mitigation for these, which are taken into account in the decision-making process. Strategic environmental assessment (SEA) aims to provide a high level of protection of the environment from development. It is mandatory for plans and/or programmes that relate to large-scale changes in land use. Environmental monitoring describes the processes and activities that need to take place in order to characterise and assess the quality of an environment over time. ♦ **Use and interpretation of hydrographs in environmental monitoring** — peak rainfall; peak discharge; lag time; base flow; and factors affecting base flow, including runoff, groundwater, and soil water. ♦ **Main roles of key environmental agencies in Scotland** NatureScot (NS), Scottish Environmental Protection Agency (SEPA), Forestry and Land Scotland (FLS) and Scottish Forestry (SF), and Marine Scotland (MS). Roles common to the named agencies include enforcing legislation; advising Scottish ministers, local authority planners, land owners, land managers, land users, and voluntary organisations; shaping national policies; educating the public; and research and monitoring. Scottish Natural Heritage was rebranded as NatureScot in 2020. The agency's statutory functions remain unchanged. Forestry in Scotland is managed by two agencies: — Forestry and Land Scotland — looks after, manages and promotes Scotland's national forests and land, and provides timber supplies — Scottish Forestry — responsible for forestry policy, support and legislation ♦ **Key role of sites of special scientific interest (SSSIs) and marine protected areas (MPAs)**

Living environment

- **Implementation of government policy leading to legislation and initiatives**

  A policy is a plan of action that focuses on a specific target. The methods and principles needed to achieve the policy are set out in a strategy. Legislation and initiatives are then implemented in order to achieve the aims of the strategy and policy. Focus should be on the need for policy, legislation and initiatives. There is no requirement to know specific legislation.

Earth's resources

1 Geosphere

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Bauxite, chemical weathering, constructive plate boundary, convection, convection currents, convergence, core, crust, destructive plate boundary, district heating scheme, divergence, earthquake magnitude, extrusive rock, fault, fold mountains, frictional heat, geothermal energy, geothermal gradient, gravitational contraction, gravitational potential energy, greenhouse gas, ground source heat pump, hydrothermal vent, intrusive rock, kinetic energy, laterite, lava, leaching, magma, mantle, metallic mineral, ocean trench, open cast mining, ore, ore deposit, overburden, particulates, percolation, plate boundary, plate tectonics, radioactive decay, rift valley, runoff, smelting, subduction zone, superheating, tailings

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Earth's internal heat**

- **Sources of Earth's internal heat**

  Extra-terrestrial impacts — during Earth's formation the kinetic energy contained in colliding extra-terrestrial bodies was converted to heat energy upon impact.

  Gravitational contraction — in the early stages of formation, the Earth contracted into a smaller volume, resulting in gravitational potential energy converting to heat energy. At the same time, frictional heat was generated by denser iron and nickel-rich material sinking to the core.

  Decay of radioactive elements — disintegration of natural radioactive elements in the mantle and crust generates heat energy.

- **Heat flow — convection**

  Convection occurs in both the mantle and the core. This is a circulation pattern in which warmer low-density material rises and cooler high-density material sinks. This transfers heat to the Earth's surface and drives plate tectonics.

Earth's resources

b **Mechanisms of plate boundaries**

- **Plate tectonics**

  The surface of the Earth is covered by seven large rigid plates and a number of smaller plates. These plates are all in motion, and not all in the same direction or at the same speed. The movement is caused by convection currents occurring in the underlying mantle. Intense geological activity occurs at plate boundaries, where plates move away from each other, past one another, or towards each other.

- **Constructive plate boundaries**

  These occur where convection currents in the upper mantle are diverging. If this occurs below a continent, a rift valley will form. This type of plate boundary is mostly found in oceans, where the plate type is oceanic on both sides. As the plates move apart, the underlying mantle melts, forming magma. The magma rises upwards, erupting through the crust and filling the gap between the plates, creating new oceanic crust. A chain of underwater volcanoes is created along the spreading plate margins.

  Hydrothermal vents are often located near constructive plate boundaries. Deep faults form when the oceanic plates move apart. Cold seawater percolates down through the faults and is superheated through contact with the magma, before returning to the seafloor via hydrothermal vents.

  The superheated fluids often contain dissolved metallic minerals. As the fluids make contact with the seawater and cool, the dissolved minerals are deposited on the sea floor. The minerals often accumulate in substantial volumes, which can potentially be exploited.

- **Destructive plate boundaries**

  These margins occur where convection currents in the upper mantle are converging, forcing the plates above to move towards each other. Subduction zones occur where continental plate and oceanic plates converge. The oceanic plate moves below the continental plate because it is denser, also carrying down oceanic sediments and seawater. The addition of the sediments and seawater lowers the melting point of the plate materials. The magma generated from subduction zones has high levels of gas present and is very explosive. This molten material forces its way up through faults to the surface of the continental plate, erupting as a volcano. Molten material reaching the surface is known as lava, and cools to form extrusive rock. Magma that cools and solidifies before reaching the surface forms intrusive rock.

  The magma carries concentrated metallic minerals into the upper crust. Significant metallic mineral deposits are often found near ancient plate boundaries.

  As the oceanic plate moves below the continental plate, a deep ocean trench forms at the junction. Subduction also causes crumpling along the edge of the continental plate, forming fold mountain chains. Earthquakes at this boundary can be of high magnitude due to the release of frictional pressure that builds up between the two plates.

Earth's resources

c **Aluminium**

- **Formation of bauxite ore deposits**

  Bauxite is an ore rich in aluminium oxide and is found in extractable quantities in areas associated with subduction zones.

  Bauxite forms in tropical areas around the equator, where high temperatures and abundant rainfall result in extreme chemical weathering of rock. As water percolates through the soil in the hot, humid climate, nutrients dissolve and leach downwards. The soil that remains, known as laterite, can be rich in aluminium oxides and form rich ore deposits near the surface.

- **Environmental impacts of mining and processing bauxite ore**

  The majority of world bauxite production is from surface mines, extracted by open cast mining.

  Environmental issues associated with bauxite mining include:
  - landscape changes through removal of timber, vegetation, rock and soil, with associated impacts on ecosystems and biodiversity
  - control of erosion and runoff from the mine
  - mining disturbs the movement, quality and distribution of water in the area
  - disposal of the overburden, tailings and other waste
  - dust, noise and emissions caused by mining operations and transport

  Environmental issues associated with processing of bauxite include:
  - smelting and processing require enormous inputs of electricity, water and resources, such that power plants are often constructed nearby
  - smelting and processing releases high levels of greenhouse gases, particulates, and other harmful substances
  - bauxite is often transported long distances to countries with processing plants

d **Geothermal energy**

- **Geothermal gradient**
- **Sources of geothermal energy**
  - groundwater: steam and hot water
  - ground source: 'hot rocks'
- **Production of geothermal energy**
  - steam or hot water can be extracted and used to generate electricity or piped directly to district heating schemes
  - ground source heat pumps
- **Benefits and challenges of using geothermal energy**

Earth's resources

2 Hydrosphere

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Aquifer, condensation, Coriolis effect, evaporation, evapotranspiration, global ocean conveyor belt, groundwater, Gulf Stream, infiltration, ocean circulation, ocean gyre, percolation, precipitation, runoff, sublimation, thermohaline circulation, transpiration, upwelling

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Hydrological cycle**

- **Movement processes** — evaporation, condensation, precipitation, infiltration, percolation, transpiration, evapotranspiration, sublimation, runoff
- **Storage**:
  - surface: atmospheric moisture, snow, ice, watercourses, lakes, oceans
  - subterranean: groundwater, aquifers

b **Oceanic circulation**

- **Global ocean conveyor belt**

  The global ocean conveyor belt is a constantly moving system of deep ocean circulation driven by thermohaline circulation and surface wind currents.

  As ocean water in polar regions cools it forms sea ice, drawing out the freshwater and causing the surrounding water to get saltier. This increases its density and the cold water starts to sink. Surface water is pulled in to replace the sinking water, which then also becomes cold and salty enough to sink. This initiates the deep ocean currents driving the global ocean conveyor belt.

  The Gulf Stream transports warm water away from the equator. As more warm water is transported north, the cooler water sinks and moves south of the equator down towards Antarctica. Eventually, the cold bottom waters return to the surface through mixing and upwelling, continuing the ocean conveyor belt that encircles the globe.

  The water that returns to the surface through upwelling is usually rich in nutrients. These boost the growth of primary producers, which support the marine food web.

- **Factors affecting oceanic circulation** — thermohaline circulation, continental location, surface winds, Coriolis effect

Earth's resources
♦ **Ocean gyres** Global winds drag on the water's surface, causing it to move and build up in the direction that the wind is blowing. The wind direction is influenced by the Coriolis effect, resulting in the deflection of major surface ocean currents to the right in a clockwise spiral in the northern hemisphere and to the left in an anti-clockwise spiral in the southern hemisphere. These major spirals of ocean-circling currents occur north and south of the equator, but not at the equator as the Coriolis effect is absent there. The edges of a gyre and its content constantly change with ocean currents and winds, but the circulating nature of ocean gyres traps marine debris and can distribute this over huge surface areas and throughout the top of the water column.
3 Biosphere
Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately: Bio-crude oil, biodiesel, bioethanol, biofuel, biological weathering, biomethanol, brown earth soil, capillary action, chemical weathering, climate, decomposition, eluviation, humification, illuviation, leaching, parent material, physical weathering, podzol soil, pore space, processed biofuel, relief, soil profile, soil structure, soil texture, translocation, weathering This list is not exhaustive, and terms listed here may apply in more than one area.
a **Soils** ♦ **Inputs** — parent material, organisms, relief, climate, time ♦ **Formation processes**: — weathering: physical, chemical and biological — decomposition and humification — translocation: leaching, eluviation, illuviation, capillary action ♦ **Composition** — mineral matter, from disintegration and decomposition of rocks — organic matter, from the decay of plant residues, animal remains and microbial tissues — water, from the atmosphere and reactions in the soil (chemical, physical and microbial) — air or gases, from the atmosphere and from reactions of roots, microbes and chemicals in the soil — organisms: macro (worms, insects) and micro (bacteria) — impact of mineral particle size (sand, silt, clay), organic matter, and pore space on soil structure, soil texture, water and nutrient retention, drainage, aeration, and land use

Earth's resources
♦ **Characteristics of brown earth and podzol soil profiles** — candidates should be able to draw and annotate brown earth and podzol soil profiles — formation of brown earths and podzol soils — the role of temperature and precipitation, and the resulting biological conditions ♦ **Commercial uses of brown earth and podzol soils**
b **Processed biofuels — biodiesel, bio-crude oil, biomethanol, bioethanol** ♦ **Sources** ♦ **Advantages and disadvantages of using processed biofuels**
4 Atmosphere
Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately: Albedo, biome, Coriolis effect, equatorial rainforest, Ferrel cell, global energy budget, Hadley cell, hot desert, ice sheet, insolation, latitude, Milankovitch cycles, natural climate change, natural greenhouse effect, Polar cell, solar flare, solar radiation, sunspot, surface wind patterns, temperate rainforest, tri-cellular model, tundra This list is not exhaustive, and terms listed here may apply in more than one area.
a **Composition of the atmosphere** — nitrogen, oxygen, argon, carbon dioxide, methane, water vapour, and small amounts of other gases
b **Atmospheric circulation** ♦ **Global energy budget** Refers to the balance between incoming and outgoing solar radiation. Insolation varies at different times of the year and for different latitudes. Approximately two-thirds of incoming solar radiation is absorbed by the atmosphere (clouds, water vapour, gases, dust) and Earth's surface (land, water, plants). The remainder is reflected by Earth's surface, clouds, atmospheric gases and dust. The proportion of solar radiation that is reflected by a body or surface is known as the albedo. This can range from a value of 0 (no reflection) to 1 (100% reflection). The average albedo for Earth is 0·31. The amount of reflected energy changes with surface character. Snow and ice reflect solar energy back into space and have a high albedo, whereas the albedo for forests, oceans, and deserts is low as more energy is absorbed by ground and water.

Earth's resources

- **Tri-cellular model**

  There is a net gain of solar energy in tropical latitudes and a net loss towards the poles due to the angle at which insolation strikes the Earth's surface. Atmospheric and oceanic circulation redistributes this energy, so energy is moved from areas of surplus (between 38° north and south) to areas of deficit (above 38° north and below 38° south). This process maintains the global energy balance.

  The tri-cellular model explains the redistribution of energy from areas of surplus to areas of deficit:
  - Hadley, Ferrel and Polar cells
  - Surface wind patterns
  - Coriolis effect

- **Biomes**
  - Influence of temperature and precipitation in determining geographic distribution of plants and animals
  - High atmospheric pressure — hot desert, tundra
  - Low atmospheric pressure — rainforest (equatorial and temperate)

c **Natural climate change**

Geological records spanning millions of years indicate a number of significant variations in Earth's climate, evidenced by ice ages and warmer interglacial periods.

- **Long term** — orbital changes (Milankovitch cycles), plate tectonics

  Milankovitch cycles — as Earth orbits around the Sun, cyclical variations in Earth–Sun geometry combine to produce variation in the amount of solar energy reaching Earth. These include changes in:
  - The shape of Earth's orbit around the Sun. This varies from elliptical to nearly circular. When the orbit is circular, the amount of insolation received on an annual basis is greater and the Earth's temperature increases.
  - The tilt of Earth's axis towards or away from the Sun. The angle of tilt varies over time. Greater tilt means more severe seasonal variation (warmer summers, colder winters), and vice versa. Cool summers allow snow and ice to persist at high latitudes, building up into ice sheets. The high albedo of snow and ice causes additional cooling.
  - The orientation of the Earth's axis of rotation. This changes over a period of time, and is driven by tidal changes influenced by the Sun and the Moon. This results in one polar hemisphere being closer to the Sun than the other, changing the amount of insolation reaching each.
  - Plate tectonics — geological and fossil evidence supports the theory that Earth's continental plates have changed position and shape. Once part of a giant landmass at the South Pole, the breaking up and movement of the continental plates to their current positions has impacted on atmospheric and oceanic circulation, both of which have affected climate.

Earth's resources
♦ **Short term** — volcanic activity, sunspot activity Volcanic activity reduces the Earth's temperature due to the introduction of ash and other particulates into the upper atmosphere. This results in less insolation reaching Earth. In the longer term, volcanoes introduce higher levels of carbon dioxide and other greenhouse gases into the atmosphere, which trap heat. Sunspot activity — sunspots are storms on the Sun's surface that are marked by intense magnetic activity, resulting in solar flares and ejection of hot gases. During periods of maximum sunspot activity the Sun emits more energy.

Sustainability

The focus of this topic should be on the environmental, economic and social components of sustainability, and the relationship between these. These should be considered with regard to developed and developing countries.

1 Global challenges

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Energy security, food security, water security

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Demand for global resources**

- **Food**: increasing population; changes in consumer demand; and changes brought about by development and climatic change.
- **Water**: increasing population; increasing demand by agriculture and industry; and changes brought about by development and climatic change.
- **Energy**: increasing population; changes in consumer demand; increasing demand by transportation, domestic, agriculture, industry; and changes brought about by development and climatic change.

b **Security of access to food, water and energy**

- **Food** — access, quantity and quality.
- **Water** — areas of the world that are most likely to experience water insecurity are places with low rainfall, or rapid population growth in a freshwater scarce area, or areas with international competition over water sources, or combinations of these.
- **Energy** — access to 'cheap' energy has become essential to the functioning of modern economies, but the uneven distribution of energy supplies among countries has led to significant vulnerabilities.

2 Food

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Agrochemicals, algal bloom, aquaculture, bioaccumulation, biological oxygen demand (BOD), biomagnification, crop rotation, diversification, eutrophication, genetic modification (GM), high yield varieties, hydroponics, intensive agriculture, marginal land, mechanisation, metabolisation, nutrient enrichment, persistent organic compounds (POPs), pollutant, selective breeding, sustainability, sustainable development, trophic level

This list is not exhaustive, and terms listed here may apply in more than one area.

Sustainability

Strategies to increase global food production

- **Development of intensive agriculture** — changes in land management: larger fields, crop rotation, drainage, hedgerow removal, cultivation of marginal land, conservation practices, diversification
- **Changes in technology** — mechanisation, agrochemicals (fertilisers, pesticides), irrigation, selective breeding, high yield varieties, GM crops, hydroponics
- **Aquatic food production**
  - aquaculture: high density cages, pesticide use, selective breeding, GM, hormone use
  - marine fisheries: stock management
- **Impacts of intensive food production** — use of nitrate-based and phosphate-based fertilisers, and pesticides

Nitrates and phosphates absorbed by plants are used for growth. The use of chemical fertilisers and phosphate-based detergents has greatly increased the levels of nitrates and phosphates entering waterbodies. These cause nutrient enrichment of the water, known as eutrophication, which enhances aquatic plant growth.

Algae in nutrient-enriched water undergo a population explosion, which is referred to as an algal bloom. As the bloom spreads across the water surface, light and oxygen are prevented from penetrating the water, which affects aquatic life. When the algae and aquatic organisms die, they are decomposed by bacteria, increasing the BOD of the waterbody. At the same time, the decomposition process releases more nitrates and phosphates into the water, causing further eutrophication.

Pesticides belong to a group of chemicals known as persistent organic pollutants (POPs), which are compounds that are resistant to environmental degradation.

Pesticides applied in fields can enter waterbodies, where they are absorbed by aquatic invertebrates through their skin, gills or lungs. The pollutant is stored in the tissues of the organism at a rate faster than it can be metabolised or excreted, a process known as bioaccumulation. This does not cause much damage at lower trophic levels.

As a consumer eats more contaminated prey, the level of pollutant gradually builds up in its tissues. This predator will in turn be consumed as prey, and the concentration of the pollutant will increase as it is passed up the food chain, eventually reaching toxic levels. The dietary uptake of the pollutant and its movement through trophic levels is known as biomagnification. This causes significant harm to organisms in the higher trophic levels, such as impairment of the immune and reproductive system.

Sustainability

3 Water

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Anaerobic digestion, biogas, biological oxidation, blackwater, coagulation, desalination, disinfection, drip irrigation, effluent, filtration, floc, flocculation, greywater, pathogen, purification, screening, sedimentation, sewage liquor, sewage sludge

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Sustainable management of water resources**

- **Desalination** — including reasons for desalination. A knowledge of methods of desalination is not required.
- **Water conservation methods in agriculture and industry**
  - agriculture: drip irrigation, drought-resistant crops
  - industry: modification of processes, replacement of equipment, reuse of greywater and blackwater

b **Improving water quality**

- **Methods used to improve water quality**

  The water purification process has multiple stages. Developed countries tend to follow the full process but developing countries may use a much reduced programme, depending on resources.

  Methods:
  - Screening, to remove larger pieces of debris from surface water.
  - Coagulation and flocculation involves the addition of a coagulant chemical that causes smaller particles to clump together, forming floc.
  - Sedimentation, to allow the floc to settle out as sludge.
  - Filtration, to remove bacteria, parasites and remaining suspended particles. Methods used in developed and developing countries are to be included.
  - Disinfection, to kill pathogens. Methods used in developed and developing countries are to be included.

c **Sewage treatment**

- **Methods used in sewage treatment**
  - Preliminary treatment — screening to remove bulky solids, and grit removal.
  - Primary treatment — sedimentation to remove remaining solids. Produces sludge and liquor; sludge is removed and treated, liquor passes to the next stage.
  - Secondary treatment: biological oxidation using micro-organisms and aeration removes dissolved and suspended organic matter. Sludge is removed and treated, liquor passes to the next stage.
  - Tertiary treatment: filtration, to remove remaining suspended matter and toxins from the liquor, which is now known as effluent.
  - Discharge of effluent to river or sea.

Sustainability
— End uses of sewage sludge: heat-treated and used as fertiliser; turned into sludge cake and used for energy generation through incineration; anaerobic digestion to generate biogas, used for heat and electricity generation.
4 Energy
Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately: Catalyst, electrolysis, fission, fracking, fuel cell, gasification, hydrogen power, pyrolysis, shale gas, steam methane reforming This list is not exhaustive, and terms listed here may apply in more than one area.
a **Shale gas** ♦ **Extraction of shale gas** — fracking ♦ **Benefits and challenges of extraction of shale gas**
b **Hydrogen power** ♦ **Sources** — natural gas, coal, water, biomass ♦ **Energy production from these sources** — steam methane reforming, gasification, pyrolysis, electrolysis Steam methane reforming involves the reaction of natural gas with steam in the presence of a catalyst to produce hydrogen and carbon. Gasification or pyrolysis of coal or biomass produces a mix of hydrogen and carbon monoxide. Electrolysis involves the splitting of water molecules into hydrogen and oxygen using electricity and an electrolyser device (fuel cell). ♦ **Advantages and disadvantages of using hydrogen as a fuel**
c **Nuclear energy** ♦ **Source** — uranium ore ♦ **Production** — fission Fission is the main process used for generating nuclear energy, and involves splitting of atoms to release energy which can then be harnessed. Uranium-235 (^{235}U) is used in the fission process as its atoms have relatively large nuclei that are easy to split. When ^{235}U undergoes fission, the nucleus splits into two smaller nuclei plus a few neutrons, releasing heat energy and gamma radiation. The neutrons hit other uranium nuclei and cause them to split, causing a chain reaction. The chain reaction must be controlled in a nuclear reactor to stop it going too fast.

Sustainability
In a nuclear power station, the energy released through fission is used to heat water and generate steam, which turns turbines and generates electrical power. ♦ **Advantages and disadvantages of nuclear power generation**
5 Waste management
Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately: Circular economy, closed loop recycling, energy recovery, food use-by date, incineration, landfill, life cycle analysis, linear economy, obsolescence, open loop recycling, planned obsolescence, psychological obsolescence, technological obsolescence, waste disposal, waste hierarchy, waste prevention, waste recovery, waste recycling, waste reuse This list is not exhaustive, and terms listed here may apply in more than one area.
a **Life cycle analysis (LCA)** ♦ **Purpose** LCA examines the total environmental impact of a product through every step of its life, from obtaining raw materials to disposal. It is a systematic process, identifying and quantifying all inputs (materials, energy, fuels) and outputs (products, waste, emissions) for a whole life cycle or for individual stages. Manufacturers can then evaluate the results and consider where change might be made. ♦ **Circular and linear economic models** The circular economy has been devised as an alternative to the 'take, make, dispose' nature of the linear model, as a solution to waste generation.
b **Waste generation** ♦ **Globalisation of supply chains** ♦ **Obsolescence** — technological, planned, psychological ♦ **Packaging** Packaging is used to facilitate transport and storage of products to protect them from damage. It is used to display products such as food and technological gadgets. Packaging protects against unnecessary waste but is itself considered waste. Pressure from government and society is forcing the packaging industry to consider how its products can be made more sustainable. In addition to reducing the volume of packaging, focus is on use of renewable energy in sourcing, manufacturing, transporting and recycling processes; use of renewable or recycled source materials; and amending production practices.

Sustainability

c **Waste hierarchy**

- **Purpose** — ranks waste management options according to what is best for the environment.
- **Prevention** — using less material in design and manufacture; keeping products for longer; reuse; using less hazardous materials; improved quality control and process monitoring, food use-by dates and impact on food waste, education.
- **Preparation for reuse** — checking, cleaning, repairing, refurbishing, whole items or spare parts.
- **Recycling** — turning waste into a new substance or product, including composting.

  Open loop and closed loop recycling

  In open loop recycling, a loss of quality often occurs with each recycling cycle, limiting the number of times the material can be recycled. An example is plastic, which is reprocessed into a lower grade product each time. Eventually it will not be recyclable and will become waste.

  In closed loop recycling, a product can be recycled indefinitely back into itself without any impact on its quality. An example is aluminium. Recycling aluminium requires approximately 5% of the energy needed to produce it from bauxite, reducing waste, resource depletion, and anthropogenic greenhouse gas emissions.
- **Recovery of energy and materials from waste**
- **Disposal — landfill and incineration without energy recovery**

d **Impact of waste on the environment**

Impacts on air quality; water quality; landscape, including the marine environment; biodiversity; and climate change.

Sustainability

6 Anthropogenic climate change

Candidates should be familiar with the definitions of the following terms, and be able to use them appropriately:

Anthropogenic, anthropogenic greenhouse gas, climate change, desertification, enhanced greenhouse effect, global warming, greenhouse gas, sea level, soil stability, weather

This list is not exhaustive, and terms listed here may apply in more than one area.

a **Anthropogenic greenhouse gases** — carbon dioxide, methane, nitrous oxide, water vapour

- **Sources** — candidates must know two sources of each of the anthropogenic greenhouse gases.

b **Impacts of global warming and climate change**

— changes in weather patterns; snow and ice cover; soil stability, including desertification; sea level, and ocean currents

— impacts on ecosystems, species distribution, and biodiversity; and on food production

c **Minimising the impacts of anthropogenic climate change**

Appraisal of sustainable strategies at individual, local, national, and international levels.

Apparatus and techniques

In addition to the key areas, candidates must have knowledge of the following pieces of apparatus and techniques. Where it is not possible to carry out a field work technique, candidates should be made aware of the purpose and methodology of the technique through teaching.

Apparatus

- beaker
- balance
- measuring cylinder
- dropper and/or pipette
- test tube
- stopwatch
- funnel
- crucible
- oven
- microscope
- quadrat
- transect
- thermometer
- anemometer
- rain gauge
- floats
- test kits: soil pH, soil nitrate and/or nitrite
- ID cards and/or keys: plants and animals

Techniques

- qualitative techniques — identification of species using paired statement keys
- quantitative techniques used for sampling plants and animals
- random sampling — simple, systematic, stratified
- measuring abiotic factors
- assessing distribution of species using transect, quadrat, and biotic and biodiversity indices
- assessing population of species using capture-mark-recapture
- interpreting case study documentary evidence, including Ordnance Survey map content, sketch maps, photographic evidence, tabular data, and/or short passages of text. The ability to read and provide grid references is not required.

Reporting experimental and/or field work

Candidates should be familiar with the following:

- setting an aim and/or hypothesis
- selecting information: quantitative and qualitative, discrete and continuous
- planning, designing and undertaking experimental/field work procedures safely
- summarising experimental/field work procedures
- drawing labelled diagrams of experimental/field work apparatus
- presenting data in tabular form, with appropriate headings and units of measurement
- presenting data in graphical form: bar graph, line graph, pie chart, scatter graph or other graphical form appropriate to environmental science, with appropriate scales, labels, keys and units, and including a line of best fit (straight or curved) if appropriate, to represent the trend observed in experimental/field work data
- processing data (using calculations and units, where appropriate)
- comparing and/or analysing data sets
- drawing valid conclusions from the data and giving explanations supported by evidence/justification, and related to the aim
- evaluating experimental/field work procedures and suggesting and justifying improvements
- citing and referencing sources of data/information

Calculations

Candidates should be familiar with the following methods of calculation:

- measures of average: mean, median
- measures of spread: standard deviation, interquartile range
- ratio
- percentage increase and decrease
- calculations involving number substitution in formulae

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level, and can be found on the SCQF website.

Skills for learning, skills for life and skills for work

This course helps candidates to develop broad, generic skills. These skills are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work and draw from the following main skills areas:

1 Literacy

1.2 Writing

2 Numeracy

2.1 Number processes
2.2 Money, time and measurement
2.3 Information handling

4 Employability, enterprise and citizenship

4.6 Citizenship

5 Thinking skills

5.3 Applying
5.4 Analysing and evaluating
5.5 Creating

Teachers and/or lecturers must build these skills into the course at an appropriate level, where there are suitable opportunities.

Course assessment

Course assessment is based on the information provided in this document.

The course assessment meets the key purposes and aims of the course by addressing:

- breadth — drawing on knowledge and skills from across the course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in experimental and/or field work procedures or theoretical contexts as appropriate

This enables candidates to apply:

- breadth and depth of skills, knowledge and understanding from across the course to answer questions in environmental science
- skills of scientific inquiry, using related knowledge, to carry out a meaningful and appropriately challenging task in environmental science and communicate findings

The course assessment has three components: two question papers and an assignment. The relationship between these three components is complementary, to ensure full coverage of the knowledge and skills of the course.

Course assessment structure: question papers

Question paper 1 — 20 marks

Question paper 2 — 100 marks

The question papers have a total mark allocation of 120 marks. This contributes 80% to the overall marks for the course assessment

The question papers give candidates an opportunity to demonstrate the following skills, knowledge and understanding:

- making accurate statements
- describing information and providing explanations and integrating knowledge
- applying environmental science knowledge to new situations, analysing information and solving problems
- planning or designing experiments/field work procedures to test given hypotheses or to illustrate particular effects
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence and/or information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experiments/field work investigations and suggesting improvements

Question paper 1

This paper assesses the application or extension of knowledge and/or skills in unfamiliar situations, field work and theoretical contexts. It also assesses scientific inquiry skills, analytical-thinking skills and the impact of applications on society and the environment.

This paper comprises a case study of an application of environmental science, with short, structured-response questions worth a total of 20 marks. These questions typically have a mark allocation of 1–3 marks. The paper samples knowledge and understanding plus a selection of skills. In a final question, candidates are asked to use the source materials and their own environmental science knowledge to draw a conclusion, for example to recommend a resolution to an issue, and provide justification for this. This question is worth 4–5 marks.

Data and information pertaining to the case study are provided in a separate supplementary booklet.

Approximately 50% of the marks are awarded for demonstrating and applying knowledge and understanding, and approximately 50% for applying scientific inquiry, analytical thinking, problem-solving skills, and the impacts of applications of environmental science on society and the environment.

Question paper 2

This paper has two sections.

Section 1

Section 1 contains structured-response questions totalling 80 marks. This section samples knowledge and understanding and a selection of skills by presenting candidates with appropriately challenging context-based questions of around 10 marks, broken down into sub-parts.

Section 2

Section 2 has a total of 20 marks available to candidates. It consists of:

- one pair of structured extended-response questions, with candidates required to select and answer one of the options
- one pair of unstructured extended-response questions, with candidates required to select and answer one of the options

Each extended-response question is worth 10 marks.

The structured extended-response questions may integrate key areas and skills from different areas of the course.

Setting, conducting and marking question papers

The question papers are set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA.

Candidates have 45 minutes to complete question paper 1.

Candidates have 2 hours and 30 minutes to complete question paper 2.

Specimen question papers for Higher courses are published on SQA's website. These illustrate the standard, structure and requirements of the question papers candidates sit. The specimen papers also include marking instructions.

Course assessment structure: assignment

Assignment 20 marks

The assignment has a total mark allocation of 20 marks. This is scaled to 30 marks by SQA. This contributes 20% to the overall marks for the course assessment.

The assignment assesses the application of skills of scientific inquiry and related environmental science knowledge and understanding.

It allows assessment of skills that cannot be assessed through the question paper, for example, the handling and processing of data gathered from experimental/field work by the candidate.

Assignment overview

The assignment gives candidates an opportunity to demonstrate the following skills, knowledge and understanding:

- applying knowledge of environmental science to new situations, interpreting information and solving problems
- planning or designing and carrying out experiments/field work investigations to test given hypotheses or to illustrate particular effects
- recording detailed observations and collecting data from experiments/field work investigations
- selecting information from a variety of sources
- presenting information appropriately in a variety of forms
- processing information (using calculations and units, where appropriate)
- making predictions and generalisations from evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- evaluating experimental/field work investigations and suggesting improvements
- communicating findings/information effectively

The assignment offers challenge by requiring candidates to apply skills, knowledge and understanding in a context that is one or more of the following:

- unfamiliar
- familiar but investigated in greater depth
- integrating a number of familiar contexts

Candidates research and report on a topic that allows them to apply skills and knowledge in environmental science at a level appropriate to Higher.

The topic must be chosen with guidance from teachers and/or lecturers and must involve experimental/field work investigations.

The assignment has two stages:

- research
- report

The research stage must involve experimental or field work which allows measurements or counts to be made. Candidates must also gather data/information from the internet, books, journals, or maps.

Candidates must produce a report on their research.

Setting, conducting and marking the assignment

Setting

The assignment is:

- set by centres within SQA guidelines
- set at a time appropriate to the candidate's needs
- set within teaching and learning and includes experimental/field work at a level appropriate to Higher

Conducting

The assignment is:

- an individually produced piece of work from each candidate
- started at an appropriate point in the course
- conducted under controlled conditions

Marking

The assignment has a total of 20 marks. The table gives details of the mark allocation for each section of the report.

Section	Expected response	Marks
Aim	An aim that describes clearly the purpose of the investigation.	1
Underlying environmental science	An account of environmental science relevant to the aim of the investigation.	3
Data collection and handling	A brief summary of an approach used to collect experimental/field work data.	1
	Sufficient raw data from the candidate's experiment/field work.	1
	Data, including any mean and/or derived values, presented in a correctly produced table(s).	1
	Data/information relevant to the experiment/field work investigation obtained from an internet/literature source, **or** data relevant to the aim from a second experiment/field work investigation.	1
	A citation and reference for a source of internet/literature data or information.	1
Graphical presentation	An appropriate format from the options of bar graph, line graph, scatter graph, pie chart or other display method appropriate to environmental science	1
	The axis/axes of the graph has/have suitable scale(s).	1
	The axes of the graph have suitable labels and units.	1
	Accurately plotted data points and a line (line graph) or clear bar tops (bar graph) or angles (pie chart) or a line of best fit (scatter graph).	1
Analysis	Analysis of experimental/field work data.	1
	A correctly completed extended or statistical calculation based on the experimental/field work data	1
Conclusion	A valid conclusion that relates to the aim and is supported by all the data in the report.	1
Evaluation	Evaluation of the investigation.	3
Structure	A clear and concise report with an informative title.	1
TOTAL		**20**

The report is submitted to SQA for marking.

All marking is quality assured by SQA.

Assessment conditions

Controlled assessment is designed to:

- ensure that all candidates spend approximately the same amount of time on their assignments
- prevent third parties from providing inappropriate levels of guidance and input
- mitigate concerns about plagiarism and improve the reliability and validity of SQA awards
- allow centres a reasonable degree of freedom and control
- allow candidates to produce an original piece of work

Detailed conditions for the assessment are given in the assignment assessment task.

Time

It is recommended that no more than 8 hours is spent on the **whole** assignment. A maximum of 2 hours is allowed for the report stage.

Supervision, control and authentication

There are two levels of control.

Under a high degree of supervision and control	Under some supervision and control
♦ the use of resources is tightly prescribed ♦ all candidates are within direct sight of the supervisor throughout the session(s) ♦ display materials which might provide assistance are removed or covered ♦ there is no access to e-mail, the internet or mobile phones ♦ candidates complete their work independently ♦ interaction with other candidates does not occur ♦ no assistance of any description is provided	♦ candidates do not need to be directly supervised at all times ♦ the use of resources, including the internet, is not tightly prescribed ♦ the work an individual candidate submits for assessment is their own ♦ teachers and/or lecturers can provide reasonable assistance

The assignment has two stages:

Stage	Level of control
♦ research	conducted under some supervision and control
♦ report	conducted under a high degree of supervision and control

Resources

Please refer to the instructions for teachers and lecturers within the assignment assessment task.

It is not permitted at any stage to provide candidates with a template or model answers.

In the research stage:

- teachers and/or lecturers must ensure that a range of topics is available for candidates to choose from
- teachers and/or lecturers must minimise the number of candidates investigating the same topic within a class
- teachers and/or lecturers must agree the choice of topic with the candidate
- teachers and/or lecturers must provide advice on the suitability of the candidate's aim
- teachers and/or lecturers can supply a basic list of instructions for the experimental/field work procedure(s)
- candidates must undertake research using **only** websites, journals, books and maps
- a wide list of URLs and/or a wide range of books, journals and maps may be provided

Teachers and/or lecturers must not:

- provide an aim
- provide candidates with experimental/field work data
- provide candidates with a blank or pre-populated table for experimental/field work results
- provide candidates with feedback on their research

The only materials which can be used in the report stage are:

- the instructions for candidates, which must not have been altered
- the experimental/field work method(s), if appropriate
- the candidate's raw experimental/field work data, which may be tabulated; the table must not have additional blank or pre-populated columns for mean and derived values
- numerical and/or graphical data from an internet/literature source, which must not include sample calculations
- extract(s) from internet/literature sources to support the description of the underlying environmental science, which must not include sample calculations
- a record of the source(s) of data or extracts from the internet/literature

Candidates must not have access to a previously prepared draft of a report or any part of a report.

In addition, candidates must not have access to the assignment marking instructions during the report stage.

Candidates must not have access to the internet during the report stage.

Teachers and/or lecturers must not provide any form of feedback to a candidate on their report.

Following completion of the report stage candidates must not be given an opportunity to redraft their report.

Teachers and/or lecturers must not read the reports before they are submitted to SQA.

Reasonable assistance

The term 'reasonable assistance' is used to describe the balance between supporting candidates and giving them too much assistance. Candidates must undertake the assessment independently. However, reasonable assistance may be provided before the formal assessment process (research stage and report stage) takes place. If candidates have been entered for the correct level of qualification, they will not require more than a reasonable level of assistance to carry out the assignment.

Evidence to be gathered

The following candidate evidence is required for this assessment:

- a report

The report is submitted to SQA, within a given timeframe, for marking.

The same report cannot be submitted for more than one subject.

Volume

There is no word count.

Grading

Candidates' overall grades are determined by their performance across the course assessment. The course assessment is graded A–D on the basis of the total mark for all course assessment components.

Grade description for C

For the award of grade C, candidates will typically have demonstrated successful performance in relation to the skills, knowledge and understanding for the course.

Grade description for A

For the award of grade A, candidates will typically have demonstrated a consistently high level of performance in relation to the skills, knowledge and understanding for the course.

Equality and inclusion

This course is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

For guidance on assessment arrangements for disabled candidates and/or those with additional support needs, please follow the link to the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Further information

The following reference documents provide useful information and background.

- Higher Environmental Science subject page
- Assessment arrangements web page
- Building the Curriculum 3–5
- Guide to Assessment
- Guidance on conditions of assessment for coursework
- SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work
- Coursework Authenticity: A Guide for Teachers and Lecturers
- Educational Research Reports
- SQA strategy for e-Assessment
- SQA e-assessment web page
- SCQF website: framework, level descriptors and SCQF Handbook

Appendix 1: course support notes

Introduction

These support notes are not mandatory. They provide advice and guidance to teachers and lecturers on approaches to delivering the course. You should read these in conjunction with this course specification, the specimen question paper and the assignment assessment task.

Developing skills, knowledge and understanding

This section provides further advice and guidance about skills, knowledge and understanding that you could include in the course. Teachers and lecturers have considerable flexibility to select contexts that will stimulate and challenge candidates, offering both breadth and depth.

Candidates are actively involved in developing their skills, knowledge and understanding by following an investigative approach. Learning and teaching build on candidates' prior knowledge, skills and experience. A holistic approach is encouraged to aid candidates' understanding of the linkages between the Earth's systems and natural and anthropogenic actions that can impact on the Earth's natural balance.

Teachers and lecturers can use group work to simulate real-life situations, share tasks and promote team-working skills. Practical activities and investigative work can offer opportunities for group work, which should be encouraged.

Where appropriate, experimental/field work procedures should give candidates the opportunity to select activities and/or carry out extended study. Investigative and experimental work is part of the scientific method of working and can fulfil a number of educational purposes. Experimental and field work procedures should include the use of technology and equipment that reflects current scientific use in environmental science. Field work provides an opportunity for practical work, using first-hand experience of an ecosystem to develop knowledge, understanding and problem-solving. The 'apparatus and techniques' table in this course specification details the techniques and equipment that candidates should have knowledge of, as these may be assessed in the question paper. Teachers and/or lecturers are responsible for ensuring that appropriate risk assessment has been carried out and that candidates have guidance on the safe and correct use of equipment.

In addition to programmed learning time, candidates are expected to contribute their own time.

Effective partnership working can enhance the learning experience. Where appropriate, candidates should study locally relevant contexts, with visits if possible. Guest speakers from industry, further and higher education could be invited to share their knowledge of environmental science.

Technology makes a significant contribution to practical work in environmental science. Computer-interfacing equipment can detect changes in variables, allowing experimental results to be recorded over short periods of time and experiments to be completed in class-time. Results can also be displayed in real time, which helps to improve understanding. Data-logging equipment, video cameras or camera traps can be set up to record data and make observations over periods of time longer than a class lesson, which can be subsequently downloaded and viewed for analysis.

Approaches to learning and teaching

Assessment should be integral to, and improve, learning and teaching. The approach should involve candidates and provide supportive feedback. Self-assessment and peer-assessment techniques are encouraged, wherever appropriate. Assessment information can be used to set learning targets and next steps.

Teaching should involve an appropriate range of approaches to develop knowledge and understanding; and skills for learning, life and work. Learning should be experiential, active, challenging and enjoyable, and include appropriate practical experiments and/or field work activities and could be learner-led. A variety of active learning approaches is encouraged, including peer-teaching and assessment, individual and group presentations, role-playing and game-based learning, with learner-generated questions.

As part of learning and teaching and preparation for assessment, it is recommended that candidates carry out several investigations that meet the requirements of the assignment as stipulated in the course specification. This should help candidates develop the necessary skills and prepare them for subsequent assessment.

Suggested activities and resources, which could be used to enhance teaching and learning, are detailed in the following table. Teachers and lecturers may also devise their own learning activities. All resources named were correct at the time of publication but may be subject to change.

Note: access to STEM resources requires teachers and lecturers to register for a free account.

Suggested learning activities and resources

Activities in the suggested learning activities and resources column are not mandatory. They offer examples of suggested activities, from which you could select a range of suitable activities. It is not expected that all will be covered.

Living environment	Suggested learning activities and resources
1 Investigating ecosystems and biodiversity	
a **Assessing biodiversity** ♦ **Biodiversity classifications** — ecosystem diversity, species diversity, genetic diversity	
♦ **Species richness and relative abundance**	Identify variations in a single habitat type (for example grassland) and factors that affect species richness and relative abundance within that habitat. Resources available from: NatureScot — guide to types of species-rich grassland James Hutton Institute — grassland biodiversity

Living environment	Suggested learning activities and resources
1 Investigating ecosystems and biodiversity	
b **Sampling plants and animals** ♦ **Qualitative techniques** — construction and use of paired statement keys	Identify flora and fauna using paired statement keys during site visits and research. Construct keys using principal features of flowering plants, vertebrates and invertebrates.
♦ **Quantitative techniques** — an understanding of the assessment of: density; relative abundance; percentage cover; frequency; distribution (biotic and biodiversity indices, to include Simpson's biodiversity index for terrestrial species, Trent biotic index for aquatic species, and Lincoln index for capture-mark-recapture). Candidates are not required to learn formulae.	Carry out a field work investigation into several local habitats, for example soil, forest, wetland, using appropriate sampling techniques. A range of ecosystems may be explored using field work, a variety of media, and internet research. Produce and present an investigation report.

Living environment	Suggested learning activities and resources
1 Investigating ecosystems and biodiversity	
♦ **Sampling techniques** — transect (point, line and belt); quadrat, including use for assessing density, percentage cover, frequency, and relative abundance; capture-mark-recapture; evaluation of invasive and non-invasive sampling techniques	Investigate changes in species richness across a footpath, using a transect line and quadrat. Science and Plants for Schools (SAPS) — species richness investigation using random sampling (practical 1) and systematic sampling (practical 2). Investigate and compare relative abundance (density and frequency) using quadrats and random sampling. Scottish Seabird Centre — rocky seashore, including assessment of slope SAPS — meadows (practical 3). Use Simpson's diversity index to assess woodland ground vegetation. Offwell Woodland and Wildlife Trust Use the Lincoln index to estimate population size. Offwell Woodland and Wildlife Trust Use the Trent biotic index to estimate environmental damage in a freshwater ecosystem, using kick sampling and identification keys. Nuffield Foundation Additional resources are available from: STEM Learning, Nuffield Foundation — ecology-based practicals. STEM/University of Nottingham — designing investigations.

Living environment	Suggested learning activities and resources
1 Investigating ecosystems and biodiversity	
♦ **Randomisation and statistical analysis in sampling** — random sampling (simple, systematic and stratified); determination of mean, median and mode; determination of standard deviation and interquartile range; reliability and validity of results. Candidates are not required to learn formulae.	Introduce sampling — what type of sampling to use, comparison of results, including processing and interpreting raw data (freshwater and terrestrial). Offwell Woodland and Wildlife Trust Field Studies Council BBSRC — bioscience maths, including capture-mark-recapture, experimental design, vectors, symmetry, geometry, differential equations, division, Pythagoras' theorem, coordinates, factorials, variance, standard deviation. Royal Geographical Society (RGS) — applying data-handling skills in an ecology context.
c **Measuring abiotic factors** ♦ **Aquatic** — temperature, water flow rate, dissolved oxygen content, biological oxygen demand (BOD), pH, salinity, tidal effects ♦ **Terrestrial** — temperature, light intensity, soil (moisture, pH and nutrients), wind velocity (speed and direction), precipitation, slope	Consider the impact of abiotic factors on species presence or absence, including the tolerance ranges of species, for example impact of acidification on marine species. EPA — dissolved oxygen and biological oxygen demand Arboretum — measuring slope. The Geography Site — measuring the velocity of a river.

Living environment	Suggested learning activities and resources
1 Investigating ecosystems and biodiversity	
♦ **Effects of abiotic factors on the frequency and distribution of organisms**	Collect and analyse data on abiotic factors studied through field work and relate this to the distribution of organisms. Field Studies Council — seashore zonation UK ocean acidification research programme Seebacher, F. and Post, E. (2015) 'Climate change impacts on animal migration' in *Climate Change Responses 2:5*.
2 Interdependence	
a **Succession** ♦ **Seral stages in primary and secondary succession**	Compare environmental distribution through, for example, graph interpretation, data-handling exercises. James Hutton Institute — presentations on vegetation succession, including moorland and sand dunes.
♦ **Influence of climate, biotic, and edaphic factors on succession**	Investigate the effects of climatic, biotic and edaphic factors on plant growth. SAPS — fertilisers, the effects of minerals on plant growth SAPS — response of seedlings to light American Phytopathological Society — effect of environment on plant growth.
♦ **Characteristics of a climax community** — stable community, high biodiversity, complex food webs, high biomass	

Living environment	Suggested learning activities and resources
2 Interdependence	
b **Energy conversion, transfer and loss in food chains and webs**	Use data collected from field study sites to investigate feeding relationships and construct food webs. Analyse food webs from various ecosystems. Use food web games to show inter-relationships. Investigate decomposers in relation to soil studies and leaf litter analysis.
♦ **Primary productivity — gross and net**	Environmental Literacy Council — measuring primary productivity in grass. University of New Hampshire — calculating net primary productivity. NASA — map animation showing net primary productivity (NPP).
♦ **Secondary productivity and ecological efficiency**	University of Michigan — the flow of energy through higher trophic levels.
♦ **Impact of endotherms and ectotherms on energy transfer**	Analyse data on energy transfer and food chains and/or webs and carry out calculations on % energy transferred and lost.

Living environment	Suggested learning activities and resources
2 Interdependence	
c **Population dynamics**	
♦ **The effects of density-dependent factors on the stability of ecosystems**	Consider the impact that a change at one trophic level can have on other trophic levels in a food chain/web and ecosystem.
♦ **Population growth — exponential and logistic population models**	Trophic cascades: How wolves change rivers (film, 4:34 mins) How whales change climate (film, 4:52 mins)
♦ **Population oscillations — carrying capacity, population overshoot, population crash**	STEM, Nelson Thornes — the concept of a niche, including species sharing a niche. University of Michigan — predator–prey cycles. Simulistics.com — modelling predator–prey interactions. Cornell Institute for Biology Teachers — modelling predator–prey population oscillations. STEM, OPAL — the impact of pony grazing. STEM — parasites (TED talk, animations). The Biology Project — modelling exponential and logistic population growth.
♦ **The effects of density-independent factors on the stability of ecosystems**	Consider the short- and long-term impacts on biodiversity and ecosystem stability of wildfires, floods, volcanic eruptions.

Living environment	Suggested learning activities and resources
3 Human influences on biodiversity	
a **Species reduction or increase through human activities and the influence on biodiversity**	Investigate past influences using data-based case studies, maps, visits to museums or sites of archaeological interest. Compare food webs between native and plantation woodland.
♦ **Habitat fragmentation, destruction, rewilding**	Habitat fragmentation: NatureScot Trees for Life Forest Research Keystone species: Trees for Life — Scots pine as a keystone species. Rewilding Britain — keystone species and trophic cascades Rewilding: Rewilding Britain Rewilding Europe BBC's The Forum: episode on Rewilding (41 mins)
♦ **Harvesting practices**	Compare the impacts of sustainable vs unsustainable harvesting. PNAS — sea otters, kelp forests, and the extinction of Steller's sea cow. Sustainable Harvest International — sustainable harvesting case studies.

Living environment	Suggested learning activities and resources
3 Human influences on biodiversity	
♦ **Reintroduction of nationally extinct species, both current and potential** — success, failure and conflict.	Research the reintroduction of the capercaillie into Scotland and why the species continues to face an uncertain future. Reintroduction programmes: Association of Zoos and Aquariums IUCN
♦ **Point and diffuse pollution of air, land and water**	Data sets: Air quality in Scotland — pollution data across Scotland, updated hourly. SEPA — environmental data. Pollution control: Environmental Agency — State of the environment: water quality in England SEPA Environment Agency

Living environment	Suggested learning activities and resources
3 Human influences on biodiversity	
♦ **Plagioclimax** — moorland management for grouse, including muirburn and conservation grazing. ♦ **Conservation practices** — protecting wildlife sites; targeting action on priority species and habitats; embedding consideration of biodiversity in policy and decision-making; engaging people and encouraging behaviour change.	Muirburn: NatureScot — Muirburn Code RSPB — costs and benefits of grouse moor management to biodiversity and the wider environment Conservation grazing: Scottish Wildlife Trust 'flying flock' National Trust Investigate case studies: Parliamentary Office of Science and Technology Joint Nature Conservation Committee (JNCC) Conservation Gateway

Living environment	Suggested learning activities and resources
3 Human influences on biodiversity	
b **Environmental assessment and monitoring**	
♦ **Purpose of environmental assessment and monitoring**	Find environmental statements for projects in your area via the internet. GOV.UK — understanding the environmental statement Academy9 — dualling of the A9.
♦ **Use and interpretation of hydrographs in environmental monitoring** — peak rainfall; peak discharge; lag time; base flow; and factors affecting base flow, including runoff, groundwater, and soil water.	Study hydrographs of major rivers running in areas of different climates (for example, compare a hydrograph for the Nile with that for the Congo). Obtain water level data and rainfall data from SEPA and use these to construct a hydrograph for a river in your area.
♦ **Main roles of key environmental agencies in Scotland** — NatureScot (NS), Scottish Environmental Protection Agency (SEPA), Forestry and Land Scotland (FLS) and Scottish Forestry, and Marine Scotland (MS).	
♦ **Key role of sites of special scientific interest (SSSIs) and marine protected areas (MPAs)**	NatureScot — SSSI Scottish Government — MPA
♦ **Implementation of government policy leading to legislation and initiatives**	Investigate the need for policies, legislation and initiatives relating to Scotland's environment. Scottish Government

Earth's resources	Suggested learning activities and resources
1 Geosphere	
a **Earth's internal heat** ♦ **Sources of Earth's internal heat** ♦ **Heat flow — convection**	 Scientific American — why is the Earth's core so hot? The Earth 3D — convection currents and tectonic plates (animation, 1:06 mins).
b **Mechanisms of plate boundaries** ♦ **Plate tectonics**	Study remote sensing images of the Earth, for example satellite, aerial photography, Google Earth, visible light, infrared, radar, lasers. Examine examples of false colour images. Research mineral formation at plate boundaries. Model the main plate tectonic-driving forces: Earth Learning Idea — what drives the plates? The Geological Society — what is a plate? BGS — what causes earthquakes?

Earth's resources	Suggested learning activities and resources
1 Geosphere	
♦ **Constructive plate boundaries**	Model processes at a constructive plate margin: Earth Learning Idea: mantle plume. The Geological Society (case studies, fact sheets, podcasts): Divergent plate boundaries Earthquakes Volcanoes Additional resources available from: BGS (booklet) — earthquakes. National Oceanic and Atmospheric Administration (NOAA) — hydrothermal vents.
♦ **Destructive plate boundaries**	The Geological Society (case studies) — convergent plate boundaries. USGS — subduction

Earth's resources	Suggested learning activities and resources
1 Geosphere	
c **Aluminium** ♦ **Formation of bauxite ore deposits**	Map the worldwide distribution of bauxite deposits. Consider why they are distributed this way. Bauxite formation: Earth Science — aluminium from laterites Paragominas Mine, Brazil
♦ **Environmental impacts of mining and processing bauxite ore**	International Aluminium Institute (resources, data, statistics, animations): World aluminium Sustainable bauxite mining report
d **Geothermal energy**	
♦ **Geothermal gradient**	Energy Education — geothermal gradient.

Earth's resources	Suggested learning activities and resources
1 Geosphere	
♦ **Sources of geothermal energy** — groundwater: steam and hot water — ground source: 'hot rocks'	BGS — geothermal energy UKGEOS — the Glasgow Observatory US Office of Energy Efficiency and Renewable Energy (activities) National Energy Authority — geothermal in Iceland. Research countries which have a high geothermal energy potential, and how they make use of the resource.
♦ **Production of geothermal energy** — steam or hot water can be extracted and used to generate electricity or piped directly to district heating schemes — ground source heat pumps	Energy Saving Trust — ground source heat pumps Krater, J. and Rose, M. (2009) 'Development of Iceland's geothermal energy potential for aluminium production – a critical analysis' UK District Energy Association Earth Learning Idea — geothermal power simulations
♦ **Benefits and challenges of using geothermal energy**	

Earth's resources	Suggested learning activities and resources
2 Hydrosphere	
a **Hydrological cycle** ♦ **Movement processes** — evaporation, condensation, precipitation, infiltration, percolation, transpiration, evapotranspiration, sublimation, runoff ♦ **Storage:** — surface: atmospheric moisture, snow, ice, watercourses, lakes, oceans — subterranean: groundwater, aquifers	Modelling the water cycle: Earth Learning Idea — cycling water and heat in the lab. UCAR — water cycle activity.
b **Oceanic circulation**	Examine maps of ocean currents to see the effects of the Coriolis effect. Investigate ocean surface currents. Investigate why UK seas are ice-free while ice forms elsewhere at similar latitude, for example Hudson Bay. Design and carry out an experiment with water at different temperatures and salinity. Examine satellite images of sea surface temperature.

Earth's resources	Suggested learning activities and resources
2 Hydrosphere	
♦ **Global ocean conveyor belt**	Understand the role that the ocean conveyor belt plays in moving heat and nutrients around the globe. NOAA (resources, animations): Global conveyor belt Upwelling
♦ **Factors affecting oceanic circulation** — thermohaline circulation, continental location, surface winds, Coriolis effect	EarthRef (activity, presentation, resources) — link between water density, thermohaline circulation, coastal upwelling and marine animals. NOAA — surface ocean currents, Coriolis effect, trade winds
♦ **Ocean gyres**	SERC Carleton (activity with resources) — ocean gyre circulation and patterns of primary productivity. NOAA — Great Pacific Garbage Patch.

Earth's resources	Suggested learning activities and resources
3 Biosphere	
a **Soils** ♦ **Inputs** — parent material, organisms, relief, climate, time. ♦ **Formation processes:** — weathering: physical, chemical and biological — decomposition and humification — translocation: leaching, eluviation, illuviation, capillary action ♦ **Composition** ♦ **Characteristics of brown earth and podzol soil profiles** ♦ **Commercial uses of brown earth and podzol soils**	Analyse soil samples from different areas to compare humus, mineral, and moisture content. Use a sedimentation test to assess soil texture (proportions of sand, silt, and clay content) in soils from different areas. Note: this resource is from North America; make sure to use a UK soil texture classification triangle to determine soil texture type (develop the skill of using a triangular graph grid). Label soil profiles of a podzol and a brown earth soil. James Hutton Institute (Higher Geography resources) — presentations include: soils; soil terminology (including soil formation inputs and processes); and posters (soil, brown earths, podzols, gley soils, soil terminology). Scotland's Environment — including 'The State of Scotland's Soils' report and wider impacts. Cranfield University/National Soil Resources Institute — 'A guide to better soil structure.'

Earth's resources	Suggested learning activities and resources
3 Biosphere	
b **Processed biofuels (biodiesel, bio-crude oil, biomethanol, bioethanol)** ♦ **Sources** ♦ **Advantages and disadvantages of using processed biofuels**	Investigate different generations of biofuels and their sources. Biotechnology and Biological Sciences Research Council (BBSRC): Biofuels overview Practical biofuel activities Bioenergy and biofuels discussion toolkits
4 Atmosphere	
a **Composition of the atmosphere** — nitrogen, oxygen, argon, carbon dioxide, methane, water vapour, and small amounts of other gases	Investigate the percentages of the main atmospheric gases. Smithsonian Institution (activities and resources). UCAR
b **Atmospheric circulation** ♦ **Global energy budget**	Investigate the natural greenhouse effect. Australian gov NASA: atmosphere's energy budget, including natural greenhouse effect. Earth's global energy budget teacher guide, including activities on land vs water, albedo, clouds. BBC Bitesize — global heat budget (Higher Geography resource). UCAR — radiation and albedo experiment. National Snow and Ice Data Center — sea ice, including albedo.

Earth's resources	Suggested learning activities and resources
4 Atmosphere	
♦ **Tri-cellular model**	BBC Bitesize — redistribution of energy by atmosphere and oceanic circulation (Higher Geography resources). Met Office — global circulation patterns. SERC Carleton — atmospheric pressure and wind (animations, including Coriolis effect). Geofile Online — variations in weather patterns on the ITCZ.
♦ **Biomes**	Investigate the world's biomes, linking these with atmospheric circulation, precipitation, and temperature. National Geographic — Köppen climate classification. National Snow and Ice Data Center — Arctic climatology and meteorology.
c **Natural climate change** ♦ **Long term** — orbital changes (Milankovitch cycles), plate tectonics	BGS What causes the Earth's climate to change? Climate through time (poster). NASA — Milankovitch cycles
♦ **Short term** — volcanic activity, sunspot activity	Scientific American — the role of sunspots and solar winds in climate change. Solar and heliospheric observatory (SOHO) — our star, the Sun.

Sustainability	Suggested learning activities and resources
1 Global challenges	
a **Demand for global resources** ♦ **Food:** increasing population; changes in consumer demand; and changes brought about by development and climatic change. ♦ **Water:** increasing population; increasing demand by agriculture and industry; and changes brought about by development and climatic change. ♦ **Energy:** increasing population; changes in consumer demand; increasing demand by transportation, domestic, agriculture, industry; and changes brought about by development and climatic change.	Investigate causes of exponential human population growth and its effect on food/water/energy supply. Carry out a comparison of food intake/water usage/energy usage in developed vs developing countries. Investigate changing demands as countries become more developed and switch diets, and the resulting impacts on food provision. UN — water, food and energy demand. FAO aquastat — water use database. World Bank — global consumption database. International Energy Agency — world energy outlook, global shifts in the energy system. Global Dietary Database — global diets, by country and year. University of California — entomophagy.

Sustainability	Suggested learning activities and resources
1 Global challenges	
b **Security of access to food, water and energy** ♦ **Food** ♦ **Water** ♦ **Energy**	Global food security programme World Food Programme — food security analysis. UNESCO — water security, including data. Global Education (teaching resources).
2 Food	
Strategies to increase global food production ♦ **Development of intensive agriculture** — changes in land management: larger fields, crop rotation, drainage, hedgerow removal, cultivation of marginal land, conservation practices, and diversification.	Investigate a food production system with focus on maximising yields, and consider possible environmental impacts of such practices. Use data sets for processing and presenting practice. Research and appraise the advantages and disadvantages of these strategies. UK Government — UK agriculture data, including historical data. NFUS — agriculture in Scotland. Robinson Library — timeline of agricultural developments. University of Reading — history of agriculture. Conservation Agriculture Association UK OISAT — crop rotation and non-chemical pest management. FAO — sustainable land management. Farmers Guide — diversifying farming businesses.

Sustainability	Suggested learning activities and resources
2 Food	
♦ **Changes in technology** — mechanisation, agrochemicals (fertilisers, pesticides), irrigation, selective breeding, high yield varieties, GM crops, hydroponics.	Research and appraise the advantages and disadvantages of these strategies. Bayer — a multi-national pharmaceutical and life sciences company, including agronomy. STEM/Practical Action — technical briefs: developing salt tolerant crops; rainwater harvesting; micro-irrigation. Mechanisation: FAO — sustainable agricultural mechanization. Fertilisers and pesticides: FAO — world fertiliser trends and outlook (PDF published annually). Our World in Data (maps, graphs, data). House of Commons Library — bees and neonicotinoids. UK Parliament — UK insect decline and extinctions Precision agriculture: NESTA CEMA — key technologies and concepts. Irrigation: CDC — types of agricultural water use.

Sustainability	Suggested learning activities and resources
2 Food	
♦ **Aquatic food production** — aquaculture: high density cages, pesticide use, selective breeding, GM, hormone use — marine fisheries: stock management	Selective breeding, high yield varieties and GM crops: The Royal Society — GM in agricultural development. Wellcome Genome — what is selective breeding? Global Food Security — the Green Revolution. National Geographic — the next green revolution. Hydroponics: Thanet Earth — sustainable integrated farm management, CHP electricity generation and export, by-product reuse, rainwater capture and recycling, predator control, bee pollination. Includes resources and activities. Simply Hydroponics (activities). Investigate an aquaculture system, with focus on maximising yields. Investigate the distribution and density of fish farms in Scotland and consider their environmental impact, and steps taken by industry to minimise the impacts. Scottish Government — Scotland's aquaculture. Fish count — development of intensive fish farming. Zero Waste Scotland — integrated multi-trophic aquaculture (including case study). FAO — global aquaculture production statistics.

Sustainability	Suggested learning activities and resources
2 Food	
♦ **Impacts of intensive food production** — use of nitrate-based and phosphate-based fertilisers, and pesticides	Eutrophication: UN Education Programme — use of satellite technology to monitor eutrophication WWF — marine eutrophication, including minimisation. SAPS — practical investigations into eutrophication Bioaccumulation and biomagnification: USGS — biomagnification and biomagnification. Pollution Issues – bioaccumulation and biomagnification. Safer Chemicals, Healthier Families — persistent, bioaccumulative and toxic chemicals (PBTs).

Sustainability	Suggested learning activities and resources
3 Water	
a **Sustainable management of water resources**	Research water conservation methods and appraise the effects and impacts of the methods. STEM — world water (resources and activities).
♦ **Desalination** — including reasons for desalination. A knowledge of methods of desalination is not required.	Desalination: USGS — saline water: desalination. Aqua Tech — mega-scale desalination. Earth Echo — desalination activities.
♦ **Water conservation methods in agriculture and industry** — agriculture: drip irrigation, drought-resistant crops	Water conservation: agriculture Colorado State University — subsurface drip irrigation. ISAAA — biotechnology for the development of drought-tolerant crops.
— industry: modification of processes, replacement of equipment, reuse of greywater and blackwater	Water conservation: industry Alliance for Water Efficiency — water saving tips: commercial, industrial and institutional water use. RUAF — water management. Hydro International — industrial water reuse.

Sustainability	Suggested learning activities and resources
3 Water	
b **Improving water quality** ♦ **Methods used to improve water quality**	Investigate UN Sustainable Development Goals (SDGs) aiming to improve access to clean water and sanitation for all. Water UK — drinking water quality. UN — SDG 6: clean water and sanitation. UNICEF — water and sanitation data. WHO: Drinking water quality guidelines Water treatment methods Treatment technology FAO — water quality monitoring, standards and treatment. Practical Action — including clean water and sanitation: compost toilets, hand pumps, sand dams, solar distillation. WaterAid — WASH (water, sanitation and hygiene). STEM — water quality activities.

Sustainability	Suggested learning activities and resources
3 Water	
c **Sewage treatment** ♦ **Methods used in sewage treatment**	Investigate the impact of untreated sewage on freshwater ecosystems. Research treatment methods, for example septic tanks, pit latrines, composting toilets, piped removal, sewage farms, and the use of biotechnology in sewage treatment. Appraise the environmental impacts of such treatments and consider where these treatments may be used most. Water UK — wastewater treatment. Thames Water — sewage treatment. BORDA/WEDC — decentralised wastewater treatment systems and sanitation in developing countries.

Sustainability	Suggested learning activities and resources
4 Energy	
a **Shale gas** ♦ **Extraction of shale gas** — fracking ♦ **Benefits and challenges of extraction of shale gas**	Consider the debate for and against fracking, including energy security, wider social issues, etc. GOV.UK — guidance on fracking: developing shale gas in the UK. Scottish Government — 'Scottish Government says no to fracking'. BGS — shale gas.
b **Hydrogen power** ♦ **Sources** — natural gas, coal, water, biomass ♦ **Energy production from these sources** — steam methane reforming, gasification, pyrolysis, electrolysis ♦ **Advantages and disadvantages of using hydrogen as a fuel**	Make hydrogen through electrolysis of water. STEM — a hydrogen-oxygen fuel cell (activity). STEM — hydrogen powered cars, including principles of the fuel cell. International Energy Agency — hydrogen production and storage. Chamco — What is Gasification? — including comparison with pyrolysis

Sustainability	Suggested learning activities and resources
4 Energy	
c **Nuclear energy** ♦ **Source** — uranium ore ♦ **Production** — fission ♦ **Advantages and disadvantages of nuclear power generation**	Research the pros and cons of nuclear power, from the point of view of parties for and against its use. Research recent nuclear disasters. Whatisnuclear.com — introduction to nuclear energy. World Nuclear Association: Nuclear power in the world today Chernobyl accident Fukushima Daiichi accident EDF — nuclear energy. Christodouleas, J.P., Forrest, R.D., Ainsley, C.G. and Tochner, Z. (2011) 'Short-term and long-term health risks of nuclear-power-plant accidents' in *New England Journal of Medicine* 364: 2334-2341.

Sustainability	Suggested learning activities and resources
5 Waste management	
a **Life cycle analysis (LCA)** ♦ **Purpose** ♦ **Circular and linear economic models**	Produce a life cycle analysis of a range of household objects, including those made of composite materials. Environment Agency — supermarket carrier bags. Environment Agency — disposable vs reusable nappies. Waste and Resources Action Programme (WRAP) — food and drink, plastic packaging, clothing and textiles, collection and recycling. UL — materials in mobile phones. Ellen MacArthur Foundation — circular economy.
b **Waste generation** ♦ **Globalisation of supply chains** ♦ **Obsolescence** — technological, planned, psychological ♦ **Packaging**	Examine clothing labels to establish where the items were made, then investigate the company's ethics policy. Carry out a class survey to gather views on what influences technology replacement, for example mobile phones. Examine food packaging to determine type of packaging and how it should be disposed. CDP — closing the gap. Raconteur — supply chain strategies. BBC — obsolescence. Packaging News

Sustainability	Suggested learning activities and resources
5 Waste management	
c **Waste hierarchy** ♦ **Purpose** — ranks waste management options according to what is best for the environment. ♦ **Prevention** — using less material in design and manufacture; keeping products for longer; reuse; using less hazardous materials; improved quality control and process monitoring, food use-by dates and impact on food waste, education. ♦ **Preparation for reuse** — checking, cleaning, repairing, refurbishing, whole items or spare parts. ♦ **Recycling** — turning waste into a new substance or product, including composting. **Open loop and closed loop recycling** ♦ **Recovery of energy and materials from waste** ♦ **Disposal — landfill and incineration without energy recovery**	Carry out a waste audit in school or college to determine waste strategy for students, kitchens, etc. Contact local authority (LA) waste officer to find out how waste is handled within the LA area, including the school or college's waste. Compare yearly data for individual LAs and/or Scotland to see changes over time. Gauge student understanding of food use-by, sell-by and best-before dates by examining food packaging. SEPA: Waste data for Scotland and by local authority. Energy from waste FAQs DEFRA: Waste hierarchy guidance Food and drink waste hierarchy Energy from waste guidance Temarry Recycling Inc — open loop vs closed loop recycling HSE — landfill, incineration, energy from waste, anaerobic digestion. Zero Waste Scotland — how businesses can cut costs, reduce waste, save energy and resources. Food Standards Agency — use-by and best-before dates, reducing food waste, etc.

Sustainability	Suggested learning activities and resources
5 Waste management	
d **Impact of waste on the environment** ♦ Impacts on air quality; water quality; landscape, including the marine environment; biodiversity; and climate change.	For any given waste type, consider the implications of its disposal, and its local/national/global impact. This could include examples such as the waste hierarchy, fly-tipping, and littering.

Sustainability	Suggested learning activities and resources
6 Anthropogenic climate change	
a **Anthropogenic greenhouse gases** — carbon dioxide, methane, nitrous oxide, water vapour	Investigate data on increasing atmospheric levels of greenhouse gases from anthropogenic sources.
♦ **Sources** — candidates must know two sources of each of the anthropogenic greenhouse gases.	BGS — man-made greenhouse gases.
b **Impacts of global warming and climate change**	Consider different viewpoints in the media in relation to climate change.
— changes in weather patterns; snow and ice cover; soil stability, including desertification; sea level, and ocean currents	Investigate changes in species distribution/behaviour/adaptation, for example the winter coat of arctic hare, alpine flowers in Scotland, bird species expanding breeding range in UK, migration of butterflies from the continent into UK. Use the Woodland Trust's 'Nature's Calendar' to record first sighting of species; to find out if species are appearing earlier each year.
— impacts on ecosystems, species distribution, and biodiversity; and on food production	IPCC — assessment reports, including physical science basis; impacts, adaptation and vulnerability; and mitigation of climate change. Effects of climate change: NASA WWF Union of Concerned Scientists

Sustainability	Suggested learning activities and resources
6 Anthropogenic climate change	
c **Minimising the impacts of anthropogenic climate change** Appraisal of sustainable strategies at individual, local, national, and international levels.	Consider changes that can be made by individuals in response to government policy, strategies and initiatives. Consider the influence of the media in informing the public, for example Blue Planet 2 and other documentaries on marine plastics. Carrier bag charge: GOV.UK — carrier bags: why there's a charge Zero Waste Scotland — reducing carrier bag use

Glossary of environmental science terms

Environmental science is a subject that involves the use of scientific terminology which may be new to the candidate. The following glossary is intended to provide support to candidates who are building their vocabulary and developing skills in environmental science.

Abiotic	Relating to a non-living feature of an ecosystem, such as light intensity, precipitation, temperature, wind speed or wind direction.
Adaptation	Any feature which makes an organism well suited to living in its environment.
Agrochemical	A chemical such as a fertiliser, hormone, pesticide or soil treatment that improves the production of crops.
Albedo	The proportion of light that is reflected by a body or surface.
Algal bloom	A rapid growth of microscopic algae in water, often resulting in a coloured scum on the surface.
Anaerobic digestion	A process in which bacteria are used to decompose organic matter in an oxygen-free environment, producing biogas and sludge.
Anthropogenic	Caused or influenced by human activity.
Anthropogenic greenhouse gas	Emission of natural greenhouse gas enhanced by human activity. Includes water vapour, carbon dioxide, methane, nitrous oxide, ozone, and fluorocarbons (CFCs, HCFCs and HFCs).
Aquaculture	The rearing of aquatic animals or cultivation of aquatic plants for food.
Aquifer	An underground layer of water-bearing permeable rock or drift deposits (sediments such as sand and gravel) from which groundwater can be extracted.
Assimilation	The conversion of nutrients obtained from outside the body into a useful form that is incorporated into the tissues and organs.
Autotroph	An organism that can produce its own food; usually a green plant that produces its own food via photosynthesis, through the conversion of light energy into chemical energy. Also known as a producer.
Base flow	Water that percolates downwards until it reaches the groundwater reservoir and then flows to surface streams as groundwater discharge.
Bauxite	An ore rich in aluminium oxide, found in extractable quantities in areas associated with subduction zones.
Bioaccumulation	The gradual build-up over time of a chemical or heavy metal in a living organism, through absorption via skin, gills or lungs. Build-up occurs either because the chemical is taken up at a rate faster than it can be used or excreted, or because the chemical or heavy metal cannot be metabolised.
Biocrude oil	A biofuel obtained by heating dried biomass in an oxygen-free environment. Also known as pyrolysis oil or bio-oil.
Biodiesel	A diesel fuel derived from oils and fats in animals or plants.

Biodiversity	The variety of species and ecosystems on Earth and the ecological processes of which they are part. Can be further categorised as ecosystem diversity, species diversity, and genetic diversity.
Bioethanol	An alcohol made by fermentation of carbohydrates from plant materials. It can be mixed with petrol as a fuel for vehicles.
Biofuel	Combustible biomass or a fuel derived from biomass.
Biogas	Gas produced through the fermentation of organic matter.
Biological oxidation	The process by which bacteria and other micro-organisms consume dissolved oxygen and organic substances in sewage.
Biological oxygen demand (BOD)	A measure of the amount of dissolved oxygen used by aerobic micro-organisms when decomposing organic matter in water. Is measured in mg l^{-1} of oxygen consumed over a 5 day period at 20 $^{\circ}$C.
Biological weathering	A form of physical weathering caused by animals, plants, fungi and micro-organisms.
Biomagnification	Arises through consumption of organisms containing bioaccumulated chemicals or heavy metals. The pollutants transfer to the consumer and thus move up through the food chain.
Biomass	The mass of organisms in a given area or volume.
Biome	A regional or global land area characterised by the plants, animals and climate in the area. Temperature and precipitation have a major influence.
Biomethanol	A biofuel produced by gasification of biomass. This involves reactions using steam, intense pressure and limited oxygen.
Biotic	Relating to a living feature of an ecosystem, such as competition, food supply, disease, predation.
Biotic index	A scale showing the quality of an environment based on the types of organisms which inhabit it.
Blackwater	Waste water and sewage from toilets. Can be treated and recycled to produce water for non-potable use, that is not fit for drinking purposes but can be reused for flushing toilets or in industrial processes.
Brown earth soil	A soil type typically found under deciduous forest, with leaf litter resulting in a rich humus. Characterised by indistinct A- and B-horizon boundaries as a result of mixing by soil organisms, especially earthworms.
Capillary action	The movement of soil moisture in any direction within soil as water moves through pore spaces from wet areas to drier areas. Often results in salts from groundwater being raised to the soil surface.
Capture-mark-recapture	A method used in ecology to estimate the size of a population.
Carnivore	An animal that obtains its energy by consuming other animals.
Carrying capacity	The maximum population size of a species that the environment can sustain indefinitely.
Catalyst	A substance that increases the rate of a chemical reaction without undergoing any permanent chemical change.

Chemical weathering	Rainwater reacts with mineral grains in rocks to form new minerals (clays) and soluble salts. These chemical reactions occur particularly when the rainwater is slightly acidic.
Circular economy	An approach where resources, waste, emissions, and energy loss are minimised through use of long-lasting design, maintenance, repair, reuse, reprocessing, and recycling.
Climate	Large-scale, long-term weather patterns.
Climate change	A large-scale, long-term shift in Earth's weather patterns or average temperatures. Encompasses global warming.
Climax community	The final stage of succession, in which a community of plants and animals remains stable and exists in balance with each other and their environment.
Closed loop recycling	Recycling of a material indefinitely without degradation of products, for example glass, aluminium.
Coagulation	Chemical treatment of wastewater to separate out small suspended particles from the water.
Community	All the organisms that live together in an ecosystem.
Competition	An interaction that occurs between organisms whenever there is shared demand for a limited resource.
Condensation	The process of a vapour or gas turning into a liquid.
Constructive plate boundary	This occurs where convection currents in the upper mantle are diverging, forcing the plates apart. Magma rises through the gap, creating new oceanic crust.
Consumer	Any organism that gains its energy from other organisms. Also known as a heterotroph.
Convection current	A circulation pattern in which warmer low-density material rises and cooler high-density material sinks.
Convergence/convergent plate boundary	Two or more tectonic plates move together. See destructive plate boundary.
Core	The Earth's inner core is solid, composed of an iron-nickel alloy, and surrounded by a liquid outer core of molten iron and nickel.
Coriolis effect	The Earth's rotation causes a deflection in the surface wind patterns and surface ocean currents across the globe. The anti-clockwise rotation of the Earth deflects winds to the right in the northern hemisphere and to the left in the southern hemisphere, but has no effect at the equator.
Crop rotation	The practice of growing different crops in succession on the same land, chiefly to avoid depletion of the soil but also to control weeds, diseases and pests.
Crust	The outer layer of the Earth. May be continental or oceanic, and comprise igneous, metamorphic or sedimentary rocks.
Decomposer	An organism that obtains its energy by breaking down dead organic matter, for example bacteria and fungi.
Decomposition	The breaking down of organic materials into smaller constituent parts, especially by the action of decomposers.
Density	The number of individuals of the same species present per unit area or unit volume.

Density-dependent	Interactions between organisms which reduce the population when numbers are high and allow the population to increase when numbers are low.
Density-independent	Factors, usually natural disasters, which reduce the reproduction rate or increase the death rate of organisms independently of population density.
Deposition	The settling out of rock fragments and sediments after transportation by water, wind, ice or gravity.
Desalination	The process of removing salt from seawater.
Desert	An area that receives an average annual precipitation of less than 25 cm.
Desertification	The process by which fertile land becomes desert.
Destructive plate boundary	This occurs where convection currents in the upper mantle are converging, forcing the plates above to move towards each other. The denser plate subducts below the less dense plate, resulting in a net loss of crust.
Detritivore	An animal that obtains its energy by consuming dead organic matter. Examples of detritivores include wood louse, earthworm, maggot.
Diffuse pollution	Pollution that arises from land activities spread across large areas that have no specific point of discharge.
Disinfection	The process of cleaning something, especially with a chemical, in order to destroy pathogens.
Dissolved oxygen concentration	A measure of the amount of free oxygen dissolved in water, which can be used to determine the quality of water and assess its ability to support life.
Distribution	The manner in which a group is arranged geographically. Can change seasonally, in response to resource availability, and in response to other external factors.
District heating scheme	A network of pipes used to deliver heat (hot water or steam) from the point of generation to an end user.
Divergence/divergent plate boundary	Two or more tectonic plates move apart. See constructive plate boundary.
Diversification	This is the branching out from traditional farming by adding new money-making activities such as introducing specialist crops or production methods, offering bed and breakfast, leisure and recreation activities.
Diversity index	A measure of species diversity in a community or area. Takes relative species abundance into account and provides more information about community composition than simply species richness.
Drip irrigation	A method of controlled irrigation in which water is slowly delivered to the root system of plants, either dripped onto the soil surface above the roots or directly to the root zone.
Earthquake magnitude	Earthquakes generate vibrations, known as seismic waves. The magnitude or size of an earthquake can be estimated from the amplitude and length of a seismic wave.
Ecosystem	A natural biological unit made up of living and non-living parts ie the community and the habitat.

Ecological efficiency	The percentage of biomass produced by one trophic level that is transferred and incorporated into biomass at the next trophic level.
Ecosystem diversity	The variation in habitats, living communities, and ecological processes in the living world.
Ectotherm	An animal that relies on external environments for temperature control instead of generating their own body heat.
Edaphic	Relating to the physical, chemical and biological characteristics of soil that affect living organisms.
Effluent	Liquid waste material discharged by farming, industry or sewage works into a river or the sea.
Electrolysis	The splitting of water molecules into hydrogen and oxygen using electricity and an electrolyser device (fuel cell).
Eluviation	The movement of suspended or dissolved compounds (for example Al or Fe salts) by percolating water from an upper into a lower horizon. The upper horizon is described as eluviated or E-horizon.
Endotherm	An animal that uses internally generated heat to maintain body temperature independent of external temperature change.
Energy recovery (from waste)	The conversion of non-recyclable waste materials into usable heat, electricity or fuel through processes such as combustion, gasification, pyrolysis, anaerobic digestion, or landfill gas recovery.
Energy security	The uninterrupted availability of energy sources at an affordable price. Or, the association between national security and the availability of natural resources for energy consumption.
Enhanced greenhouse effect	The enhancement of the natural greenhouse effect through anthropogenic emissions of greenhouse gases, trapping increasing quantities of heat.
Environmental assessment	The process of estimating and evaluating significant short-term and long-term effects of a programme or project on the quality of the location’s environment.
Environmental impact assessment (EIA)	Aims to protect the environment by ensuring that a local planning authority has full knowledge of possible significant environmental effects of a proposed development, and mitigation for these, and takes these into account in the decision-making process.
Environmental monitoring	Describes the processes and activities that need to take place in order to characterise and monitor the quality of an environment over time.
Equatorial rainforest	A forest typically found between 5° North and 5° South of the equator. Has no dry season and all months have an average precipitation of at least 60 mm.
Erosion	The breaking down of rock fragments into smaller pieces and sediments due to collision with other rock fragments during transportation.
Eutrophication	Excessive nutrient enrichment in a waterbody which causes a dense growth of algae or plant life. The algae and surface vegetation prevent light and oxygen penetrating the water, which affects survival of aquatic plants and invertebrates.

Evaporation	The process of turning from liquid into vapour or gas.
Evapotranspiration	The water lost to the atmosphere through evaporation from the land surface and from plant leaves.
Exponential population growth model	A model which illustrates how a population may grow over time if there are no limits to resources. If plotted, the line forms a J-shape and is sometimes called a J-curve.
Extrusive rock	Any rock derived from magma that flows onto the Earth's surface as lava or explodes violently into the atmosphere.
Fault (geology)	A fracture in rock due to stresses from a tectonic event.
Ferrel cell	Part of the tri-cellular model, the Ferrel cell lies between 30°N and 60°N (replicated in southern hemisphere). It lies between the Hadley and Polar cells, and is driven by events occurring in these two cells. It is characterised by sinking cold air near 30° and rising warm air nearer 60°.
Filtration (sewage)	Any mechanical, physical or biological operation that separates solids from fluids.
Fission	The splitting of atoms to release energy which can then be harnessed.
Floc	A loosely clumped mass of fine particles.
Flocculation	The clumping of individual particles into clot-like masses or precipitating into small lumps.
Fold mountains	Occur near convergent plate boundaries. Subduction of one plate under another results in layers of sediments lying at the junction being crumpled and folded, appearing above sea level as a range of mountains.
Food security	Exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.
Food use-by date	Foods can be eaten up until the stated use-by date but not after, providing storage instructions stated on the packaging have been followed correctly.
Fracking	The injecting of liquid at high pressure into subterranean rocks to force open fissures and extract oil or gas. Also known as hydraulic fracturing.
Frequency	The chance of finding a species within a defined area, for example a quadrat. It is the number or percentage of samples in which a particular species occurs, and takes no account of density or distribution.
Frictional heat	A force opposite the direction of movement due to the rubbing of surfaces in contact. The rubbing generates heat energy.
Fuel cell	A cell producing an electrical current direct from a chemical reaction.
Gasification	The conversion of organic matter into gas, by reacting the material at high temperatures, without combustion, with a controlled amount of oxygen and/or steam.
Genetic diversity	The variety of genetic characteristics involved in the genetic makeup of a species.

Genetic modification (GM)	Genetic material (DNA) which has been altered in a way that does not occur naturally.
Geothermal energy	The energy stored in the form of heat below the Earth's surface.
Geothermal gradient	The rate of increasing temperature vs increasing depth in the Earth's interior. Away from tectonic plates, temperature increases by around 2·5 °C per 100 m depth.
Global energy budget	The balance between incoming and outgoing solar radiation.
Globalisation	The process by which the world is becoming increasingly interconnected as a result of massively increased trade and cultural exchange.
Global ocean conveyor belt	A constantly moving system of deep-ocean circulation driven by thermohaline circulation and surface wind currents.
Global warming	A gradual increase in the overall temperature of the atmosphere, generally attributed to increases in anthropogenic greenhouse gases.
Gravitational contraction	The collapse of gas and dust to form stars, planets and other objects, under gravitational attraction.
Gravitational potential energy (GPE)	When an object is above the Earth's surface it has GPE. Gravitational contraction resulted in the GPE being converted to heat energy.
Grazing	A method of feeding in which herbivores feed on grasses and herbage.
Greenhouse gas (GHG)	A gas that traps heat in the atmosphere. Natural GHGs include water vapour, carbon dioxide, methane, and nitrous oxide. Anthropogenic GHGs include enhanced levels of the natural GHGs plus ozone and halocarbons.
Greywater	Domestic wastewater other than sewage. May come from sinks, showers, baths, dishwashers, washing machines, etc.
Gross primary productivity (GPP)	The rate at which autotrophs produce biomass in a given area and time period.
Ground source heat pump (GSHP)	Pipes buried below ground, with a circulating mixture of water and antifreeze, absorb heat from the ground which can be removed using a heat exchanger and used to heat a building or to provide hot water.
Groundwater	Water that occupies pore spaces in rock, sediments and soil. The area where groundwater collects is known as an aquifer.
Gulf Stream	An ocean current that transports warm water away from the Gulf of Mexico north into the Atlantic, bringing warmth to the UK and northern Europe.
Habitat	The place where a plant or animal lives.
Habitat destruction	The process by which natural habitat is damaged to the extent that it is no longer able to support species and communities. This may be through a natural event such as flooding or a volcanic eruption, but is more usually caused by anthropogenic activities such as land drainage or deforestation.
Habitat fragmentation	The reduction of a large habitat area into smaller, scattered remnants.

Hadley cell	Part of the tri-cellular model, the Hadley cell lies between the equator and 30°N (replicated in the southern hemisphere). Warm air rises at the equator and travels to around 30°N, where it cools and sinks to the surface, creating an area of high pressure, before returning to the tropics.
Herbivore	An animal that feeds on plant material.
Heterotroph	An animal that must meet its energy requirements by ingesting other organisms or organic matter derived originally from plants. Also known as a consumer.
High yield varieties	A crop that has been specially bred or selected to produce more than the natural varieties of the same species.
Humification	The transformation of raw organic matter (for example leaves) into humus, where no recognisable plant parts remain.
Hydrograph	A graph showing how a waterbody reacts after a period of rainfall. The discharge flow is measured past a specific point and over a given time, and is usually expressed in cubic metres per second (often abbreviated to cumecs).
Hydroponics	The cultivation of plants in a soil-less medium or, more commonly, in an aquatic-based environment. Uses mineral nutrient solutions to feed the plants.
Hydrothermal vent	Forms as a result of volcanic activity on the sea floor. Water seeps down through cracks in the crust and comes into contact with magma in the upper mantle, dissolving metals and minerals as it becomes super-heated. The super-heated water erupts as a geyser from the hydrothermal vent, with the dissolved metals and minerals precipitating out on contact with cold seawater and forming a chimney around the vent.
Ice sheet	A mass of glacial land ice extending more than 50 000 km².
Illuviation	The process of deposition of soil materials moved from the upper (eluviated) horizon to the lower (illuviated) horizon.
Incineration (waste)	Controlled burning at high temperatures, reducing waste in mass and/or volume and converting it into ash.
Infiltration	The physical movement of water through soil (relative to the soil's porosity and permeability).
Initiative	An action implemented in order to achieve the aims of a strategy and policy.
Insolation	The total amount of solar radiation energy received on a given surface during a given time period.
Intensive agriculture	Farming that uses a lot of machinery, labour, chemicals, etc in order to maximise crop yield or keep as many animals as possible on a set plot of land.
Interdependence	A relationship between species that helps to prevent overpopulation of a particular species to ensure the survival of the species as a whole.
Interquartile range	A measure of the spread of data. Data are arranged in ascending order and then split equally into quarters. Interquartile range is the difference between the upper limit of the lowest quarter and the lower limit of the upper quarter.
Inter-specific competition	Competition between individuals belonging to two or more different species who have very similar resource requirements which are in short supply.

Intra-specific competition	Competition between individuals of the same species for the same limited resource.
Intrusive rock	Rock formed from magma that cools and solidifies with the Earth's crust, ie does not reach the surface.
Invasive non-native species (INNS)	A species introduced through human action (accidental or deliberate) outside its native distribution and which has a serious negative impact on native species, our health or our economy.
Keystone species	A species on which other species in an ecosystem largely depend, such that loss of the keystone species would drastically change the ecosystem.
Kinetic energy	The energy an object possesses because of its motion.
Lag time	The time it takes for precipitation to find its way from land to a river.
Landfill	The disposal of waste material by burying it in a pit.
Laterite	A soil formed under conditions of high temperature and heavy rainfall with alternate wet and dry periods, which leads to leaching of soil, leaving only oxides of iron and aluminium.
Latitude	A geographic coordinate specifying the north–south position of a point on the Earth's surface.
Lava	Molten rock generated by geothermal energy and expelled through fractures in the crust or via a volcanic eruption.
Leaching	The movement of dissolved substances with percolating water in soil.
Legislation	Laws passed by the government.
Life cycle analysis (LCA)	A systematic quantitative assessment for products or processes that identifies and quantifies the inputs and outputs for a whole life cycle or individual stages. It assesses all energy, materials and transport involved in making, using and disposing of a product.
Lincoln index	A method of estimating population sizes of individual animal species using capture-mark-recapture.
Linear economy	An economy based on 'produce, use and throw' with no attempt at recovery of materials or energy.
Liquor (sewage)	The liquid remaining once sewage sludge has been removed. Must be processed further before being released to the environment as effluent.
Logistic population growth model	A model which illustrates how a population may grow exponentially until it reaches the carrying capacity of its environment, then will slow until resources become available again. If plotted, the line forms an S-shape and is often called an S-curve.
Magma	Hot fluid or semi-fluid material present below or within the Earth's crust.
Mantle	Lies between the crust and outer core. Composed of magma (semi-molten rock).
Marginal land	Land that is of little agricultural value because of problems with access, water control, terrain, environmental restrictions, etc.

Marine protected area (MPA)	A formal conservation designation to protect nationally important marine wildlife, habitats, geology, and undersea landforms.
Mechanisation	The improving of farm labour productivity through use of machinery, implements and tools.
Metabolisation	The chemical process by which matter is broken down into simpler substances.
Metallic mineral	A mineral is a solid, naturally occurring, inorganic substance. A metallic mineral is one that contains one or more metallic elements.
Milankovitch cycles	Cyclical variations in Earth-Sun geometry that combine to produce variation in the amount of solar energy reaching Earth — 'stretch, wobble and roll' or eccentricity, obliquity and precession impact on global climate patterns.
Native species	One that occurs naturally within a given ecosystem, rather than as the result of accidental or deliberate introduction by humans.
Natural climate change	Natural cycles in Earth's climate have resulted in ice ages and warmer interglacial periods. These have been driven by factors such as orbital changes, plate tectonics, volcanoes, and sunspot activity.
Natural greenhouse effect	Natural atmospheric processes that maintain the Earth's average surface temperature at about 15 °C. Without this, the temperature would be around 30 °C cooler and too cold to sustain life.
Net primary productivity (NPP)	The rate at which an ecosystem accumulates energy or biomass, excluding the energy used for the process of respiration. NPP = GPP – respiration
Niche	The role played by a species within a community: where it lives, what it eats, and what eats it.
Non-native species	A species introduced through human action (accidental or deliberate) outside its native distribution.
Nutrient enrichment	Excessive inputs of macro-nutrients (nitrate, ammonia and phosphate) into the aquatic environment.
Obsolescence	The process of falling into disuse or becoming out of date.
Ocean circulation	The large-scale movement of waters in the ocean basins.
Ocean gyre	A major spiral of ocean-circling currents that occurs north and south of the equator, but not at the equator as the Coriolis effect is absent there.
Ocean trench	A geological structure which occurs undersea along the boundary of a tectonic plate, specifically along subduction zones.
Omnivore	An animal that obtains its energy by consuming both plant and animal material.
Open cast mining	The removal of mineral resources from the Earth's surface through large holes or pits.

Open loop recycling	The process of converting a material from one or more products into a new product, involving a change in the properties of the material (usually degradation in quality), for example plastics.
Ore	A naturally occurring solid material from which a metal or valuable mineral can be extracted profitably.
Overburden	Waste rock and soil overlying a mineral deposit that must be removed before extraction of the mineral can take place.
Parasitism	A symbiotic relationship between organisms of different species in which the host is a source of food and a habitat for the parasite. The parasite is dependent on the host but the host can live without the parasite.
Parent material	In soil science, parent material includes bed rock, weathered rock or surface deposits (transported and deposited by wind, water or ice).
Particulates	Particulate matter includes all solid and liquid particles suspended in air, for example dust, pollen, soot, smoke, liquid droplets.
Pathogen	An agent that causes disease, such as a bacterium, virus or fungus.
Peak discharge	The time when a river reaches its highest flow.
Peak rainfall	The time of highest rainfall.
Percentage cover	A measure of the amount of cover of a particular species in a quadrat.
Percolation	The movement of water through soil by gravity and capillary action.
Permeability	A measure of the amount of water able to pass through a rock.
Persistent organic pollutants (POPs)	Organic compounds that are resistant to environmental degradation. Includes pesticides.
Physical weathering	Weathering caused by changes in temperature, freeze-thaw, or effects of wind, rain and waves. Also known as mechanical weathering.
Plagioclimax	A stable plant community which is maintained by persistent human interference, such as burning and grazing.
Planned obsolescence	This is when a product is designed to have an artificially limited life span.
Plate boundary	A boundary between two or more plates, which can be moving towards each other (convergent), away from each other (divergent), or past each other (transform).
Plate tectonics	A scientific theory describing the large-scale motion of plates of crust and upper mantle.
Podzol soil	A soil type typically found under coniferous forest or on upper slopes of upland areas where precipitation is heavy. The soil is acidic, with few soil organisms; its main decomposers are fungi. It is characterised by distinct horizons, including eluviated A-horizon and illuviated B-horizon with iron pan.
Point pollution	Pollution that is discharged from a single location.

Polar cell	Part of the tri-cellular model, the Polar cell lies from 60°N to the North Pole (replicated in the southern hemisphere). Cold air sinks at the North Pole, creating an area of high pressure, before flowing south at the surface, where it is warmed by contact with land and/or ocean and rises around 60°N, creating an area of low pressure.
Policy	A plan of action that focuses on a specific target.
Pollutant	A substance that contaminates air, water or soil.
Pollution	The presence in the environment of substances in quantities that cause harm to the environmental components.
Population	A group of individuals of the same species living in the same area at the same time.
Population crash	A sudden decline in the numbers of individual members in a population, species or group of organisms, usually in response to scarcity of resources, intra-specific competition and/or other biotic factors.
Population dynamics	The study of the factors and their interactions that influence the number and density of populations in time and space.
Population growth	An increase in the size of a population over a given time period.
Population oscillation	A pattern characterised by a population explosion, resulting in overshoot of the carrying capacity, followed by population crash, then recovery of the environment and resources, which allows the population to recover and then exceed the carrying capacity again.
Population overshoot	A temporary situation that occurs when a population exceeds its carrying capacity, before lack of resources causes a population crash.
Pore space	The volume in soil or rock that can be filled with water or air. The pore space properties determine fluid flow through the soil or rock, known as porosity.
Porosity	A measure of a rock's ability to hold fluid.
Precipitation	Moisture that falls from the air to the ground (rain, snow, sleet, hail, drizzle, fog, mist).
Predator	An animal that lives by killing and consuming other animals.
Predator–prey cycle	As a population of one species increases, its predator populations will increase in response. As the prey numbers fall due to predation, the predator numbers will also fall due to reducing resource availability.
Prey	An animal that is hunted and killed by another for food.
Primary consumer	A herbivore that eats the autotroph/producer in a food chain.
Primary productivity	A measure of the rate at which new organic matter develops through photosynthesis.
Primary succession	The colonisation of a new site by communities of plants and animals after an event has removed all existing soil, for example glaciation or a lava flow. This type of succession must first wait for soil to develop sufficiently to support colonising species.

Processed biofuel	A biofuel that has been subject to an industrial process.
Psychological obsolescence	This is when a consumer is persuaded that they need a new product even when their existing product is working well.
Purification	The removal of undesirable chemicals, biological contaminants, suspended solids, and gases to produce water fit for a specific purpose.
Pyrolysis	The chemical decomposition of organic material through the application of heat in the absence of air and oxygen.
Quadrat	A frame enclosing a known unit area which is used to assess species abundance.
Qualitative data	Descriptive data, can be used to prepare species lists.
Quantitative data	Numerical data gathered through measuring or counted.
Radioactive decay	The process by which an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic waves, thereby transitioning towards a more stable state.
Random sampling	Sampling where every individual in a population has an equal and independent chance of being selected, ie sampling without conscious decision.
Reforestation	The process of replanting an area with trees. Differs from afforestation, which is the planting of new areas where there was no previous tree cover.
Relative abundance	How common or rare a species is relative to other species in a defined area or community. Is expressed as a percentage of the total number of organisms in the area.
Reliability	The extent to which an experiment, test, or measuring procedure yields the same results on repeated trials. For the data to be reliable, the variation across the values must be small.
Relief	The highest and lowest elevation points on a land surface. Also known as terrain.
Respiration	A chemical process in which energy is released from stores in the body.
Rewilding	Intentional activities which initiate or accelerate the recovery of a habitat or an ecosystem with respect to its health, integrity and sustainability.
Rift valley	Forms when two continental plates diverge, causing stretching and fracturing of the crust. The land between the faults collapses into a deep, wide valley.
Runoff	The flow of water over land as surface water.
Screening (sewage)	The removal of larger objects such as rags, paper, plastics, and metals at a wastewater treatment plant.
Sea level	Mean sea level is the average height of the ocean's surface between high and low tide. Relative sea level is the position and height of the sea relative to the land.
Secondary consumer	An animal that eats the primary consumer in a food chain.
Secondary productivity	The assimilation of food into new biomass through the transfer of organic material between trophic levels.

Secondary succession	Succession that occurs on a pre-existing soil after primary succession has been disrupted or destroyed and the ecological community has been disturbed.
Sedimentation	The settling out of suspended particles and floc on sewage liquor.
Selective breeding	The breeding of plants and animals for particular characteristics.
Seral stages	The stages of succession in an ecosystem advancing towards its climax community. Examples of seres include xerosere, hydrosere, psammosere.
Sewage liquor	A mixture of raw or settled wastewater and suspended solids.
Sewage sludge	The semi-liquid slurry residue from the wastewater treatment process.
Shale gas	Natural gas (methane) found trapped within impermeable shale deposits.
Simple random sampling	Sampling where every individual in a population has an equal and independent chance of being selected, and the average sample should accurately represent the population.
Simpson's biodiversity index	A measure of diversity which takes into account the number of species present, plus the relative abundance of each species.
Site of special scientific interest (SSSI)	A formal conservation designation for an area which has extremely high conservation value because of its plants, animals, geological, or landscape features.
Smelting	A process by which metal is obtained from its ore by heating it beyond the melting point.
Soil profile	The layering of soil horizons.
Soil stability	The ability of soil to maintain its structure to allow passage of air and water, withstand erosive forces (wind and water), and provide a medium for plant roots.
Soil structure	Describes the physical arrangement of the solid parts of soil and of the pore spaces lying between them. Influences porosity; permeability; movement of water, nutrients and gases; and land use.
Soil texture	Refers to the overall feel of soil, reflecting the proportions of mineral particles (sand, silt, and clay) present. These, and organic matter, influence soil structure, water and nutrient retention, drainage, root penetration, soil stability, and cultivation.
Solar flare	A sudden, rapid, and intense variation in the Sun's brightness. Occurs when magnetic energy that has built up in the solar atmosphere is suddenly released.
Solar radiation	Radiant energy emitted by the Sun.
Species	A group of organisms that can interbreed to produce fertile offspring.
Species diversity	A measure of the number of different species present in a given area, rather than the abundance of each species.
Species richness	The number of species present in a sample or an area.

Standard deviation	A measure used to quantify the amount of variation or spread of a set of data values. Commonly used standard deviation formula include: for a population $s = \sqrt{\frac{\sum (x - \bar{x})^2}{N}}$ or, for a sample of a population $s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$ or $s = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$ where: s is the standard deviation N is the population size n is the sample size $\bar{x}$ is the mean $\sum$ is the 'sum of'
Steam methane reforming	The reaction of natural gas with steam in the presence of a catalyst to produce hydrogen and carbon.
Strategic environmental assessment (SEA)	Aims to provide for a high level of protection of the environment from development. It is mandatory for plans and/or programmes which relate to large-scale changes in land use.
Strategy	The methods and principles needed to achieve a policy are set out in a strategy.
Stratified random sampling	Sampling where the population is divided into categories (strata) then a random sample is selected from each category. The size of each sample should be proportional to the size of each category within the population.
Subduction zone	The point at which an oceanic plate is forced underneath a continental plate at a destructive plate boundary.
Sublimation	The process by which ice or snow goes from a solid to a gas without becoming a liquid.
Succession	The series of changes in an ecosystem when one community is replaced by another community as a result of changes in biotic and abiotic factors.
Sunspot	A sunspot is a region on the surface of the sun that is temporarily cool and dark compared to surrounding regions. Powerful magnetic fields around sunspots produce active regions on the Sun.
Superheating	The heating of a liquid, under pressure, to a temperature higher than its boiling point, without actually boiling.

Sustainability	The relationship or balance between social, economic and environmental issues.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Surface wind patterns	The arrangement, location, velocity of the various dominant wind patterns blowing across the Earth's surface.
Systematic random sampling	Sampling where a starting point is randomly chosen, and then a regular pattern of sampling is used to collect the sample.
Tailings	Waste from the mining industry. May be solid waste material (gangue) or fine waste suspended in water.
Technological obsolescence	This is when a new technology or product supersedes the old, even if the old technology is still functional.
Temperate rainforest	Coniferous or broadleaf/deciduous forests that occur in the temperate zone (average temperature between 0-20 °C, largely influenced by nearby ocean) and receive at least 200 cm of annual rainfall.
Tertiary consumer	An animal that eats the secondary consumer in a food chain.
Thermohaline circulation	Circulation driven by differences in seawater density, caused by temperature and salinity.
Transect	A method which investigates distribution of organisms in relation to a fixed area by recording all the species found at points or in a quadrat placed at certain intervals along a line.
Translocation	The downward movement of water or materials in soil. Includes leaching, eluviation, illuviation, and capillary action.
Transpiration	The evaporation of water from a plant’s leaves, stem or flowers.
Transportation	The movement of rock fragments by water, ice, wind or gravity from the place where they were originally weathered.
Trent biotic index	A measure which uses freshwater invertebrates to compare water quality at different points in a stream or river.
Tri-cellular model	A model that explains the redistribution of energy from areas of surplus to areas of deficit via three different air masses — the Hadley, Ferrel, and Polar cells.
Trophic	Relating to feeding and nutrition.
Trophic level	A level or position in a food chain, occupied by a group of organisms that have a similar feeding mode, ie autotrophs and heterotrophs (herbivores, carnivores, omnivores).
Tundra	May be arctic or alpine. Arctic tundra is located in the northern hemisphere encircling the North Pole and is known for its cold, desert-like conditions, and very short growing season of around 60 days. Alpine tundra is located at high altitude where trees cannot grow, temperatures are low, and the growing season is around 180 days.
Upwelling	The rising up of deep, cold, nutrient-rich water in the open ocean or along coastlines.
Validity	Encompasses the entire experiment and establishes whether the data obtained meet all the requirements of the research method.

Waste hierarchy	A ranking of waste management options according to what is best for the environment. Gives top priority to waste prevention. When waste is created, it gives priority to preparing it for reuse, then recycling, then energy recovery, with disposal to landfill as a last resort.
Waste prevention	The process of minimising the quantity (weight and volume) and hazardousness of waste.
Waste recovery	The selective extraction of disposed materials for a specific next use, such as recycling, composting or energy generation.
Waste recycling	Reprocessing materials into new products.
Waste reuse	The process of refilling or finding another use for a product without processing it other than cleaning.
Water security	Exists when all people, at all times, have sustainable access to adequate quantities of water of acceptable quality for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.
Weather	The state of the atmosphere at a particular place and time with respect to variables such as temperature, moisture, wind velocity, and air pressure.
Weathering	The exposure and breaking down of rocks *in situ* at the Earth's surface over geological time due to interaction with the atmosphere.

Preparing for course assessment

Each course has additional time which may be used at the discretion of teachers and/or lecturers to enable candidates to prepare for course assessment. This time may be used near the start of the course and at various points throughout the course for consolidation and support. It may also be used towards the end of the course, for further integration, revision and preparation and/or gathering evidence for course assessment.

During delivery of the course, opportunities should be found:

- for identification of particular aspects of work requiring reinforcement and support
- to develop skills of scientific inquiry and investigation in preparation for the assignment
- to practise question paper techniques

Developing skills for learning, skills for life and skills for work

Teachers and/or lecturers should identify opportunities throughout the course for candidates to develop skills for learning, skills for life and skills for work.

Candidates should be aware of the skills they are developing and teachers and/or lecturers can provide advice on opportunities to practise and improve them.

SQA does not formally assess skills for learning, skills for life and skills for work.

There may also be opportunities to develop additional skills depending on approaches being used to deliver the course in each centre. This is for individual teachers and lecturers to manage.

Candidates are expected to develop broad generic skills as an integral part of their learning experience.

For this course, it is expected that the following skills for learning, skills for life and skills for work will be significantly developed, with potential opportunities to practise or improve these skills provided in the following tables. These are based on SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work. The level of these skills should be appropriate to the level of the course.

Some examples of potential opportunities to practise or improve these skills are provided, as follows:

Literacy

Writing means the ability to create texts which communicate ideas, opinions and information, to meet a purpose and within a context. In this context, 'texts' are defined as word-based materials (sometimes with supporting images) which are written, printed, Braille or displayed on screen. These will be technically accurate for the purpose, audience and context.

1.2 Writing

Candidates develop the skills to effectively communicate key areas of environmental science, make informed decisions and describe, clearly, environmental science issues in various media forms.

Candidates have the opportunity to communicate applied knowledge and understanding throughout the course, with an emphasis on applications and environmental, economic, social, and ethical impacts.

There will be opportunities to develop the literacy skills of listening and reading, when gathering and processing information in environmental science.

Numeracy

This is the ability to use numbers in order to solve problems by counting, doing calculations, measuring, and understanding graphs and charts. This is also the ability to understand the results.

Candidates have opportunities to extract, process and interpret information presented in numerous formats including tabular and graphical. Practical work provides opportunities to develop time and measurement skills.

2.1 Number processes

Number processes means solving problems arising in everyday life through carrying out calculations, when dealing with data and results from experiments/investigations and everyday class work, making informed decisions based on the results of these calculations and understanding these results.

2.2 Money, time and measurement

This means using and understanding time and measurement to solve problems and handle data in a variety of environmental science contexts.

2.3 Information handling

Information handling means being able to interpret environmental science data in tables, charts, maps and other graphical displays to draw sensible conclusions throughout the course. It involves interpreting the data and considering its reliability in making reasoned deductions and informed decisions. It also involves an awareness and understanding of the chance of events happening.

Employability, enterprise and citizenship

4.6 Citizenship

Citizenship includes having concern for the environment and for others, being aware of rights and responsibilities, being outward-looking towards society; being able to recognise one's personal role in this context, being aware of global issues, understanding one's responsibilities within these and acting responsibly. Candidates develop citizenship skills, when considering the applications of environmental science on our lives, as well as ethical implications.

Thinking skills

This is the ability to develop the cognitive skills of remembering and identifying, understanding, applying. The course allows candidates to develop skills of applying, analysing and evaluating. Candidates can analyse and evaluate practical work and data by reviewing the process, identifying issues and forming valid conclusions. They can demonstrate understanding and application of the key areas and explain and interpret information and data.

5.3 Applying

Applying is the ability to use existing information to solve environmental science problems in different contexts, and to plan, organise and complete a task, such as an investigation.

5.4 Analysing and evaluating

Analysis is the ability to solve problems in environmental science and make decisions that are based on available information. It may involve the review and evaluation of relevant information and/or prior knowledge to provide an explanation. It may build on selecting and/or processing information, so is a higher skill.

5.5 Creating

This is the ability to design something innovative or to further develop an existing thing by adding new dimensions or approaches. Candidates can demonstrate their creativity, in particular, when planning and designing environmental science experiments or investigations. Candidates have the opportunity to be innovative in their approach. Candidates also have opportunities to make, write, say or do something new.

In addition, candidates will also have opportunities to develop working with others.

Working with others

Learning activities provide many opportunities, in all areas of the course, for candidates to work with others. Experimental and field work activities and investigations, in particular, offer opportunities for group work, which is an important aspect of environmental science and should be encouraged.

Appendix 2: question paper brief

The question paper will sample knowledge, understanding and skills from across the course.

Content

120 marks will be evenly distributed across each of the three content areas:

- Living environment (40 ± 6 marks)
- Earth's resources (40 ± 6 marks)
- Sustainability (40 ± 6 marks)

<table>
<tr><th rowspan="2">Skills, knowledge and understanding in each section</th><th rowspan="2">Paper 1 (application of environmental science)</th><th colspan="2">Paper 2</th><th rowspan="2">Total</th></tr>
<tr><th>Section 1</th><th>Section 2</th></tr>
<tr><td>Demonstrating knowledge and understanding of environmental science by making statements, describing information, providing explanations, and integrating knowledge.</td><td rowspan="2">10 ± 2</td><td rowspan="2">55 ± 5</td><td rowspan="2">20</td><td rowspan="2">85 ± 7</td></tr>
<tr><td>Applying knowledge of environmental science to new situations, interpreting information, and solving problems.</td></tr>
<tr><td>Planning and/or designing experimental/field work investigations to test given hypotheses or to illustrate particular effects.</td><td rowspan="8">10 ± 2</td><td rowspan="8">25 ± 2</td><td rowspan="8">0</td><td rowspan="8">35 ± 4</td></tr>
<tr><td>Selecting information from a variety of sources.</td></tr>
<tr><td>Presenting information appropriately in a variety of forms.</td></tr>
<tr><td>Processing information/data (using calculations and units, where appropriate).</td></tr>
<tr><td>Making predictions and generalisations based on evidence/information.</td></tr>
<tr><td>Drawing valid conclusions and giving explanations supported by evidence/justification.</td></tr>
<tr><td>Suggesting improvements to experimental/field work investigations.</td></tr>
<tr><td>Total</td><td>20</td><td>80</td><td>20</td><td>120</td></tr>
</table>

Grade ‘A’ type marks

Approximately 30% of marks are designed to be grade ‘A’ type marks.

Administrative information

Published: June 2021 (version 3.1)

History of changes

Version	Description of change	Date
2.0	Course support notes and question paper brief added as appendices.	June 2018
3.0	Mandatory knowledge: the Forestry Commission has now been replaced with two organisations — Scottish Forestry and Forestry and Land Scotland. Assignment section, 'Resources' sub-section: ♦ information added that there must be a range of topics available for candidates to choose from and that teachers/lecturers must minimise the numbers investigating the same topic within a class ♦ teachers/lecturers can supply a basic list of instructions for the experimental procedure ♦ candidates must undertake research using only websites, journals, books, and maps ♦ information added to the bullet points about raw experimental data, internet/literature data and extracts ♦ list of items that candidates cannot have access to in the report stage replaced with 'Candidates **must not** have access to a previously prepared draft of a report or any part of a report.' Glossary: formula for the standard deviation of a population has been added.	September 2019
3.1	Scottish Natural Heritage (SNH) updated to NatureScot (NS) on page 10 and in course support notes. Historic reference to Forestry Commission Scotland removed on page 10. Hyperlinks checked, and updated where required. (pages 43 to 76)	June 2021

Note: you are advised to check SQA's website to ensure you are using the most up-to-date version of this document.