

APPLIED



WJEC Level 3 Applied Extended Diploma in
**ENVIRONMENTAL
SCIENCE**

REGULATED BY OFQUAL AND CCEA REGULATION
DESIGNATED BY QUALIFICATIONS WALES

SPECIFICATION

Teaching from 2015
For award from 2017

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SUMMARY OF AMENDMENTS

Version	Description	Page number
2	Learners are allowed two resits of each external unit.	8
	For internal assessment please consult WJEC's 'instructions for conducting controlled assessment'.	9
	Clarification of the 'near pass' rule.	14
	Grading the qualification	14-15
	Clarification of resit rules.	147

Contents

	Page
1. Introduction	
1.1 Qualification title and code	2
1.2 Statement of purpose	2
2. Qualification Structure	4
3. Assessment	5
3.1 External assessment	5
3.2 Internal assessment	9
3.3 Synoptic assessment	12
3.4 Standardisation	13
4. Grading	14
4.1 Unit grading	14
4.2 Qualification grading	14
5. Units	16
Unit 1	16
Unit 2	33
Unit 3	48
Unit 4	63
Unit 5	76
Unit 6	90
Unit 7	105
Unit 8	118
Unit 9	134
6. Entry Procedures	146
7. External Moderation	147
8. Awarding and Reporting	150
9. Access Arrangements	151
10. Post-Results Services	152
11. Classification codes	153
12. The wider Curriculum	153
Appendices	
1. Unit Structure	156
2. Grade Descriptors	158
3. Skills Mapping	163

1. INTRODUCTION

1.1 Qualification title and code

This specification covers the following qualification:

WJEC Level 3 Applied Extended Diploma in Environmental Science.

The Ofqual qualification number is: 601/4551/1

The Qualifications Wales designation number is: C00/0726/4

1.2 Statement of purpose

The Level 3 Applied Extended Diploma in Environmental Science has been developed for learners aged 16+, who have enjoyed and already been successful in science. Typically, learners starting this qualification will already have science qualifications at level 2, e.g. GCSEs in science subjects, GCSE Additional Applied Science or equivalent level 2 vocational science qualifications, e.g. WJEC Award in Applied Science and WJEC Award in Science for Work.

The Level 3 Applied Extended Diploma in Environmental Science is an Applied General qualification which is the same size as two GCE A levels. It should fill approximately two thirds of a learner's timetable. This allows for the study of additional vocational or academic qualifications alongside it, e.g. GCE AS/A level biology, chemistry or geography.

The main purpose of the qualification is to provide learners with the knowledge, understanding and skills in scientific principles to enable them to progress to higher education or employment in areas related to environmental science. The qualification requires learners to apply biological, chemical and physical principles to environmental issues and to provide solutions to environmental problems.

Learners who follow this qualification will study eight units. The units that will be studied are:

- Managing energy for a sustainable future;
- The living environment and conservation;
- Monitoring our physical environment;
- Scientific principles and the environment;
- Dealing with pollution;
- Climate change **or** Transport systems and the environment;
- Managing agriculture for a sustainable future;
- Environmental impact analysis.

Each unit has a clear environmental purpose which focuses the learning of scientific principles and skills in the unit in a meaningful environmental context. The units have been written to help develop the:

- knowledge and understanding of biological, chemical and physical principles underlying environmental science;
- skills necessary to perform laboratory and field work;
- ability to solve problems in an environmental context;
- skills needed to do project based research and presentation;
- ability to learn in work-related contexts;
- ability to work alongside others in a professional manner;
- skills for independent learning and development. These are very important to employers and higher education.

Learners who complete the qualification should have a broad appreciation of work in the environmental sector allowing for progression into further education, employment or training.

Progression

When supported by other appropriate qualifications such as GCSE English and mathematics, and at level 3, such as GCE AS/A levels, e.g. in a science, geography or another vocational qualification, the WJEC Level 3 Applied Extended Diploma in Environmental Science will enable progression to higher education. The qualification is designed to enable progression on to degree courses in areas such as Environmental Studies, Environmental Science etc.

A significant proportion of career opportunities in this sector are at degree level. There are opportunities for suitably qualified individuals to work as pollution scientists, biodiversity officers, water quality experts, environmental managers, waste managers, conservation officers, environmental consultants etc.

Employability

The qualification equips learners with a wide range of laboratory skills, as well as scientific knowledge and understanding related to environmental science. In addition, the qualification is intended to develop the ability to work alongside others. These skills are required by technicians working in laboratories and support staff (e.g. conservation wardens) in the environmental and related sectors.

Examples of employers who offer opportunities for suitably qualified individuals include: conservation organisations; the Environment Agency; Natural Resources Wales; water companies; waste management companies; DEFRA; local authorities and private sector industry.

2. QUALIFICATION STRUCTURE

WJEC Level 3 Applied Extended Diploma in Environmental Science

The units are summarised in the table below.

Unit number	WJEC entry code	Unit title	Mandatory/ optional	Assessment (external/ internal)	GLH
1.	4473U1	Managing energy for a sustainable future	mandatory	internal	90
2.	4473U2	The living environment and conservation	mandatory	external	90
3.	4473U3	Monitoring our physical environment	mandatory	internal	90
4.	4473U4	Scientific principles and the environment	mandatory	external	90
5.	4473U5	Dealing with pollution	mandatory	external	100
6.	4473U6	Climate change	optional	internal	100
7.	4473U7	Transport systems and the environment	optional	internal	100
8.	4473U8	Managing agriculture for a sustainable future	mandatory	internal	100
9.	4473U9	Environmental impact analysis	mandatory	external	60

Learners need to complete **eight** units to achieve the WJEC Level 3 Applied Extended Diploma in Environmental Science. They are required to complete seven mandatory units and one of the two optional units, i.e. either unit 6 **or** unit 7. Unit 4 is synoptic for units 1 to 3. Unit 9 is synoptic for the **whole** qualification.

Cash in Diploma: 4473QD

Cash in Extended Diploma: 4473QE

3. ASSESSMENT

WJEC Level 3 Applied Extended Diploma in Environmental Science is assessed using a combination of internal and external assessment. The relative weighting of the internal and external assessment is shown in the table below.

	Internal				External			
Unit no.	1	3	6 or 7	8	2	4	5	9
%	12	12	12	12	12	14	12	14

3.1 External assessment

3.1.1 Unit 2 & 5

These units are each externally assessed by an assignment which is set and marked by WJEC. Assessments for each unit will be provided annually by WJEC in September of the academic year in which they are to be taken via the WJEC secure website. The assessment must be completed and submitted for marking in the same academic year as it is set. Centres are **not** allowed to modify the provided assignment for units 2 or 5.

The assessments are carried out by the learners under controlled conditions. The controls (time, supervision, resources and collaboration) for task taking are described within the assessment. The general principles for the control of the external assessment of units 2 and 5 are outlined below.

Controls for task taking (external assessment)

There are five areas of task taking that are controlled: time, resources, supervision, collaboration and resubmission.

Time

Each assessment will specify the total amount of time available for summative external assessment.

Resources

The supervisor should ensure suitable resources are provided to all learners to ensure fair and valid assessment takes place. Where specific resource controls must be in place, these will be stated in the assignment.

Supervision

Learners must be supervised whilst completing externally set assessment tasks. Assessments will specify the level of supervision required. Centres must have in place systems to ensure learners cannot access evidence they have been developing outside of supervised activities.

Authentication

Supervision is in place to ensure the authenticity of evidence produced for summative assessment. Supervisors should **not** provide input or guidance to learners during the controlled assessment time. This includes providing formative feedback on the evidence being produced. Supervisors can provide guidance on the requirements of the task and remind learners of the performance bands and how they can be interpreted. Assessors must intervene where there a health and safety issue is observed. Learners can review and redraft evidence independently within the time controls for the assessment.

Learners must sign a declaration to confirm that all evidence submitted for marking by WJEC is their own work and that any sources used have been acknowledged.

Supervisors must sign a declaration to confirm that evidence submitted for marking by WJEC was completed under the controlled conditions set out in the assignment.

Collaboration

The assessment will indicate whether:

- group work may take place;
- group work is forbidden.

3.1.2 Unit 4

Unit 4 is assessed through one written **two hour (90 marks)** examination available in the summer of each year. Unit 4 is intended to examine the underpinning scientific concepts of units 1 to 3. Each paper will consist of two sections (Section A and B). All questions in the paper will be compulsory.

Section A

- Questions will be based upon a pre-release article and connected specification content.
- The pre-release article is intended to provide an environmental context for questions in section A. It will also contain environmental data and information for analysis and/or evaluation.
- Between 22 and 25 marks will be available for Section A.

Section B

- Questions set within an environmental context related to units 1 - 3. All questions will require the learner to engage with stimulus material. Stimulus material may include images, diagrams, photographs, graphs and information.

All papers will include synoptic questions that link to the context of units 1 to 3.

Assessment criteria from each learning outcome from unit 4 will be assessed in the examination. Marks will be apportioned to each learning outcome of unit 4 as follows:

Learning Outcome	AO1	AO2	AO3	AO4	Total
Allowed range	18-24	18-24	18-24	23-29	90

3.1.3 Administration of pre-release material (unit 4)

The pre-release article will be available for centres to download from the WJEC website from the last week of April. Teachers can use the pre-release material in lessons with learners after it has been released on the WJEC website.

Learners will be issued with a clean copy of the pre-release article for the examination. Learners are not permitted to take an annotated copy of the pre-release article into the examination.

3.1.4 Unit 9

This is an externally assessed **synoptic** unit which is assessed through an original, extended investigation to undertake an environment impact analysis of a particular location. The investigation will be set and marked by WJEC.

Details of the assessment are as follows.

- A short list of investigation titles is provided annually in January of the academic year in which they are to be completed via the WJEC website.
- These investigation titles will be based upon the skills, techniques, concepts, theories, and knowledge from across the qualification content, i.e. units 1 to 8.
- Each candidate will carry out an investigation based upon **one** of the titles.
- The investigations must be completed and submitted for marking in the same academic year the as they are set.
- Centres are required to ensure that a variety of titles are selected by a cohort of learners.
- The investigation is to be carried out by the learners under controlled conditions.
- The controlled conditions and the nature of the evidence that needs to be produced will be outlined on the Learner Summary Sheet that accompanies the assessment. Centres should be aware that the exact nature of the evidence for tasks may be varied from year to year e.g. the evidence for **task 3** may require a written report for a technical audience **or** a presentation to a non-technical audience.

The controls for task taking are described below.

Task taking

There are five areas of task taking that are controlled: time, resources, supervision, collaboration and resubmission.

Time

The assessment will specify the amount of time available for each task in the investigation. The total time to carry out the assessment will be 24 hours. These hours are allocated on the Learner Summary Sheet between the tasks making up the assessment.

Resources

The centre needs to ensure suitable resources are available to all learners to ensure fair and valid assessment takes place.

Supervision

Assignments will specify the level of supervision required. Centres must have in place systems to ensure learners cannot access evidence they have been developing outside of supervised activities.

Authentication

Supervision is in place to ensure the authenticity of evidence produced for summative assessment. Assessors are not allowed to provide input or guidance to learners during the assessment. This includes providing formative feedback on the evidence being produced. Assessors can provide guidance on the requirements of the task and remind learners of the performance bands and how they can be interpreted. Assessors must intervene where there is a health and safety issue is observed.

Learners can review and redraft evidence independently within the time controls for the assessment.

Learners must sign a declaration to confirm that all evidence submitted for marking by WJEC is their own work and that any sources used have been acknowledged.

Assessors must sign a declaration to confirm that evidence submitted for marking by WJEC was completed under the controlled conditions set out in the assessment.

Collaboration

The assessment for unit 9 does **not** allow for group work.

3.1.5 Resitting external assessment

Learners are allowed **two** resits of each external unit. The highest grade will contribute towards the overall grade for the qualification.

3.2. Internal assessment

These units are internally assessed and externally moderated:

- Unit 1 Managing energy for a sustainable future;
- Unit 3 Monitoring our physical environment;
- Unit 6 Climate change;
- Unit 7 Transport systems and the environment;
- Unit 8 Managing agriculture for a sustainable future.

For internal assessment please consult 'WJEC's Instructions for conducting controlled assessment'. This document can be accessed through the WJEC website (www.wjec.co.uk). Each centre must ensure that internal assessment is conducted in accordance with these controls.

The following principles apply to the assessment of each internally assessed unit.

- Units are assessed through summative controlled assessment.
- Controls for assessment of each internally assessed unit are provided in a model assignment.
- Each internally assessed unit must be assessed independently. Learners may produce a piece of evidence that contributes to assessment criteria for more than one unit. This is acceptable provided it can be clearly attributed to a specified assessment criterion and has been produced under the appropriate controlled conditions for each unit.
- Performance bands are provided to enable centres to mark the controlled assessment.

There are three stages of assessment that will be controlled:

- task setting;
- task taking;
- task marking.

Controls

Task setting

For internal assessment, WJEC has produced model assignments for each unit. Centres are, however, allowed to modify the assignment within specified parameters. This will allow centres to tailor the assessment to local needs.

The model assignment has been written to ensure the following controls are in place.

- Each unit is assessed through one assignment.
- Each assignment must have a brief that sets out an applied purpose. An applied purpose is a reason for completing the tasks that would benefit society, a community, organisation or company. Further details are in the rationale in Section 1.2.

- The assignment can specify a number of tasks but tasks must be coherent, i.e. show how the assessment requirements all contribute to the achievement of the applied purpose of the assignment.
- The assignment must provide each learner with the opportunity to address all assessment criteria and all performance band requirements.
- The assignment must indicate the acceptable forms of evidence. These must conform to those forms set out in the model assignment.
- Where a centre has adapted the model assignment, there must be evidence of quality assuring its fitness for purpose. Sample documentation for this activity is provided with each model assignment.

Model assignments are available from the WJEC secure website.

Task taking

There are five areas of task taking that are controlled: time, resources, supervision, collaboration and resubmission.

Time

Each model assignment will specify the total amount of time available for summative assessment. Centres have the discretion for how that time is allocated to each task.

Resources

The assessor can determine which resources should be provided to all learners to ensure fair and valid assessment takes place. Where specific resource controls must be in place, these will be stated in the model assignment.

Supervision

Learners must normally be supervised by an assessor whilst completing controlled assignment tasks. Model assignments will specify if supervision is not required. Centres must have in place systems to ensure learners cannot access evidence they have been developing outside of supervised activities.

Authentication

Supervision is in place to ensure the authenticity of evidence produced for summative assessment. Assessors are not expected to provide input or guidance to learners during the controlled assessment time. This includes providing formative feedback on the evidence being produced. Assessors can provide guidance on the requirements of the task and remind learners of the performance bands and how they can be interpreted. Assessors must intervene where there is a Health and Safety hazard observed.

Learners can review and redraft evidence independently within the time controls for the assessment.

Learners must sign a declaration to confirm that all evidence submitted for moderation is their own work and that any sources used have been acknowledged.

Assessors must sign a declaration to confirm that evidence submitted for moderation was completed under the controlled conditions set out in the model assignments.

Collaboration

The model assignment will indicate whether:

- group work must take place;
- group work is forbidden;
- centres can elect to complete tasks through group work.

Where group work takes place, the following principles must be applied.

- Tasks should allow each member of the group to have full access to all performance bands for all assessment criteria;
- Learners must provide an individual response as part of any task outcome;
- Evidence of individual response may include written evidence (e.g. notes, evaluations, mind maps, etc.) and/or audio-visual evidence (e.g. recordings, photographs, drawings, designs, etc.);
- Evidence must be clearly attributable to each individual member of the group;
- Individual contributions must be clearly identified and stated on the accompanying authentication sheet which must be signed by both the teacher and the candidate;
- Assessment of the individual must be based on the individual contribution to the evidence produced;
- Learners' achievement must not be affected by the poor performance of other group members;
- Learners' achievement must not benefit from the performance of other group members.

Resubmission

Learners may resubmit internally assessed units. The learner must submit a new assessment, completed within the same levels of control. They cannot improve previously submitted work.

Learners have one resit opportunity for each assessed unit.

Where an individual learner who has previously submitted group work for assessment wishes to resit an internally assessed unit, one of the following options **must** be taken:

- the candidate must create a new piece of work within the same group;
- the candidate must create a new piece of work within a new group;
- the candidate must create a new piece of work with non-assessed candidates;
- the candidate must create an individual piece of work.

The same levels of control for group work, as outlined above, will apply to candidates who choose to re-sit.

Task marking

All marking of evidence must be made against the assessment criteria and performance band statements given in each unit specification. Evidence marked must comply with the controlled requirements set out in the model assignment.

Written evidence must be annotated to show how it relates to the assessment criteria and performance band requirements.

Performance evidence, for example of giving a presentation, must be made on observation records. Observation records will include a description of learner performance as well as a summative statement on the quality of that performance. Where performance is observed by someone other than an assessor, the 'witness' must complete a witness statement. Assessors will need to authenticate the statement either through scrutiny of supporting evidence and/or questioning of the learner and/or witness. If the statement is authenticated, it can be allowed to contribute to the evidence for assessment. Evidence of authentication will also need to be included. Each model assignment that allows performance evidence will include a sample observation record and witness statement.

Marking should only be undertaken by a designated assessor. An assessor should have appropriate expertise in the subject and level for a specified unit. The assessor is responsible for ensuring that:

- Assessment is conducted under specified controlled conditions;
- They are clear about the requirements of the learning outcomes, assessment criteria and performance band statements prior to commencing controlled assessment;
- Evidence presented for assessment is authentic;
- Assessment decisions are accurately recorded;
- Evidence is appropriately annotated;
- Observation records contain sufficient detail for objective corroboration of decisions;
- Judgements are only made against the performance band statements.

3.3 Synoptic assessment

Synoptic assessment

'requires a candidate to identify and use effectively in an integrated way an appropriate selection of skills, techniques, concepts, theories, and knowledge from across the course content.'

'Level 3 Vocational Qualifications for 16-19 year olds. Technical Guidance for Awarding Organisations' DfE p14

Unit 4: Scientific principles and the environment

Unit 4, in the WJEC Level 3 Applied Diploma in Environmental Science, is an externally assessed synoptic unit that examines learners understanding of key underpinning biological, chemical and physical principles used in units 1 to 3 of the qualification. It has been designed to enable learners to identify and use skills, techniques, concepts, theories, and knowledge from across the units 1 to 3. The unit will seek to examine learners understanding of these principles utilising the contexts provided by units 1 to 3 through external examination.

Unit 9: Environmental Impact Analysis

This is an externally assessed synoptic unit which requires candidates to identify and apply a selection of skills, techniques, concepts, theories and knowledge developed from across the whole qualification content in order to complete an environmental impact analysis for a particular location. This unit allows learners to reinforce their learning from all units in different contexts in order to complete the impact analysis.

3.4 Standardisation

Centres are expected to standardise internal assessment decisions. This is the process by which centres ensure that all learners are judged to the same standard across different assessors, teaching groups and from year to year. Evidence of standardisation should be submitted with learner evidence.

Where more than one assessor is involved, the centre must appoint a Lead Assessor. The role of the Lead Assessor is to:

- Document all activities;
- Ensure that the assignment presented to learners is fit for purpose and complies with all controls;
- Ensure all assessors have appropriate documentation in place to support fair and valid assessment decisions;
- Ensure all assessment activities are in accordance with the task taking controls for the unit;
- Sample assessment judgements at appropriate times to ensure the performance bands are correctly and consistently applied;
- Provide feedback to assessors;
- Provide support to assessors on interpretation of performance band requirements.

4. GRADING

This is a unitised specification which allows for an element of staged assessment. Results for a unit have a shelf-life limited only by the shelf-life of the specification.

Unit grades (Pass, Merit or Distinction) will be awarded on the basis of the grading descriptions. Grading descriptions are provided to give a general indication of the standards of achievement likely to have been shown by learners awarded particular grades for assessment. The descriptions must be interpreted in relation to the content specified by the unit; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met these overall. Shortcomings in some aspects of the assessment may be balanced by better performances in others. Learners who fail to achieve a Pass grade in a particular unit will be awarded a U (unclassified grade) for that unit.

A 'near pass' rule has been introduced for all **external units**. A candidate will achieve a pass (or higher) grade for the qualification if they meet the following two requirements:

- i) Achieve the total UMS required at the relevant grade for the qualification
- ii) Obtained at least the minimum UMS for the relevant external units

Individual unit results are reported on a uniform mark scale (UMS). The grade equivalences for the Level 3 Applied Extended Diploma in Science are given in the following table.

Unit	Assessment type	Raw Mark	weighting %	UMS mark	UMS grade boundaries			
					D	M	P	N
1	Internal	120	12	120	96	72	48	
2	External	120	12	120	96	72	48	36
3	Internal	120	12	120	96	72	48	
4	External	90	14	140	112	84	56	42
5	External	100	12	120	96	72	48	36
6 or 7	Internal	100	12	120	96	72	48	
8	Internal	100	12	120	96	72	48	
9	External (Synoptic)	100	14	140	112	84	56	42

The Level 3 Applied Extended Diploma in Environmental Science qualification is reported on a four point scale: Pass, Merit, Distinction, Distinction*. The attainment of learners who do not reach the minimum standard for a pass grade will receive a U (unclassified) grade and will not receive a qualification certificate.

Learners may only resit the internally assessed unit once and may resit the externally assessed unit twice, with the better result counting before aggregation for the qualification award. A learner may retake the whole qualification more than once.

To achieve a Pass qualification grade learners must score a minimum of 400 uniform marks overall.

To achieve a Merit, Distinction or Distinction* learners must obtain:

- the minimum UMS mark for the qualification grade (see **Table:** UMS and qualification grade);

and

- a minimum of a pass grade in units 4 and 9.

Table: UMS and qualification grade

Grade	Distinction*	Distinction	Merit	Pass	Max. Mark
Mark	900	800	600	400	1000

Units 1 to 4 are common to the WJEC Diploma in Environmental Science. If learners fail to complete the Extended Diploma in Environmental Science, they may cash-in these units against the Level 3 Applied Diploma qualification. Centres should consult sections 4 and 7 of the WJEC Diploma in Environmental Science specification for further information.

5. UNITS

Unit 1 Managing energy for a sustainable future

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit develops knowledge and understanding of how energy can be managed to provide a sustainable energy future for the planet. The unit will develop an understanding of the principles of energy transfer; their application to the use of both renewable and non-renewable energy sources, and the transfer of heat energy.

The unit will enable the learners to gain skills to model, measure and analyse energy transfers in the context of both generation of electricity and energy use. Learners will make recommendations to manage energy generation and energy use for a sustainable future.

Unit introduction

How do we deal with the problems of increased World energy demand? The multiple factors of increased population, industrialisation, living standards, mass global transport and diminishing resources are exerting extreme and complex strains on our global ecosystems. How do we manage our thirst for energy whilst developing a sustainable future? How are renewable and non-renewable energy sources converted to electricity? How do we control the transfer of heat energy to ensure the maximum efficiency of its usage? This unit will help you analyse sustainability and the transfer of energy using modelling and mathematical skills. Physicists and engineers work within the wider energy sector. They are employed by large and small scale energy generation and usage companies in addition to the large number employed by technology companies all over the World developing energy-efficient devices, processes, systems and buildings. The physicists and engineers employed by these organisations must have practical problem solving and mathematical skills in order to model and develop new ways of harnessing and using energy whilst not compromising our sustainable future.

This unit is designed to help you understand the ways that scientists and engineers involved with the energy sector work so that you will be able to develop a sustainable model of energy usage. You will be taught how to measure and analyse numerically the transfer of energy in a range of contexts and learn the necessary practical skills and techniques to carry out investigations into energy generation and heat transfer. In addition, you will gain the necessary skills to carry out an energy audit of a system (e.g. engine, machine, building).

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 know principles of sustainable energy	AC1.1 describe the concept of sustainable energy	Sustainable energy <ul style="list-style-type: none"> • definitions • reduced dependence on non-sustainable energy sources • improving efficiency of systems using energy • differences with low-carbon energy, alternative energy Technologies that support sustainability <ul style="list-style-type: none"> • renewable energy sources (e.g. geothermal, solar, wind, tidal) • technologies to improve efficiency
	AC1.2 describe drivers of sustainable energy	Drivers of sustainable energy e.g. <ul style="list-style-type: none"> • government policy • intergovernmental agreements and protocols • future energy needs • energy security

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 understand principles of energy	AC2.1 describe fundamental concepts relating to energy	Scientific terms <ul style="list-style-type: none"> • forms of energy • useful, wasted energy • energy, work, power • specific heat capacity • specific latent heat • thermal conductivity coefficient • U-values, R-values • current, voltage, resistance • electrical power Units <ul style="list-style-type: none"> • e.g. amp, volt, ohm, watt, kilowatt hour, joule, joule/second
	AC2.2 explain energy transfer using scientific concepts	Scientific concepts <ul style="list-style-type: none"> • Conservation of Energy • Zeroth Law • Newton’s law of cooling • thermal conductivity • conduction, convection and radiation (and factors that affect these)
	AC2.3 explain how electrical energy can be generated	Solar energy <ul style="list-style-type: none"> • generation of electrical current from PV cell • photoelectric effect Turbine - generator systems <ul style="list-style-type: none"> • energy transfer in turbine systems • systems involving generation of steam • e.g. biomass, geothermal, fossil fuels • systems not involving steam generation e.g. wind, tidal

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 understand how to reduce energy waste	AC3.1 describe information required to complete an energy audit	Purpose of an energy audit <ul style="list-style-type: none"> • analysis • prioritise actions Information <ul style="list-style-type: none"> • construction • insulation • energy supplier and consumption • typical use
	AC3.2 explain how energy is lost in a system	Systems <ul style="list-style-type: none"> • power generation systems • devices e.g. refrigerators, electronic systems • buildings
	AC3.3 evaluate ways to reduce energy loss in a system	System <ul style="list-style-type: none"> • power generation systems • devices e.g. refrigerators, electronic systems • buildings Evaluation <ul style="list-style-type: none"> • effectiveness • cost • environmental impact of measures

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to investigate energy transfer	AC4.1 plan to collect energy transfer data	Plan <ul style="list-style-type: none"> • information required • procedures and equipment • timescales and sequencing of activities • proforma to record data
	AC4.2 prepare equipment to measure energy transfers	Equipment <ul style="list-style-type: none"> • relevant measuring devices and meters • relevant connection equipment (e.g. connecting wires) Preparation <ul style="list-style-type: none"> • check equipment (e.g. damage, low battery) • set up equipment e.g. <ul style="list-style-type: none"> • selecting correct connections • selection of appropriate range and units • zeroing
	AC4.3 obtain data relating to energy transfers	Data <ul style="list-style-type: none"> • primary data Primary data <ul style="list-style-type: none"> • data relevant to energy use • data relevant to generation/consumption electricity • data relevant to heat loss from systems (e.g. buildings - window area etc.) Follows safe working practice
	AC4.4 record data	Recording documentation <ul style="list-style-type: none"> • laboratory notebook • proforma • LMS/database Records <ul style="list-style-type: none"> • all key information recorded • data recorded to correct precision • entries legible

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 <i>continued</i>	AC4.5 process data using numerical methods	Data <ul style="list-style-type: none"> • primary data, secondary data Primary data <ul style="list-style-type: none"> • defined in AC4.3 Secondary data <ul style="list-style-type: none"> • power • capacity/volume • specific heat capacity • specific latent heat • density • thermal conductivity • U-values Numerical methods <ul style="list-style-type: none"> • record raw data to appropriate significant figures • process data using mathematical equations • presentation of calculations • use of significant figures in calculations
	AC4.6 interpret graphic information showing energy transfer	Graphic information <ul style="list-style-type: none"> • graphs • Sankey diagrams Graphs e.g. <ul style="list-style-type: none"> • electrical characteristics (VI graphs) • solar power graphs • temperature-time graphs Sankey diagrams <ul style="list-style-type: none"> • energy flow through systems • efficiency of systems • effect of changing efficiency on energy flow

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 continued	AC4.7 evaluate data and procedures	Evaluation <ul style="list-style-type: none"> • quality of data • effectiveness of procedures Evaluates in terms of <ul style="list-style-type: none"> • accuracy ('trueness') • precision • repeatability • outliers • bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO5 be able to report on sustainability	AC5.1 present data in tables	Tables <ul style="list-style-type: none"> • style, effectiveness, information contained (data, units)
	AC5.2 present data in graphs	Graphs <ul style="list-style-type: none"> • size, scale • labels: titles, axis labels, key, units, captions • relevant best fit lines/curves • using software and handwritten
	AC5.3 present data in Sankey diagrams	Sankey diagrams <ul style="list-style-type: none"> • drawn to scale • software, hand
	AC5.4 make recommendations on energy sustainability	Sustainability <ul style="list-style-type: none"> • energy generation systems • systems to improve efficiency of energy use Recommendations <i>Based upon:</i> <ul style="list-style-type: none"> • evidence • cost • practicality • effectiveness, improved efficiency, reduction in dependence on unrenowable energy sources

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO5 <i>continued</i>	AC5.5 communicate outcome of investigation	Reporting style <ul style="list-style-type: none"> • technical and scientific language • clarity • language style • spelling, punctuation and grammar • structure of report Communication method <ul style="list-style-type: none"> • written

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO1 know principles of sustainable energy	AC1.1 describe the concept of sustainable energy	Gives a description of some aspects of the concept of sustainable energy 1	Gives a mainly clear description of the concept of sustainable energy 2-3	Gives a clear and detailed description of the concept of sustainable energy 4
	AC1.2 describe drivers of sustainable energy	Gives a description of some drivers of sustainable energy 1-2	Gives a mainly clear description of significant drivers of sustainable energy <i>Some parts may be in detail</i> 3-4	Gives a clear and detailed description of a range of drivers, including significant drivers, of sustainable energy 5-6
LO2 understand principles of energy	AC2.1 describe fundamental concepts relating to energy	Gives a description of some fundamental concepts relating to energy 1-3	Gives a mainly clear description of a range of fundamental concepts relating to energy <i>Some concepts are described in detail</i> 4-6	Gives a clear and detailed description of a range of fundamental concepts relating to energy 7-9
	AC2.2 explain energy transfer using scientific concepts	Gives an explanation of energy transfer using some relevant scientific concepts <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of energy transfer using mostly relevant scientific concepts 3-4	Gives an accurate and coherent explanation showing detailed reasoning of energy transfer using relevant scientific concepts 5-6
	AC2.3 explain how electrical energy can be generated	Gives an explanation of how electrical energy is generated <i>Low level explanations may not always clearly show reasoning</i> 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how electrical energy is generated 4-6	Gives an accurate, detailed and coherent explanation showing detailed reasoning of how electrical energy is generated 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO3 understand how to reduce energy waste	AC3.1 describe information required to complete an energy audit	Gives a description of some information required for an energy audit 1-2	Gives a mainly clear description of the significant information required for an energy audit <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description of the significant information required for an energy audit 5-6
	AC3.2 explain how energy is lost in a system	Gives an explanation of ways in which energy is lost in a system <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of ways in which energy is lost in a system 3-4	Gives an accurate and coherent explanation with detailed reasoning of ways in which energy is lost in a system 5-6
	AC3.3 evaluate ways to reduce energy loss in a system	Makes some suitable judgements of ways to reduce energy loss from a system <i>Low level evaluations may not always clearly show reasoning</i> 1-3	Makes mainly suitable judgements with some clear reasoning of significant ways to reduce energy loss from a system 4-6	Makes suitable judgements with clear and detailed reasoning of significant ways to reduce energy loss from a system 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO4 be able to investigate energy transfer	AC4.1 plan to collect energy transfer data	Identifies some information to collect identifies some appropriate procedures and equipment to collect information Sets some achievable times to complete some aspects of the plan Devises a proforma to collect some suitable information 1-3	Identifies most information to collect identifies mainly appropriate procedures and equipment to collect information Sets achievable times to complete most aspects of the plan Devises a mainly suitable proforma to collect most required information 4-6	Identifies the information to collect Identifies appropriate procedures and equipment to collect the information Sets achievable times to complete all aspects of the plan Devises a suitable proforma to collect all the required information 7-9
	AC4.2 prepare equipment to measure energy transfers	Prepares equipment for use <i>There may be some errors in the preparation of equipment</i> 1	Correctly prepares equipment for use 2	
	AC4.3 obtain data relating to energy transfers	Obtains some suitable data Some data is obtained is within expected tolerance of instruments/ procedures used to obtain data 1-2	Obtains mainly suitable and sufficient data Most data is obtained is within expected tolerance of instruments/ procedures used to obtain data 3-4	Obtains suitable and sufficient data Consistently obtains data within expected tolerance of instruments/ procedures used to obtain data 5-6

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO4 <i>continued</i>	AC4.4 record data	Most key data is recorded Entries are generally legible Some data recorded to appropriate precision 1	All key data is recorded Most entries are legible Most data recorded to appropriate precision 2	All key data is recorded All entries are legible All data recorded to appropriate precision 3
	AC4.5 process data using numerical methods	Uses some suitable numerical methods to process data Lays out some aspects of workings Makes a limited use of significant figures 1-2	Uses suitable numerical methods to mostly accurately process data Lays out most workings clearly and logically Makes some appropriate and accurate use of significant figures 3-4	Consistently uses suitable numerical methods to accurately process data Consistently lays out workings clearly and logically Consistently makes appropriate and accurate use of significant figures 5-6
	AC4.6 interpret graphic information showing energy transfer	Makes some appropriate interpretation of graphical information 1-2	Makes a mostly accurate and appropriate interpretation of graphical information <i>Some parts are in detail</i> 3-4	Makes an accurate, appropriate and detailed interpretation of graphical information 5-6
	AC4.7 evaluate data and procedures	Gives an appropriate evaluation of some aspects of the data and procedures <i>Evaluation may be weighed towards data or procedures</i> 1-2	Gives a mostly clear and accurate evaluation of a range of aspects of the data and procedures 3-4	Gives a clear, detailed and accurate evaluation of a range of aspects of the data and procedures 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO5 be able to report on sustainability	AC5.1 present data in tables	Tables are used to present data Some correct headings, symbols and units are used 1	Mostly suitable tables are used to present data Mostly correct headings, symbols and units are used 2	Suitable tables are used to clearly present data Correct headings, symbols and units are used 3
	AC5.2 present data in graphs	Some suitable graph styles are used Mostly suitable sizes and scales are used to construct graphs Graphs have some correct labelling Draws a line of best fit which takes into account some data 1-2	Suitable graph styles are used Suitable sizes and scales are consistently used to construct graphs Graphs are mostly fully and correctly labelled Draws a line of best fit with some accuracy taking into account the data 3-4	Suitable graph styles are used Suitable sizes and scales are consistently used to construct graphs Graphs are consistently fully and correctly labelled Accurately determines a line of best fit taking into account the data 5-6
	AC5.3 present data in Sankey diagrams	Constructs some appropriate Sankey diagrams from data with some accuracy 1	Constructs mainly appropriate and accurate Sankey diagrams from data 2	Consistently constructs appropriate and accurate Sankey diagrams from data 3
	AC5.4 make recommendations on energy sustainability	Makes some suitable recommendations with some reference to data/evidence to support the recommendation 1-2	Makes suitable recommendations with mostly suitable reference to data/evidence to support the recommendations 3-4	Makes suitable recommendations with suitable and detailed reference to data/evidence to support the recommendations 5-6

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO5 <i>continued</i>	AC5.5 communicate outcome of investigation	Communicates some information from the investigation Uses some appropriate scientific and technical language Use some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Mostly clearly communicates information from the investigation Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Clearly communicates information from the investigation Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to work places involved with the generation of electricity (conventional power stations; renewable energy sites etc.)
- arranging talks by visiting speakers from companies involved with the generation of electricity, energy conservation, Environmental Science/Physics/Engineering departments at local HE establishments etc.
- arranging a visit to an energy efficient building

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of managing energy.

Example 1

An engineer from a local renewable energy generation company (wind farm, solar panel farm, HEP station) could discuss with candidates the issues associated with siting the generation facility where it is. Candidates could make a site visit and take measurements/photos of the facility and write a short report on their findings.

Example 2

Candidates could visit a local energy efficient building or a building where the management of energy is important, for example a local swimming pool or sports centre. The candidates could talk to the facilities manager/engineer about how energy is managed throughout the building and how the energy bills are minimised. Candidates could write a short report about their findings.

Example 3

A local heating engineer could visit and talk to candidates about the sorts of modern hot water boilers that are available on the market, and how they are manufactured to be so efficient. The engineer could also talk about and show samples of insulation materials and systems that can be retro-fitted to buildings to increase their energy efficiency. Candidates could write a short report on their findings.

Making Contacts

Examples of organisations that may be approached to provide help include:

- National energy companies – most of whom can be contacted through their trade association - energy-uk.org.uk
- National Renewable Energy companies – most of which can be contacted through their trade association - renewableuk.com
- The Energy Saving Trust-energysavingtrust.org.uk
- Department of Energy and Climate Change (DECC) – <https://www.gov.uk/government/organisations/department-of-energy-climate-change>

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Websites

Energy sustainability

http://en.wikipedia.org/wiki/Sustainable_energy

<http://www.rsc.org/science-activities/sustainable-energy/>

<http://www.open.edu/openlearn/science-maths-technology/science/environmental-science/introduction-sustainable-energy/content-section-0>

<http://www.open.edu/openlearn/science-maths-technology/science/environmental-science/energy-resources-wind-energy/content-section-0>

<http://www.sustainableenergyresources.co.uk/>

Solar power output activity

http://heliotronics.com/papers/SPGraphs_rev4.pdf

Energy audit

<http://energyauditinstitute.com/energy-audits.html>

Sankey Diagrams

<http://ipodphysics.com/sankey-diagrams-work.php>

<http://www.sankey-diagrams.com/tag/energy-efficiency/>

<http://appsci.tinopolis.com/contents/?article=7>

<http://www.doka.ch/sankey.htm>

http://www.foe.co.uk/news/up_in_smoke_graphic_36417

Fundamental Concepts

<http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html#c1>

[http://en.wikipedia.org/wiki/R-value_\(insulation\)](http://en.wikipedia.org/wiki/R-value_(insulation))

<http://www.thermalcalconline.com/>

Concepts of evidence

http://community.dur.ac.uk/rosalyn.roberts/Evidence/CofEv_Gott%20et%20al.pdf

Unit 2 The living environment and conservation

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit develops knowledge and understanding of biodiversity, interdependence of organisms and conservation. Learners investigate key environmental concepts, and develop the skills needed to monitor ecosystems and to know how various agencies work for the protection of the environment.

The unit will enable the learners to acquire knowledge and understanding of the interrelationships within ecosystems, how they are affected by human activity and how they may be conserved. Learners will also develop skills to monitor and measure the effect these influences are having.

Unit introduction

How do living and non-living factors interact within an ecosystem? Why have ecosystems developed in the way they have? How has human activity impacted on ecosystems? Does all human activity have to be negative? Can we conserve the environment for future generations? How can ecosystems be monitored? This unit helps provide you with the skills to understand and carry out assessment of ecosystems.

Environmental scientists need to understand the relationship between living and non-living factors on the environment. An understanding of how we as humans affect the planet on which we live is fundamental for developing more sustainable ways of living. Environmental scientists work for government agencies, universities and private companies. Environmental scientists usually begin their careers in the field; while more experienced workers will spend more time inside the office or laboratory. Some of the features which characterise the work of environmental scientists such as meeting deadlines, attention to detail, methodical approach and analytical thinking are important transferable skills, applicable in all aspects of life and work. They must also have good communication skills as liaison with other agencies is often necessary.

This unit is designed to help you to understand how an environmental biologist/scientist works so that you will be able to tackle problems and answer questions in an environmental context. You will be taught about how living and non-living factors are interdependent and how we, as humans have affected the delicate balance within ecosystems. You will learn how to measure species in their natural surroundings and the limitations of the techniques used. At the end of this unit you will have gained the relevant knowledge, understanding and practical techniques to analyse ecosystems.

Learning outcomes	Assessment criteria	Content
<i>The learner will:</i>	<i>The learner can:</i>	
LO1 understand the inter-relationships within ecosystems	AC1.1 define an ecosystem	Definition
	AC1.2 explain energy transfers between organisms in an ecosystem	Energy transfers <ul style="list-style-type: none"> • producers, primary consumers, secondary consumers, tertiary consumers, decomposers • role of photosynthesis • energy losses from food chains • efficiency of energy transfer between trophic levels • gross and net production • pyramids of number, biomass and energy
	AC1.3 explain the role of decomposers in ecosystems	Decay, nitrogen and carbon cycles <ul style="list-style-type: none"> • requirements for decay • decomposers • nitrogen fixation • nitrification • denitrification
	AC1.4 explain how factors affect ecosystem populations	Factors <ul style="list-style-type: none"> • biotic factors e.g. inter-specific and intra-specific competition, predation, mutualism, commensalism, immigration and emigration, density dependent and independent factors, birth and death rate • abiotic factors e.g. sunlight, temperature, soil, water, height and pressure • carrying capacity
	AC1.5 analyse patterns in population data	Patterns in population data <ul style="list-style-type: none"> • lag phase • log/exponential phase • stationary phase • decline phase

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 <i>continued</i>	AC1.6 describe how variation within a species brings about change	Variation and change <ul style="list-style-type: none"> • natural selection and evolutionary change • outline how variation, adaptation and natural selection relate to evolution • role of mutations in causing change (egg. MRSA, peppered moth, Warfarin resistance in rats) • supporting evidence (e.g. DNA, fossil evidence, molecular evidence) • relationship between phylogeny and classification
	AC1.7 explain the process of succession	The process of succession <ul style="list-style-type: none"> • primary succession • secondary succession • pioneers • sere • climax community

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO2 understand how human activity impacts on ecosystems</p>	<p><i>The learner can:</i></p> <p>AC2.1 describe human activity in an environment</p>	<p>Types of human activity:</p> <ul style="list-style-type: none"> • agricultural practices • fishing methods • forestation / deforestation • mining / industrial activity including historical activity • development (road construction, housing and shopping developments, recreational developments (e.g. golf courses)) • management of grass areas (e.g. frequently cut, mowed, managed) • conservation programmes
	<p>AC2.2 explain how human activity affects ecosystems</p>	<p>Human activity</p> <ul style="list-style-type: none"> • agricultural practices e.g. <ul style="list-style-type: none"> ○ intensive methods (e.g. pesticide and insecticide use, use artificial fertilisers) ○ traditional and organic methods farming • forestation / deforestation • mining / industrial activity e.g. <ul style="list-style-type: none"> ○ impacts waste on the environment (soil, waterways) • development (road construction, housing and shopping developments, recreational developments (e.g. golf courses)) e.g. habitat loss • conservation programmes <p>Explanation in terms of how activity affects ecosystems</p>

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 understand how ecosystems can be conserved	AC3.1 describe what is meant by conservation	Conservation <ul style="list-style-type: none"> • definition
	AC3.2 explain why conservation of ecosystems is necessary	Reasons <ul style="list-style-type: none"> • environmental • aesthetic • ethical • social • economic
	AC3.3 describe different conservation methods	In-situ conservation <ul style="list-style-type: none"> • habitat protection or cleaning • environmental preservation • defending the species from predators. Ex-situ conservation <ul style="list-style-type: none"> • e.g. colony relocation, human care, captive breeding and release programmes, seed banks, cryopreservation Preservationist method <ul style="list-style-type: none"> • non-interference Mechanisms <ul style="list-style-type: none"> • legal protection e.g. The Wildlife & Countryside Act (1981 & 1984) • protected environments e.g. Protected Sites of Special Scientific Interest (SSSIs), National Nature Reserves, National Parks) • trade controls e.g. CITES
	AC3.4 explain the reasons for extinction	Reasons for extinction <ul style="list-style-type: none"> • habitat degradation/loss • predation • competition • disease • genetics and demographics • climate change

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to monitor ecosystems	AC4.1 plan to obtain data about ecosystems	Plan <ul style="list-style-type: none"> • information required • procedures and equipment • timescales and sequencing of activities • proforma to record data Select appropriate techniques to gather data <ul style="list-style-type: none"> • random sampling using quadrats • use of belt transects to record changes in species distribution • identifying species, • appropriate classification of species • numbers of each species • measuring species density and percentage cover • use of abundance scales and their limitations • equipment to measure pH, temperature
	AC4.2 draw up a health and safety risk assessment	Risk assessment <ul style="list-style-type: none"> • hazards and risks • people at risk • control measures • documentation
	AC4.3 obtain data about ecosystems	Data <ul style="list-style-type: none"> • primary data Primary data e.g. <ul style="list-style-type: none"> • number of individual species • abundance of invertebrates (as indicators of water quality) • abundance of lichens (as indicators of air quality) • pH, temperature
	AC4.4 record data from ecosystems	Data e.g. <ul style="list-style-type: none"> • species found, number of individual species • abundance of invertebrates, lichens • pH, temperature Records <ul style="list-style-type: none"> • all key information recorded • data recorded to correct precision Format recording <ul style="list-style-type: none"> • tables

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 continued	AC4.5 process data from investigations	<p>Numerical methods processing data</p> <ul style="list-style-type: none"> • estimating population sizes using: $\frac{n_1 \times n_2}{n_m}$ • Simpsons index of biodiversity $D = \frac{N(N-1)}{\sum n(n-1)}$ <p style="text-align: center;">where N = total number of organisms of all species and n = total number of organisms of a particular species</p> • Statistical methods to compare populations (t- test) <p>Graphical methods processing data</p> <ul style="list-style-type: none"> • charts • graphs, trends, trend lines
	AC4.6 assess how human activity has affected an ecosystem	<p>Assessment based upon</p> <ul style="list-style-type: none"> • primary and secondary data <ul style="list-style-type: none"> ○ evenness, richness of biodiversity ○ population sizes ○ significance of high and low values of Simpsons index of Diversity (D) ○ t-test analysis ○ comparison with data from other sites
	AC4.8 evaluate data and procedures	<p>Evaluates</p> <ul style="list-style-type: none"> • quality of data • effectiveness of procedures <p>Evaluates in terms of</p> <ul style="list-style-type: none"> • repeatability • reliability • outliers • bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO1 understand the inter-relationships within ecosystems	AC1.1 define an ecosystem	Gives a definition of an ecosystem 1-2	Gives a detailed description of an ecosystem 3	
	AC1.2 explain energy transfers between organisms in an ecosystem	Gives an explanation of how energy is transferred between organisms with some accuracy <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how energy is transferred between organisms 3-4	Gives an accurate and coherent explanation showing detailed reasoning of how energy is transferred between organisms 5-6
	AC1.3 explain the role of decomposers in ecosystems	Gives an explanation of the role of decomposers in ecosystems with some accuracy <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the role of decomposers in ecosystems 3-4	Gives an accurate, detailed and coherent explanation of the role of decomposers in ecosystems 5-6
	AC1.4 explain how factors affect ecosystem populations	Gives an explanation of how some factors affect biodiversity <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how a range of factors affect biodiversity 3-4	Gives an accurate, detailed and coherent explanation of how a range of factors affect biodiversity 5-6
	AC1.5 analyse patterns in population data	Makes some appropriate analysis of population data 1-2	Makes a mostly appropriate analysis of population data showing some detailed reasoning 3-4	Makes an appropriate analysis of population data showing detailed reasoning 5-6
	AC1.6 describe how variation within a species brings about change	Gives a description of some aspects of how variation within a species brings about change 1-2	Gives a mainly clear description of how variation within a species brings about change <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description of how variation within a species brings about change 5-6
	AC1.7 explain the process of succession	Gives an explanation of the process of succession with some accuracy <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the process of succession 3-4	Gives an accurate and coherent explanation showing detailed reasoning of the process of succession 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	The learner can:	Band 1	Band 2	Band 3
LO2 understand how human activity impacts on ecosystems	AC2.1 describe human activity in an environment	Gives a description of some human activities in an environment. <i>Some aspects of the description is relevant to the environment studied</i> 1-2	Gives a clear, detailed and relevant description of human activities in an environment. <i>The description is relevant to the environment studied</i> 3-4	
	AC2.2 explain how human activity affects ecosystems	Gives an explanation of how human activity affects an ecosystem <i>Low level explanations may not always clearly show reasoning</i> 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of how human activity affects an ecosystem 4-5	Gives an accurate and coherent explanation showing detailed reasoning of how human activity affects an ecosystem 6-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO3 understand how ecosystems can be conserved	AC3.1 describe what is meant by conservation	Gives a mostly clear description of what is meant by conservation 1-2	Gives a clear and detailed description of what is meant by conservation 3-4	
	AC3.2 explain why conservation of ecosystems is necessary	Gives an explanation of why conservation of ecosystems is necessary <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning why conservation of ecosystems is necessary 3-6	Gives an accurate and coherent explanation showing detailed reasoning why conservation of ecosystems is necessary 7-9
	AC3.3 describe different conservation methods	Gives a description of some appropriate methods of conservation 1-2	Gives a mainly clear description of appropriate methods of conservation <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description of appropriate methods of conservation 5-6
	AC3.4 explain the reasons for extinction	Gives an explanation of some relevant reasons for extinction <i>Low level explanations may not always clearly show reasoning</i> 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of relevant reasons for extinction 4-6	Gives an accurate and coherent explanation showing detailed reasoning of relevant reasons for extinction 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO4 be able to monitor ecosystems	AC4.1 plan to obtain data about ecosystems	<p>Identifies some information to collect</p> <p>Identifies some appropriate procedures and equipment to collect information</p> <p>Sets some achievable times to complete some aspects of the plan</p> <p>Devises a proforma to collect some suitable information</p> <p style="text-align: center;">1-2</p>	<p>Identifies most information to collect</p> <p>Identifies mainly appropriate procedures and equipment to collect information</p> <p>Sets achievable times to complete most aspects of the plan</p> <p>Devises a mainly suitable proforma to collect most required information</p> <p style="text-align: center;">3-4</p>	<p>Identifies the information to collect</p> <p>Identifies appropriate procedures and equipment to collect the information</p> <p>Sets achievable times to complete all aspects of the plan</p> <p>Devises a suitable proforma to collect all the required information</p> <p style="text-align: center;">5-6</p>
	AC4.2 draw up a health and safety risk assessment	<p>Identifies some hazards and risks to health and safety</p> <p>Suggests some suitable control measures</p> <p>Records some parts of risk assessment accurately</p> <p style="text-align: center;">1-2</p>	<p>Identifies significant hazards and risks to safety.</p> <p>Suggests some suitable control measures for significant hazards and risks to health and safety</p> <p>Records most aspects of the risk assessment accurately and clearly</p> <p style="text-align: center;">3-4</p>	<p>Identifies the significant hazards and risks to safety.</p> <p>Suggests suitable control measures for hazards and risks to health and safety</p> <p>Records clearly and accurately the risk assessment</p> <p style="text-align: center;">5-6</p>
	AC4.3 obtain data about ecosystems	<p>Obtains some suitable data about ecosystems</p> <p>Some data is obtained is within expected tolerance of procedures used to obtain data</p> <p style="text-align: center;">1-2</p>	<p>Obtains mostly suitable and sufficient data about ecosystems</p> <p>Most data is obtained is within expected tolerance of procedures used to obtain data</p> <p style="text-align: center;">3-4</p>	<p>Obtains suitable and sufficient data about ecosystems</p> <p>Consistently obtains data within expected tolerance of procedures used to obtain data</p> <p style="text-align: center;">5-6</p>

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO4 <i>continued</i>	AC4.4 record data from ecosystems	Some key data is recorded Entries are generally legible Some data recorded to appropriate precision Some records are clear 1	Most key data is recorded Most entries are legible Most data recorded to appropriate precision Records are mostly clearly and logically presented 2-3	key data is recorded All entries are legible All data recorded to appropriate precision Records are clearly and logically presented 4
	AC4.5 process data from investigations	Uses some suitable methods to process data Some aspects of graphs/calculations are clearly presented Makes a limited use of significant figures 1-2	Uses suitable methods to mostly accurately process data Graphs/calculations are mostly clearly and logically presented Makes some appropriate and accurate use of significant figures 3-4	Consistently uses suitable methods to accurately process data Graphs/calculations are clearly and logically presented Consistently makes appropriate and accurate use of significant figures 5-6
	AC4.6 assess how human activity has affected an ecosystem	Gives an assessment of how human activity has affected biodiversity with reference to a limited range of relevant factors, with some reasoned judgements 1-2	Gives an assessment of how human activity has affected biodiversity with reference to relevant factors, with mainly reasoned judgements <i>Some parts are in detail</i> 3-4	Gives a detailed assessment of how human activity has affected biodiversity with reference to a range of relevant factors, with reasoned judgements 5-6
	AC4.7 evaluate data and procedures	Makes some suitable judgements about data and procedures some <i>Evaluation may be weighed towards data or procedures</i> 1-2	Makes mainly suitable judgements showing clear reasoning about data and procedures against a range of criteria 3-4	Makes suitable judgements showing clear and detailed reasoning about data and procedures against a range of criteria 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is externally assessed by an assignment provided by WJEC annually in September of each academic year. This assignment will be downloadable from the WJEC secure website. Further information about the assessment of this unit can be found in **section 3.1.1** of the specification.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- Arranging visits to universities with environmental Science courses
- Visits to and from companies, agencies and organisations involved with managing the environment and environmental issues. E.g. Governmental and non-governmental agencies linked to AONBs (Areas of Outstanding Natural Beauty), National Parks, Nature Reserves, SSSIs (Sites of Special Scientific Interest), Environmental Agency
- Visits to AONBs, National Parks, SSSIs to conduct fieldwork

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of the living environment and conservation.

Example 1

Council representatives (e.g. from planning departments) could be invited to speak about environmental impact assessments. They could focus on the role of councils in development planning, conservation areas, ecology and landscapes. Discussion could focus around the need to balance the requirements for food, attitudes of people towards economic development and the needs of wildlife.

Example 2

A representative from a conversation group could be invited to speak about issues associated with trying to conserve species biodiversity. For example, a proposed cull of badgers in order to reduce the spread of bovine TB. This could be followed up by learners presenting arguments for and against the proposed cull. There are numerous such issues which apply to various regions of the UK.

Example 3

Learners could visit a farm to see how human's need for food is balanced with the needs of wildlife. Learners could discuss the restrictions that apply within the farming community and issues associated with trying to reduce 'food miles'. Other issues may also be addressed depending on the farm, for example how cloning techniques may be used in plants and animals and the impact of cloning on reduction of variation.

Example 4

Representatives from the highways agency could be invited to speak or if possible learners could visit certain road building projects. They could discuss the issues surrounding destruction of habitat and how biodiversity is conserved (e.g. the construction of 'dormouse bridges' across roads). As a follow up, learners could plan their own 'road system' which balances our need for economic development with the needs of wildlife.

Making Contacts

Examples of organisations that may be approached to provide help include:

Environmental Agency
County councils (e.g. refuse collection)
Biology departments of universities
Conservation bodies
Specialist environmental laboratories

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks

There are a number of A-level Biology textbooks that can be used as a resource for this unit. Examples include

New Understanding Biology for Advanced Level (G Toole and S Toole) (4th Edition)
Advanced Biology (G Monger, M Reiss and M Roberts)

Websites

Thinkquest – lots of information on interdependence
<http://library.thinkquest.org/11353/ecosystems.htm>

Natural Selection simulation
<http://www.biologyinmotion.com/evol/index.html>

Biozone – numerous resources for the study of evolution, human impact on the environment, interdependence
<http://www.thebiozone.com/links.html>

Communities.gov.uk – an information resource for teachers regarding environmental impact assessments and planning
<http://www.communities.gov.uk/publications/planningandbuilding/environmentalimpactassessment>

Practical Biology – linked to the Society of Biology and Nuffield Curriculum Centre
www.practicalbiology.org

SEP (Science Enhancement Programme)
www.sep.org.uk

Biotechnology and Biological Sciences Research Council - many resources for teachers and student activities to teach this unit
<http://www.bbsrc.ac.uk/>

Natural Environment Research Council – numerous resources, probably more for teachers than learners
<http://www.nerc.ac.uk/site/guides/schools.asp>

The Habitable planet – simulations of effects different factors on populations
<http://www.learner.org/courses/envsci/interactives/index.php>

Unit 3 Monitoring our physical environment

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit develops knowledge and understanding of how analytical science is used to gather information about our physical environment. The unit will develop an understanding of chemical testing methods, including instrumental methods of analysis that are used by analytical scientists who study the environment.

The unit will enable the learners to gain the skills necessary to carry out and analyse samples collected from a variety of environmental sources. Candidates will also learn how to draw evidence based conclusions from the outcome of their analysis.

Unit introduction

How clean is the water that you drink? How can we determine what is present in river water? What pollutants may it contain and what is the concentration? How do we know if nitrates are being washed into river water from agricultural land? Does a gas flare from an oil rig contaminate crops with fall out of organic matter? How can we test to find the concentration of heavy metals contained in soil or sediment? This unit helps provide you with the analytical skills to understand and carry out these forms of environmental analysis.

Analytical scientists are employed within the environmental science sector by organisations such as the Environmental Agency, the National Laboratory Service and National Resources Wales, water companies as well as many independent analytical laboratories. Many of the skills that are developed by analytical scientists such as; challenging assumptions, attention to detail and methodical approaches are important transferable skills which are applicable in all aspects of life and work. This means the skills that analytical scientists gain also makes them ideal employees to work in sectors outside Environmental Science.

This unit is designed to help you understand the way in which an analytical scientist works so that you will be able to tackle problems and answer questions in an environmental context. You will be taught how to solve problems by working in a logical and systematic way, and to think critically about the limitations of the results you obtain from your analysis. You will learn the necessary practical and analytical skills and techniques to enable you to carry out an environmental investigation, make deductions and communicate your findings.

Learning outcomes	Assessment criteria	Content
<i>The learner will:</i>	<i>The learner can:</i>	
LO1 understand chemical notation	AC1.1 describe families of organic molecules	<p>Families</p> <ul style="list-style-type: none"> • functional groups • aromatic compounds <p>Functional groups</p> <ul style="list-style-type: none"> • alkanes • alkenes • phenyls • alcohols • phenols • aldehydes • ketones • carboxylic acids <p>Methods of describing families of organic molecules</p> <ul style="list-style-type: none"> • functional group names • molecular formulae • structural formulae • aliphatic / aromatic <p>Aromatic compounds</p> <ul style="list-style-type: none"> • benzene, polycyclic aromatic hydrocarbons (PAH)
	AC1.2 interpret representations of organic molecules	<p>Representations of organic molecules</p> <ul style="list-style-type: none"> • molecular formula • structural formulae • full displayed structural formulae • skeletal formulae
	AC1.3 represent inorganic chemical species using chemical notation	<p>IUPAC nomenclature of inorganic species</p> <ul style="list-style-type: none"> • ions • compounds (e.g. Use of roman numerals where a metal may have more than one oxidation state, spelling of species containing sulfur)
	AC1.4 represent reactions using balanced chemical equations	<p>Balanced chemical equations</p> <ul style="list-style-type: none"> • full symbol equations • ionic equations • use of state symbols

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 understand principles of environmental analysis	AC2.1 explain choice of methods used in analysis	<p>Methods</p> <ul style="list-style-type: none"> • sampling and analytical procedures <p>Sampling procedures <i>Choice in terms of:</i></p> <ul style="list-style-type: none"> • representative sampling • sufficiency (Will the sampling method yield sufficient data) • storage of samples (Does the method of storing samples affect the sample?) <p>Sampling from</p> <ul style="list-style-type: none"> • atmosphere, waterways, soil, organic matter <p>Analytical procedures <i>Choice in terms of:</i></p> <ul style="list-style-type: none"> • nature of information required (quantitative, qualitative) • nature of sample • limitations of the procedure <p>Analytical procedures</p> <ul style="list-style-type: none"> • chromatographic, instrumental, volumetric, chemical testing
	AC2.2 explain how mixtures are separated by chromatographic methods	<p>Chromatographic methods</p> <ul style="list-style-type: none"> • thin layer chromatography • gas chromatography • high performance liquid chromatography
	AC2.3 explain how the absorption of radiation may be used in the analysis of samples	<p>Methods of analysis</p> <ul style="list-style-type: none"> • atomic absorption spectroscopy • colorimetry • ultraviolet spectroscopy, ultraviolet detectors in gc/hplc <p>Types of samples</p> <ul style="list-style-type: none"> • samples contain metal ions • samples containing chromophores
	AC2.4 explain principles used in volumetric analysis	<p>Volumetric analysis</p> <ul style="list-style-type: none"> • acid-base titration • redox titration

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 be able to obtain analytical data on the physical environment	AC3.1 plan to collect environmental samples	Plan <ul style="list-style-type: none"> • suitable sampling points (accessibility, safety & ease of access, alternatives) • equipment for collecting sample • equipment for storing and transporting sample
	AC3.2 label samples for analysis	Labelling of samples <ul style="list-style-type: none"> • indelible pen • date/time • location • weather conditions
	AC3.3 prepare for volumetric analysis	Preparation <ul style="list-style-type: none"> • selects appropriate equipment • check equipment (damage, cleanliness) Equipment <ul style="list-style-type: none"> • volumetric equipment
	AC3.4 obtain data using volumetric equipment	Volumetric equipment <ul style="list-style-type: none"> • balance • volumetric flasks • burette • pipette • using indicator, pH meter Data <ul style="list-style-type: none"> • endpoint • mean titre
	AC3.5 obtain data using an instrumental form of analysis	Instrumental methods <ul style="list-style-type: none"> • electrodes (e.g. pH, ion-selective) • spectroscopic (e.g. colorimeter, UV spectroscopy)

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 <i>continued</i>	AC3.6 obtain data using qualitative techniques	Qualitative techniques <ul style="list-style-type: none"> • thin layer chromatography • flame tests • chemical testing • negative ions (halides, hydroxides, sulphates, sulphides, nitrates, carbonates) • cations including NH₄⁺ ions • functional groups (alcohols, aldehydes, ketones, carboxylic acids, esters, phenols, amines) • distinguishing aromatic and aliphatic compounds • melting point
	AC3.7 follow safe working practice	Safe working practice <ul style="list-style-type: none"> • works in accordance with risk assessment and laboratory requirements • correctly uses PPE • maintains tidy working area
	AC3.8 record experimental work	Recording method <ul style="list-style-type: none"> • laboratory notebook • proforma • laboratory information management systems Records <ul style="list-style-type: none"> • all key information recorded (sample identification/date/experimental details (e.g. mass used, titres etc.)) • data recorded to correct precision • entries legible

Learning outcomes	Assessment criteria	Content
<i>The learner will:</i> LO4 be able to process analytical data	<i>The learner can:</i> AC4.1 process data using graphical methods	Instrumental methods <ul style="list-style-type: none"> • ion selective electrodes • pH meters • gas chromatography/high performance chromatography • colorimetry • ultraviolet spectroscopy • atomic absorption Graphs <ul style="list-style-type: none"> • pH curves • calibration curves Graphical drawing methods <ul style="list-style-type: none"> • by hand • using software (e.g. Excel/ graphical package) Uses graphs to find e.g. <ul style="list-style-type: none"> • endpoint • concentrations (units e.g. mol dm^{-3}, ppm)
	AC4.2 calculate concentrations	Concentration calculations <ul style="list-style-type: none"> • determine concentration of standard solutions • calculate concentrations (e.g. from volumetric data)
	AC4.3 interpret retention data from chromatographic analysis	Chromatographic analysis <ul style="list-style-type: none"> • paper/thin layer chromatography • GC/HPLC Data <ul style="list-style-type: none"> • retention factor (R_f value) • retention time
	AC4.4 interpret data from qualitative analysis	Qualitative analysis <ul style="list-style-type: none"> • wet testing (flame tests etc.) • functional group tests
	AC4.5 use significant figures	Significant figures <ul style="list-style-type: none"> • records raw data to appropriate number of significant places (mass readings, titration results, instrument readings) • manipulates results to appropriate number decimal places

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO5 be able to report on investigations	AC5.1 present data in tables	Tables <ul style="list-style-type: none"> • style • effectiveness • information contained (data, units)
	AC5.2 draw evidence based conclusions	Evidence based conclusions <ul style="list-style-type: none"> • comparison of results with secondary data • conclusions based upon data • limitations of data
	AC5.3 evaluate data and procedures	Evaluation <ul style="list-style-type: none"> • quality of data • effectiveness of procedures Evaluates in terms of <ul style="list-style-type: none"> • accuracy ('trueness') • precision • repeatability • outliers • bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed
	AC5.4 communicate information from investigation	Reporting style <ul style="list-style-type: none"> • technical and scientific language • clarity • language style • structure of report • use of ICT Communication method <ul style="list-style-type: none"> • written

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO1 understand chemical notation	AC1.1 describe families of organic molecules	Uses some methods to describe some families of organic molecules 1	Uses some methods, including functional group names and molecular formulae, to accurately describe a range of families of organic molecules 2-3	Uses a wide range of methods to accurately describe a range of families of organic molecules 4
	AC1.2 interpret representations of organic molecules	Interprets some representations of organic molecules correctly 1	Correctly interprets most representations of organic molecules 2	Consistently interprets representations of organic molecules correctly 3
	AC1.3 represent inorganic chemical species using chemical notation	Uses chemical notation to represent some inorganic species correctly 1	Consistently uses chemical notation to represent inorganic species correctly 2	
	AC1.4 represent reactions using balanced chemical equations	Uses balanced equations to represent some reactions Makes a limited use of state symbols <i>Evidence may be weighed to full symbol or ionic equations</i> 1	Uses accurate balanced equations to represent reactions Makes use of state symbols <i>Evidence of both full symbol and ionic equations</i> 2-3	Consistently uses accurate balanced equations to represent reactions Consistently makes an accurate use of state symbols <i>Evidence includes both full symbol and ionic equations</i> 4

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO2 understand principles of environmental analysis	AC2.1 explain choice of methods used in analysis	<p>Gives an explanation for the choice of methods used in analysis</p> <p><i>Explanation may be weighed to sampling or analytical techniques used</i></p> <p><i>Low level explanations may not always clearly show reasoning</i></p> <p>1-2</p>	<p>Gives a mainly accurate and coherent explanation showing some detailed reasoning of the choice of methods used in analysis</p> <p><i>Explanation may be weighed to sampling and analytical techniques used</i></p> <p>3-4</p>	<p>Gives an accurate and coherent explanation showing detailed reasoning of the choice of methods used in analysis</p> <p><i>Explanation covers sampling and analytical techniques used</i></p> <p>5-6</p>
	AC2.2 explain how mixtures are separated by chromatographic methods	<p>Gives an explanation of how separation is achieved</p> <p><i>Low level explanations may not always clearly show reasoning</i></p> <p>1-2</p>	<p>Gives a mainly accurate and coherent explanation showing some detailed reasoning of how separation is achieved</p> <p>3-4</p>	<p>Gives an accurate and coherent explanation showing detailed reasoning of how separation is achieved</p> <p>5-6</p>
	AC2.3 explain how the absorption of radiation may be used in the analysis of samples	<p>Gives an explanation of how radiation is used in the analysis of samples</p> <p><i>Low level explanations may not always clearly show reasoning</i></p> <p>1-2</p>	<p>Gives a mainly accurate and coherent explanation showing some detailed reasoning of how radiation is used in the analysis of samples</p> <p>3-4</p>	<p>Gives an accurate and coherent explanation showing detailed reasoning of how radiation is used in the analysis of samples</p> <p>5-6</p>
	AC2.4 explain principles used in volumetric analysis	<p>Gives an explanation of the principles of volumetric analysis</p> <p><i>Low level explanations may not always clearly show reasoning</i></p> <p>1-2</p>	<p>Gives a mainly accurate and coherent explanation showing some detailed reasoning of the principles of volumetric analysis</p> <p>3-4</p>	<p>Gives an accurate and coherent explanation showing detailed reasoning of the principles of volumetric analysis</p> <p>5-6</p>

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO3 be able to obtain analytical data on the physical environment	AC3.1 plan to collect environmental samples	Identifies some appropriate procedures and equipment to collect and transport samples Identifies access point for collecting sample 1	Identifies mostly appropriate procedures and equipment to collect and transport samples Identifies a suitable access point for collecting sample 2	Identifies appropriate procedures and equipment to collect and transport samples Identifies suitable access points for collecting sample 3
	AC3.2 label samples for analysis	Labels samples with some key information 1	Labels samples with all key information 2	
	AC3.3 prepare for volumetric analysis	Collects equipment required for analysis 1	Collects all the appropriate equipment for analysis Checks for cleanness/ damage 2	
	AC3.4 obtain data using volumetric equipment	Obtains three titres which are concordant. Three titres show max range of 0.50 cm ³ Mean titre is within 0.50 cm ³ of expected value 1-2	Obtains three titres which are concordant. Three titres show max range of 0.30 cm ³ Mean titre is within 0.30 cm ³ of expected value Reads burette to two decimal places 3-5	Obtains three titres which are concordant. Three titres show max range of 0.15 cm ³ mean titre is within 0.10 cm ³ of expected value Reads burette to two decimal places 6-7
	AC3.5 obtain data using an instrumental form of analysis	Obtains some suitable data using an instrument Some data obtained is within expected tolerance of procedures used to obtain data 1-2	Obtains mostly suitable and sufficient data using an instrument Most data obtained is within expected tolerance of procedures used to obtain data 3-4	Obtains suitable and sufficient data using an instrument Consistently obtains data within expected tolerance of procedures used to obtain data 5-6

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO3 <i>continued</i>	AC3.6 obtain data using qualitative techniques	Obtains some suitable data using qualitative analysis 1-2	Obtains mostly suitable and sufficient data using qualitative analysis 3-4	Obtains suitable and sufficient data using qualitative analysis 5-6
	AC3.7 follow safe working practice	Maintains tidy working area at all times Works in accordance with risk assessment and laboratory requirements Uses PPE when required 1	Maintains tidy working area at all times Works in accordance with risk assessment and laboratory requirements without reminding or prompting Correctly uses PPE without reminding or prompting 2	Maintains tidy working area at all times Consistently works in accordance with risk assessment and laboratory requirements without reminding or prompting Correctly uses PPE without reminding or prompting 3
	AC3.8 record experimental work	Some experimental information recorded in compliance with laboratory and procedure requirements Most aspects of the records are legible Some data recorded to correct precision 1-2	Records experimental information in compliance with laboratory and procedure requirements Records are mostly complete and legible Most data recorded to correct precision 3-4	Records experimental information in compliance with laboratory and procedure requirements Records are complete and legible Data recorded to correct precision 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO4 be able to process analytical data	AC4.1 process data using graphical methods	<p>Mostly suitable sizes and scales are used to construct graphs</p> <p>Graphs have some correct labelling</p> <p>Most data is plotted accurately</p> <p>Draws a line of best fit which takes into account some data</p> <p>Obtains some appropriate information using graphical methods</p> <p style="text-align: center;">1-2</p>	<p>Suitable sizes and scales are consistently used to construct graphs</p> <p>Graphs are mostly fully and correctly labelled</p> <p>All data is plotted accurately and clearly</p> <p>Draws a line of best fit with some accuracy taking into account the data</p> <p>Obtains mostly accurate and appropriate information using graphical methods</p> <p style="text-align: center;">3-4</p>	<p>Suitable sizes and scales are consistently used to construct graphs</p> <p>Graphs are consistently fully and correctly labelled</p> <p>All data is plotted accurately and clearly</p> <p>Accurately determines a line of best fit taking into account the data</p> <p>Obtains accurate and appropriate information using graphical methods</p> <p style="text-align: center;">5-6</p>
	AC4.2 calculate concentrations	<p>Correctly performs some steps in the calculation of concentrations</p> <p>Some aspects of calculations are clearly presented</p> <p style="text-align: center;">1-2</p>	<p>Correctly performs most steps in the calculation of concentrations obtaining some correct values</p> <p>Calculations are mostly clearly and logically presented</p> <p style="text-align: center;">3-4</p>	<p>Correctly performs all steps in the calculation of concentration obtaining correct values</p> <p>Calculations are clearly and logically presented</p> <p style="text-align: center;">5-6</p>
	AC4.3 interpret retention data from chromatographic analysis	<p>Correctly interprets some retention data from chromatographic analysis</p> <p style="text-align: center;">1</p>	<p>Correctly interprets all retention data from chromatographic analysis</p> <p style="text-align: center;">2</p>	
	AC4.4 interpret data from qualitative analysis	<p>Draws some valid inferences from qualitative data</p> <p style="text-align: center;">1-2</p>	<p>Draws some valid inferences with reasoning from qualitative data</p> <p style="text-align: center;">3-4</p>	<p>Draws valid inferences with clear and detailed reasoning from qualitative data</p> <p style="text-align: center;">5-6</p>
	AC4.5 use significant figures	<p>Makes some appropriate use of significant figures</p> <p style="text-align: center;">1</p>	<p>Makes a mostly appropriate use of significant figures</p> <p style="text-align: center;">2</p>	<p>Makes a consistent and appropriate use of significant figures</p> <p style="text-align: center;">3</p>

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO5 be able to report on investigations	AC5.1 present data in tables	Tables are used to present data Some correct headings, symbols and units are used 1	Mostly suitable tables are used to present data Mostly correct headings, symbols and units are used 2-3	Suitable tables are used to clearly present data Correct headings, symbols and units are used 4
	AC5.2 draw evidence based conclusions	Makes some simple and mostly appropriate conclusions based upon evidence Some conclusions are linked to the evidence by the learner 1-2	Makes valid conclusions based upon evidence <i>Some parts are in detail</i> The conclusions are clearly linked to the evidence by the learner 3-4	Makes valid and detailed conclusions that are based upon evidence The conclusions are clearly and logically argued from the evidence by the learner 5-6
	AC5.3 evaluate data and procedures	Gives an appropriate evaluation of some aspects of the data and procedures <i>Evaluation may be weighed towards data or procedures</i> 1-2	Gives a mostly appropriate evaluation of a range of aspects of the data and procedures 3-4	Gives an appropriate and detailed evaluation of a range of aspects of the data and procedures 5-6
	AC5.4 communicate information from investigation	Communicates some information from the investigation Uses some appropriate scientific and technical language Uses some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Mostly clearly communicates information from the investigation Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Clearly communicates information from the investigation Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1.

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise that the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to work places with an analytical laboratory (e.g. water company NLS, NRW, local universities)
- arranging talks by visiting speakers from Environmental Agency, DEFRA, Environmental Science University departments, local HE establishments etc.
- arranging a visit to a sewage treatment plant

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of monitoring our physical environment.

Example 1

An Officer from the Environmental Agency could discuss with candidates the problems associated with contamination of drinking water by nitrates. It would be useful to link the problem to the use of fertilisers on agricultural land and rainfall washing the fertiliser into the streams. Candidates could take water samples before and after rainfall to see if there is any difference in the nitrate levels in a local area.

Example 2

A laboratory manager from the National Laboratory Service or National Resources Wales could be invited to explain how they monitor metals in water. They could explain how they analyse for a variety of different chemical species taken from water or soil samples. Samples of water from ponds and water ways in the area contaminated by copper mining could be mocked up for the learners to analyse using a colorimetric procedure. Candidates would then write a short report based upon their findings.

Example 3

A member of a local water company could give a talk on legislation relating to drinking water and how they monitor water to ensure that it is safe to drink. This could give rise to simple testing e.g. using a correctly calibrated pH meter to measure pH, measurement of chlorine and nitrates in water.

Example 4

A member of a local analytical company could describe how they test 'unknown' samples that may be illegally dumped. Candidates could then be given a problem of analysing a mocked up 'dumped drum' to find what it contains.

Making Contacts

Examples of organisations that may be approached to provide help include:

- Environmental Agency
- National Laboratory Service
- National Resources Wales
- Local Water Companies

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks/Reference books

Textbook of Qualitative Chemical Analysis (Vogel)

Websites

Volumetric analysis

<http://www.labskills.co.uk/resources.php>

Spectroscopic techniques (UV, Colorimetry, Atomic Absorption)

<http://www.usetute.com.au/spectros.html> (summary of techniques)

<http://www.usetute.com.au/aas.html> (Atomic Absorption)

Chromatographic methods (Paper/TLC/HPLC/GC)

http://chromatographyscience.blogspot.co.uk/p/introduction-to-chromatography.html#.UcwVG_nVBqV (extensive documents linked to this site; accessible

to level 3 learners)

http://www.youtube.com/watch?v=kz_egMtdnL4 (6 min RSC YouTube video HPLC aimed at schools & colleges)

<http://www.youtube.com/watch?v=dffeilGeKx8> (10 min YouTube introduction to gas chromatography)

<http://www.files.chem.vt.edu/chem-ed/sep/chromato.html>

<http://www.chemguide.co.uk/analysis/chromatogrmenu.html>

Calibration curves

<http://lab-training.com/2013/01/03/how-to-make-a-calibration-curve-and-calculate-sample-concentrations-using-excel-video-tutorial/> (How to use excel to generate a calibration curve)

Miscellaneous

http://www.omega.co.uk/ppt/pptsc.asp?ref=WTS_SERIES Water quality strips

Unit 4 Scientific principles and the environment

WJEC unit entry code

Guided learning hours 90

Aim and purpose

This unit is assessed externally and is the synoptic assessment for the programme of study in units 1 to 3. This unit draws and builds upon the context and content from units 1 to 3 and the key scientific principles that undergird these units. This unit aims to widen the scope of assessment of these principles. Since the content of this unit is intimately connected with the content and context of units 1 to 3, it cannot be divorced from the delivery of these units. It is advisable for centres to ensure an integrated teaching programme of unit 4 with units 1 to 3.

Unit introduction

How can biology help us understand ecosystems? Can physics help us find environmentally friendly ways of extracting or using energy? How can an understanding of chemistry help us understand how chemicals interact with the biosphere? How can environmental science help us look after our environment?

Environmental science is a broad discipline which requires a sound understanding of biology, chemistry and physics. Environmental science focuses on the application of biological, chemical and physical principles to the study of the physical environment and the solution of environmental problems. Environmental Scientists therefore need to have a broad understanding of a range of scientific principles in order to make meaningful interpretations of what is happening in the environment.

In this unit, you will be using scientific principles to examine problems that face the environment and solutions that environmental science may help provide. This will involve you analysing data on the environment and using your understanding of scientific principles to make judgements about the validity of the data and what the data tells you about the state of the environment. This will involve you examining key biological, physical and chemical principles that underlie all environmental science. These scientific principles are intimately linked with the work that you study in units 1 to 3.

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO1 understand biological principles of environmental science</p>	<p><i>The learner can:</i></p> <p>AC1.1 explain the role of adenosine triphosphate in biological processes</p>	<p>Adenosine triphosphate (ATP) structure</p> <ul style="list-style-type: none"> • written description of structure • diagrammatic representation of structure <p>The importance of ATP</p> <ul style="list-style-type: none"> • problem with uncontrolled release of energy • ATP as the gradual release of energy in small steps: immediate energy donor <p>ATP and ADP interchange</p> <ul style="list-style-type: none"> • conversion of ADP to ATP phosphorylation • forms of phosphorylation • endergonic reaction: amount of energy needed • hydrolysis of ATP to release energy: reaction and energy release • ATP is not stored <p>Advantages of ATP as an energy source</p> <ul style="list-style-type: none"> • only requires one enzyme • energy released in small amounts • common source of energy <p>The roles of ATP</p> <ul style="list-style-type: none"> • metabolic processes • active transport • movement • nerve transmission • synthesis of materials within cells • secretion

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 <i>continued</i>	AC1.2 analyse how the stages of respiration contribute to energy production	<p>Stages of aerobic respiration</p> <ul style="list-style-type: none"> glycolysis, link reaction, Krebs cycle, electron transport chain, summary diagram <p>Glycolysis</p> <ul style="list-style-type: none"> diagrammatic representation of process (complete chemical formulae not required) where this takes place written description of process of glycolysis link reaction diagrammatic representation of process (complete chemical formulae not required) where this takes place written description of the link reaction key terms: decarboxylation and dehydrogenation <p>Krebs cycle</p> <ul style="list-style-type: none"> diagrammatic representation of process (complete chemical formulae not required) where this takes place function of Krebs cycle overall production of ATP written description of the Krebs cycle <p>Electron transport chain</p> <ul style="list-style-type: none"> function of electron transport chain where this takes place: advantages summary of chemiosmotic theory role of oxygen <p>Anaerobic respiration</p> <ul style="list-style-type: none"> definition fermentation

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO1 <i>continued</i></p>	<p><i>The learner can:</i></p> <p>AC1.3 assess the importance of photosynthesis in ecosystems</p>	<p>Process of photosynthesis</p> <ul style="list-style-type: none"> • diagrammatic representation • written summary of process: overall equation • plants and algae as main producers • where photosynthesis takes place • photosynthetic pigments <p>Light dependant reaction</p> <ul style="list-style-type: none"> • summary of reactions • non-cyclic photophosphorylation: written summary • cyclic photophosphorylation: written summary <p>Light independent reaction</p> <ul style="list-style-type: none"> • diagrammatic representation of Calvin cycle (complete chemical formulae not required) • sequence of events: Calvin cycle • written summary of process <p>Limiting factors</p> <ul style="list-style-type: none"> • principle of limiting factors: relevance to ecosystems • temperature, carbon dioxide concentration, light intensity
	<p>AC1.4 explain how carbon is recycled in ecosystems</p>	<p>Basis of the carbon cycle</p> <ul style="list-style-type: none"> • how carbon dioxide is added • photosynthesis re-use of carbon dioxide • production of food - primary producers-food webs • role of saprobionts • diagram of the cycle <p>Human activity effecting carbon recycling in ecosystems</p> <ul style="list-style-type: none"> • burning fossil fuels • deforestation

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 <i>continued</i>	AC1.5 explain how nitrogen is recycled in ecosystems	<p>Basis of the nitrogen cycle</p> <ul style="list-style-type: none"> • flow of organic and inorganic nitrogen within an ecosystem • interchange between nitrogenous compounds and atmospheric nitrogen • living organisms need for nitrogen • plants as nitrogen fixers—role in ecosystem • decomposers releasing nitrogen back into soil • diagram of the cycle <p>Main processes</p> <ul style="list-style-type: none"> • putrefaction • nitrification • nitrogen fixation • denitrification <p>Human activity effecting nitrogen recycling in ecosystems</p> <ul style="list-style-type: none"> • farming practices • artificial fixing of atmospheric nitrogen • use of micro-organisms

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO2 understand chemical principles of environmental science</p>	<p><i>The learner can:</i></p> <p>AC2.1 explain acid-base concepts in relation to environmental analysis</p>	<p>Acid-base concepts</p> <ul style="list-style-type: none"> • pH definition • Bronsted-Lowry acid-base theory • neutralisation • weak acid, weak base, strong acid, strong base • total acidity, total alkalinity <p>Environmental analysis</p> <ul style="list-style-type: none"> • volumetric titrations • environmental samples (aquatic, rainwater)
	<p>AC2.2 apply redox theory to environmental systems</p>	<p>Redox theory</p> <ul style="list-style-type: none"> • reduction & oxidation in terms electron loss and gain • reducing agents, oxidising agents • oxidation state (oxidation numbers) • half equations <p>Environmental systems</p> <ul style="list-style-type: none"> • aquatic (e.g. rivers, streams) • reducing and oxidising environments
	<p>AC2.3 explain the role of complex ion formation in environmental systems</p>	<p>Complex ions</p> <ul style="list-style-type: none"> • coordination number • common ligands (monodentate, bidentate, polydentate) • chelating agents (e.g. EDTA) • ligand exchange and dynamic equilibrium • stability constants • acidity [e.g. $\text{Cu}^{2+}(\text{aq})$, $\text{Al}^{3+}(\text{aq})$ complexes] <p>Environmental systems</p> <ul style="list-style-type: none"> • aquatic systems (e.g. rivers, streams) sediment
	<p>AC2.4 classify chemical reactions</p>	<p>Reactions</p> <ul style="list-style-type: none"> • free radical • acid-base • redox • precipitation • complex ion formation <p>Precipitation Reactions</p> <p>Mg^{2+}, Ca^{2+}, Ba^{2+}, Al^{3+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Pb^{2+}, Sn^{2+} with OH^-, CO_3^{2-}, SO_4^{2-}, $\text{NH}_3(\text{aq})$</p>

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO2 <i>continued</i></p>	<p><i>The learner can:</i></p> <p>AC2.5 explain how free radical reactions involving pollutants occur in the environment</p>	<p>Free radicals</p> <ul style="list-style-type: none"> • free radicals as reactive species with single electron • simple dot cross diagram of free radicals ($\cdot\text{OH}$, $\text{CH}_3\cdot$, $\text{O}\cdot$, $\text{NO}\cdot$, $\text{Cl}\cdot$) <p>Free radical reactions</p> <ul style="list-style-type: none"> • <i>initiation, propagation and termination steps*</i> • role of sunlight in formation of free radicals • role weather conditions in concentrating pollutants (e.g. ground level ozone, photochemical smog) • role of emissions from combustion fossil fuels (e.g. car emissions) • CFC reactions and ozone layer • photochemical smog formation • tropospheric ozone formation <p><i>*Note: It is not required to learn detailed mechanisms but candidates must know the difference between initiation, propagation and termination steps in a given mechanism</i></p>
	<p>AC2.6 assess the persistence of pollutants in the environment</p>	<p>Pollutants</p> <ul style="list-style-type: none"> • pesticides • metal ions <p>kinetic stability</p> <ul style="list-style-type: none"> • first order kinetics of pesticide decomposition • half-life in pesticide decomposition • significance partition coefficients, soil adsorption coefficients and solubility • factors that affect pesticide decomposition (temperature, pH, light, soil type) <p>Metal ions</p> <ul style="list-style-type: none"> • mobility of metal ions • solubility metal ions and metal complexes

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 understand physical principles of environmental science	AC3.1 explain the meaning of terms used in energy transfer	Terms force, energy, work, power, efficiency, units of work, force, energy, power Contexts e.g. <ul style="list-style-type: none"> • energy generation systems, electrical devices, buildings
	AC3.2 explain energy transfer using scientific concepts	Scientific concepts <ul style="list-style-type: none"> • conservation of energy • Zeroth Law • Newton's law of cooling • thermal conductivity • conduction, convection and radiation Contexts <ul style="list-style-type: none"> • energy generation systems • renewable (solar, wind, tidal, biomass) • non-renewable (coal, gas, nuclear) • electrical devices • buildings
	AC3.3 analyse energy transfer	Contexts <ul style="list-style-type: none"> • energy generation systems • renewable (solar, wind, tidal, biomass) • non-renewable (coal, gas, nuclear) • electrical devices • buildings
	AC3.4 describe how energy is generated by a nuclear power reactor	Nuclear power <ul style="list-style-type: none"> • pressurised water and gas cooled • fission reactions • nuclear reactor (fuel rods, moderator, control rods, coolant)
	AC3.5 compare impacts of energy generation systems	Comparison <ul style="list-style-type: none"> • carbon footprint (building, maintenance, production, decommission) • waste products (includes radioisotopes) • radioisotopes (α, β, γ emitters,) • impacts of radio-isotopes(short term and long term. Damage to DNA. Storage and consequences of environmental contamination) • environmental impact of combustion carbon based fuels (e.g. impact of CO₂, oxides of sulfur and nitrogen etc.) • impact on landscape

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 <i>continued</i>	AC3.6 explain how design can be changed to reduce energy waste	Designs of <ul style="list-style-type: none"> • energy generation systems • electrical devices • buildings
	AC3.7 describe the characteristics of radiation	Radiation <ul style="list-style-type: none"> • electromagnetic; high energy particles(α and β particles); ionising, non-ionising Characteristics <ul style="list-style-type: none"> • distinguishing features, properties Electromagnetic radiation <ul style="list-style-type: none"> • wave particle duality • photon as a particle with zero mass • wave properties (amplitude, wavelength, frequency, energy) Properties electromagnetic radiation <ul style="list-style-type: none"> • reflection, refraction, absorption, energy • weak ionising effect of short wave radiation High energy particles <ul style="list-style-type: none"> • α, β particles • mass, charge Properties high energy particles <ul style="list-style-type: none"> • half-life of source • penetrating power • effect of electric field • ionising effect
	AC3.8 explain how electromagnetic radiation interacts with the atmosphere	Electromagnetic interactions <ul style="list-style-type: none"> • ultraviolet light and stratospheric ozone (ozone layer) • absorption and emission of electromagnetic radiation by greenhouse gases Atmosphere <ul style="list-style-type: none"> • troposphere, stratosphere, ozone layer, tropopause, stratopause Greenhouse effect <ul style="list-style-type: none"> • qualitative explanation of greenhouse effect • natural and enhanced greenhouse effect • impact of natural and enhanced greenhouse effect on temperature • greenhouse gases (CO₂, CH₄ etc.)

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to use data from environmental investigations	AC4.1 analyse data	<p>Data</p> <ul style="list-style-type: none"> • primary, secondary <p>Biological data</p> <ul style="list-style-type: none"> • population size • population density • pH, dissolved oxygen, temperature <p>Chemical data</p> <ul style="list-style-type: none"> • half-life data involving pesticides and radioisotopes • partition coefficients and soil adsorption coefficients of pesticides • data from chemical analysis (e.g. analytical techniques from unit 3) <p>Physical data</p> <ul style="list-style-type: none"> • data on energy flow • data on Solar output • U, R values • thermal conductivities
	AC4.2 process data	<p>Process data</p> <ul style="list-style-type: none"> • graphical methods, calculations <p>Graphical methods</p> <ul style="list-style-type: none"> • linear and non-linear graphs • trend lines • e.g. calibration graphs (instrumental analysis from unit 3); concentration time graphs; temperature time graphs; solar output graphs; graphical representations of data from units 1, 2 and 3 • Sankey diagrams <p>Calculations</p> <ul style="list-style-type: none"> • conversion to and from log forms (e.g. pH to H⁺, H⁺ to pH) • molar mass, moles, concentration • interchanging units of concentration (µg/m³, mg/100 g; g/100 g; g dm⁻³; mol dm⁻³; ppm, ppb) • estimate population sizes • Simpson's index of biodiversity • half-life calculations involving pesticides and radioisotopes • use first order equations in determining concentrations over time • energy and power calculations • efficiency calculations for power generation • transformations using given relationships

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 <i>continued</i>	AC4.3 make evidence based conclusions	Conclusions <ul style="list-style-type: none"> • comparison of data • linking of ideas • uncertainty in conclusions
	AC4.4 evaluate data	Evaluation <ul style="list-style-type: none"> • limitations of data • uncertainty • correlation coefficients • sample size • limitations of techniques • sampling method (sampling methods from units 1 to 3) • sensitivity of technique (techniques from units 1 to 3) • environmental conditions

Assessment

This unit is assessed through a written examination set each summer. Details relating to the external assessment and the management of the pre-release article accompanying the examination can be found in **section 3.1.2** and **3.1.3** of the specification.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to work places
- arranging talks by visiting speakers

This unit is closely related to the content and context of units 1 to 3. The content is therefore best integrated into the delivery of units 1 to 3.

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Many of the resources required for units 1-3 could be used with this unit. In addition, the following resources will also be useful.

Textbooks

A level Biology Textbooks
Environmental Chemistry Colin Baird (Useful as a teacher resource)

Websites

Encyclopaedia Environmental Science
<http://esper.e.mpch-mainz.mpg.de/documents/pdf/Encyclopaediamaster.pdf>

Environmental Chemistry
<http://textbook.s-anand.net/ncert/class-11/chemistry/14-environmental-chemistry>

Soil guideline values
<http://www.environment-agency.gov.uk/research/planning/64015.aspx>

Significance physical-chemical data
http://www.reach-serv.com/index.php?option=com_content&task=view&id=59&Itemid=129

Drinking water standards
<http://dwi.defra.gov.uk/consumers/advice-leaflets/standards.pdf>

Factors affecting pesticide behaviour
<http://www.gpnmag.com/factors-affecting-pesticide-behavior>
<http://longbeach.wsu.edu/cranberries/documents/howlongdoinsecticideresiduespersist.pdf>
Pesticide properties

<http://npic.orst.edu/ingred/ppdmove.htm>

Nuclear power

<http://www.world-nuclear.org/Nuclear-Basics/How-does-a-nuclear-reactor-make-electricity/>

<http://www.need.org/nuclear>

In addition websites for units 1 to 3 also provide valuable material for this unit.

Unit 5 Dealing with Pollution

WJEC unit entry code

Guided learning hours 100

Aim and purpose

This unit develops knowledge and understanding of how we can protect or improve environments threaten by pollutants. It will deal with the way in which pollutants interact with both the physical sphere and biosphere. The unit will enable the learners to use their knowledge and understanding to provide information on how to protect environments threatened by pollution or improve environments that have been damaged by pollution.

Unit introduction

How can we protect our environment? How can incidents of pollution be contained and cleared up? What can we do to reverse the impact of environments damaged by pollutants? How can we contain incidents where pollutants are released into the environment?

Scientists help local and national government authorities to assess the damage caused by pollution events and assist the cleaning and restoring of environments. Some pollution events happen very suddenly, such as an oil spill caused by a tanker running aground, whilst others happen over a much longer time scale such as heavy metals leaking from old mines or smelting works. Whatever the type of event, scientists are needed to find out what the pollutant is, what damage it has done and how the pollution can be cleaned up and the environment restored.

This unit is designed to enable you to understand the different types of pollution and how they can be dealt with. For example, you will look at the effects of the mining, extraction, uses and careless disposal of pollutants such as heavy metals on humans, other life forms and the land that we all use. You will also look at persistence of pesticides in the environment and their effect on the ecosystem. You will also look at the effects of oil spills on rivers and oceans as well as the effects of other forms of industrial, household and nuclear pollution. You will learn how pollution can be contained in order to minimise its effects and evaluate different ways of cleaning up and restoring the environment.

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 know how human activity can pollute the environment	AC1.1 describe what is meant by pollution	Pollution <ul style="list-style-type: none"> • point source; non-point source • primary, secondary pollutants • air, soil, water pollution, radioactive contamination, litter
	AC1.2 describe how human activity can result in environmental contamination	Human activities <ul style="list-style-type: none"> • extraction of raw materials (oil extraction, coal mining, metal mining) • transportation of raw materials (oil, gas pipelines, tankers) • construction • industrial activity (including use of radioactive materials in energy production, medicine, weapons) • agriculture (e.g. pesticides, fertiliser use) • household waste including sewage Environmental contamination <ul style="list-style-type: none"> • contamination of waterways, seas, oceans • release of gases into the atmosphere • contamination of land • accidents (e.g. oil spills) • illegal activity
	AC1.3 describe methods of waste disposal	Waste <ul style="list-style-type: none"> • e.g. household waste, sewage & animal waste, radioactive waste Waste disposal <ul style="list-style-type: none"> • release into the environment, land fill, incineration, recycling Sewage <ul style="list-style-type: none"> • treatment (primary, secondary, tertiary) Household waste <ul style="list-style-type: none"> • land fill sites Animal waste <ul style="list-style-type: none"> • use as slurry, manure spreading on land Radioactive waste disposal <ul style="list-style-type: none"> • storage, time scale
	AC1.4 describe how waste disposal can result in environmental contamination	Environmental contamination e.g. <ul style="list-style-type: none"> • faulty waste disposal • leaching into environmental systems

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 understand how pollutants interact with the environment	AC2.1 explain the meaning of terms relating to the behaviour of pollutants	Pollutants <ul style="list-style-type: none"> • heavy metals, hydrocarbons including aromatic hydrocarbons, gases (e.g. CFCs, SO₂, NO₂), fertilisers, pesticides, sewage and animal waste, radioactive waste Terms <ul style="list-style-type: none"> • sink, volatilization, partition coefficient, adsorption, solubility, run-off, leaching, degradation, microbiological degradation, soil adsorption coefficient, half-life • redox terms, complexation, chelate effect, stability constant, decomposition, photodecomposition • bioaccumulation, biomagnification, biodilution • LD, LD₅₀, EC₅₀ values • soil guidance value
	AC2.2 describe the composition of soil	Soil composition <ul style="list-style-type: none"> • silicate minerals, clay minerals, colloidal clay particles and electrostatically bonded cations • organic matter, humus • water • air
	AC2.3 explain how pollutants interact with the physical environment	Physical environment <ul style="list-style-type: none"> • aqueous environments • soil/sediments • atmosphere Interaction <ul style="list-style-type: none"> • solubility • retention of heavy metals by soils and sediments binding (adsorption, complexation, precipitation) e.g. mercury, cadmium • adsorption of pesticides by soils • acid/base behaviour (e.g. pH of complexes of Cu²⁺, Al³⁺, dissociation reactions of acids) • redox reactions (e.g. oxidation of oxides of sulphur and nitrogen, oxidation Fe(II) to Fe(III)) • complex formation • free radical reactions • decomposition, photodecomposition

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 <i>continued</i>	AC2.4 explain how pollutants interact with the biological environment	Interaction <ul style="list-style-type: none"> • eutrophication • plant damage (e.g. by ozone, sulphur dioxide) • microbiological interaction with organisms • bioaccumulation, biomagnification, biodilution • toxicity to organisms and humans e.g. • enzyme inhibition • DNA damage • other (e.g. oil and sea birds)
	AC2.5 describe how human health is affected by exposure to pollutants	Human health <ul style="list-style-type: none"> • exposure pathways for humans (ingestion, inhalation, consumption, contact) • toxicity and human health (e.g. phosphorus, mercury, cadmium, copper, DDT)

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 understand how to reduce the environmental impact of pollution	AC3.1 describe legislative controls to prevent environmental contamination	<p>Legislative controls</p> <ul style="list-style-type: none"> • European Community legislation • primary legislation (Acts of parliament e.g. Environmental Protection Act) • secondary legislation (Regulations, Codes of Practice e.g. Code of Good Agricultural Practice) • directives (e.g. Water Framework Directive) • role of Government agencies (e.g. National Resources Wales, Environmental Agency, DEFRA) <p>Purpose of legislation e.g. to reduce demand, restrict use, control production, improve disposal methods, encourage good practice, fine offending institutions</p>
	AC3.2 evaluate methods to reduce environmental contamination	<p>Methods</p> <ul style="list-style-type: none"> • replace potential pollutants at source (e.g. replacement of CFCs) • management of processes that may cause pollution e.g. <ul style="list-style-type: none"> ○ management water and gases into/out of mines, waste tips etc. ○ management of activities that could contaminate environment (e.g. reduced fertiliser use near waterways) ○ traffic management • recycling to reduce waste • waste treatment <ul style="list-style-type: none"> ○ primary, secondary & tertiary treatment of sewage ○ disposal animal waste from farms <ul style="list-style-type: none"> ▪ adequate storage slurry ▪ correct spreading techniques to reduce threat of contamination water ways • waste disposal • e.g. <ul style="list-style-type: none"> ○ correct construction of waste tips ○ control of what enters tips ○ incineration – temperature incineration etc. • monitoring of environment

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 <i>continued</i>	AC3.3 evaluate methods for dealing with a contaminated environment	<p>Contaminated environment</p> <ul style="list-style-type: none"> • water (e.g. oil spills, heavy metals); contaminated land (e.g. mine spoil heaps, heavy metals, oil pollution, brown field sites) <p>Methods</p> <ul style="list-style-type: none"> • contaminated land e.g. <ul style="list-style-type: none"> ○ bioremediation ○ air sparging ○ soil vapour extraction, soil washing ○ thermal treatment ○ containment and burial • water e.g. oil spills <ul style="list-style-type: none"> ○ use of physical barriers to contain spill ○ collection ○ dispersive methods (natural, dispersion by detergents) ○ burning <p>Evaluation</p> <ul style="list-style-type: none"> • effectiveness • time • cost

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to report on the impact of pollutants	AC4.1 interpret information on pollutants	Information <ul style="list-style-type: none"> • concentration data on pollutants (units of g/100cm³; ppm; ppb; mol dm⁻³; mmol dm⁻³) • pH • physical data (e.g. melting point, boiling point, solubility, partition coefficient) • stability constants (complex ions) • soil adsorption coefficients • persistence, half-life • bioaccumulation data • soil guidance values • toxicity data LD, LD₅₀, LC₅₀ • EQS (Environmental Quality Standards)
	AC4.2 assess the impact of pollutants	Impact <ul style="list-style-type: none"> • physical sphere • atmosphere • waterways e.g. oceans, rivers • soil • biosphere e.g. biodiversity, crop production • human health
	AC4.3 communicate information on environmental contamination	Audience <ul style="list-style-type: none"> • scientifically literate audience • audience with basic scientific understanding Information <ul style="list-style-type: none"> • clarity • style • language including technical and scientific; • appropriate use of English language (spelling, grammar and punctuation) • evidence based • relevance information to audience

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO1 know how human activity can pollute the environment	AC1.1 describe what is meant by pollution	Gives a mostly clear description of what is meant by the term pollution 1-2	Gives a clear and detailed description of what is meant by pollution 3-4	
	AC1.2 describe how human activity can result in environmental contamination	Gives a description with some relevant information of how human activity can result in environmental contamination 1-2	Gives a mainly clear and relevant description of how human activity can result in environmental contamination <i>Some parts are in detail</i> 3-4	Gives a clear, detailed and relevant description of how human activity can result in environmental contamination 5-6
	AC1.3 describe methods of waste disposal	Gives a description with some relevant information on waste disposal 1-2	Gives a mainly clear description with mainly relevant information on waste disposal <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description with relevant information on waste disposal 5-6
	AC1.4 describe how waste disposal can result in environmental contamination	Gives a description of how disposal of a form of waste can result in environmental contamination 1-2	Gives a mainly clear description of how disposal of waste can result in environmental contamination <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description of how disposal of waste can result in environmental contamination 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO2 understand how pollutants interact with the environment	AC2.1 explain the meaning of terms relating to the behaviour of pollutants	Gives an explanation of some relevant terms relating to the behaviour of pollutants 1-3	Gives a mostly clear and accurate explanation of most relevant terms relating to pollutants 4-6	Gives an accurate and coherent explanation with detailed reasoning of relevant terms relating to pollutants 7-9
	AC2.2 describe the composition of soil	Gives a description of some aspects of the soil composition with some accuracy 1-2	Gives a mostly clear and accurate description of the soil composition <i>Some parts are in detail</i> 3-4	Gives a clear, accurate and detailed description of the soil composition relevant to the context 5-6
	AC2.3 explain how pollutants interact with the physical environment	Gives an explanation of how pollutants interact with the physical environment with some relevance to the context <i>Low level explanations may not always clearly link ideas</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of how pollutants interact with the physical environment <i>Some parts are in detail</i> 3-4	Gives an accurate and coherent explanation with detailed reasoning of how pollutants interact with the physical environment 5-6
	AC2.4 explain how pollutants interact with the biological environment	Gives an explanation of how some relevant pollutants interact with the biological environment <i>Low level explanations may not always clearly link ideas</i> 1-2	Gives a mainly accurate and coherent explanation, with detailed reasoning, of how relevant pollutants interact with the biological environment <i>Some parts are in detail</i> 3-4	Gives an accurate and coherent explanation with detailed reasoning of how relevant pollutants interact with the biological environment 5-6
	AC2.5 describe how human health is affected by exposure to pollutants	Gives a description of how human health is affected by pollutants with some accuracy <i>Some pathways of exposure are dealt with</i> 1-2	Gives a mostly clear description of how human health is affected by pollutants <i>Most significant pathways of exposure are dealt with</i> 3-4	Gives a clear and detailed description of how human health is affected by pollutants <i>All significant pathways of exposure are dealt with</i> 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO3 understand how to reduce the environmental impact of pollution	AC3.1 describe legislative controls to prevent environmental contamination	Gives a description of some significant government controls to prevent environmental contamination 1-2	Gives a mainly clear description of most significant government controls to prevent environmental contamination 3-4	Gives a clear and detailed description of the significant government controls to prevent environmental contamination 5-6
	AC3.2 evaluate methods to reduce environmental contamination	Makes some suitable judgements of some means of reducing environmental contamination 1-2	Gives an evaluation of methods of reducing environmental contamination 3-4	Gives a detailed evaluation of methods of reducing environmental contamination 5-6
	AC3.3 evaluate methods for dealing with a contaminated environment	Makes some suitable judgements of the some methods for dealing with a contaminated environment with some accuracy 1-2	Makes mainly suitable judgements with some clear reasoning of a range of methods for dealing with a contaminated environment 3-4	Makes suitable judgements with clear and detailed reasoning of a range of methods for dealing with a contaminated environment 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO4 be able to report on the impact of pollutants	AC4.1 interpret information on pollutants	Draws some valid appropriate inferences from some information on pollutants 1-3	Draws some valid appropriate inferences with reasoning from a range of information on pollutants <i>Some parts may be in detail</i> 4-6	Draws valid and detailed inferences with reasoning from a range of information pollutants 7-9
	AC4.2 assess the impact of pollutants	Gives an assessment of some significant impacts of some pollutants 1-3	Gives an assessment with some reasoning of the most significant impacts of a range of pollutants <i>Some parts may be in detail</i> 4-6	Gives a detailed assessment with reasoning of the significant impacts of a range of pollutants 7-9
	AC4.3 communicate information on environmental contamination	Communicates some information relevant to the customer requirements Uses some appropriate scientific and technical language Use some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Mostly clearly communicates information relevant to the customer Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Clearly communicates information relevant to the customer Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is externally assessed by an assignment provided by WJEC annually in September of each academic year. This assignment will be downloadable from the WJEC secure website. Further information about the assessment of this unit can be found in **section 3.1.1** of the specification.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise that the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- Invite speakers from agencies e.g. National Resources Wales or the Environment Agency to speak on how contamination from pollution incidents have been managed.
- Invite speakers from organisations involved in reclaiming land from brown field sites.
- Use of case studies dealing with contamination of land and how the environment has been cleaned.
- Visit organisations from industry or waste management companies (e.g. nuclear industry, steel industry, oil industry) to see how they deal with waste products and the systems they employ to monitor waste. Representatives of the organisation could also discuss the procedures in place to deal with accidents that may lead to environmental damage.
- Visits from speakers who can give a global perspective on environmental contamination.

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of the dealing with pollution.

Example 1

An Officer from National Resources Wales/Environmental Agency could set the scene for a pollution incident. Learners in groups work on determining the likely environmental consequences and suggest solutions to limit damage. Learners then present their solutions to the Officer.

Example 2

Visit a brown field site (e.g. site damaged by mining or past industrial activity). Learners could be given information on the contamination of the site and work in small groups to suggest how the contaminated environment could be improved. If there are local environmental groups, it may be possible to invite a speaker to introduce the subject by describing the background to the contamination and the environmental legacy of the contamination.

Example 3

Use a case study to give a global perspective on environmental contamination e.g. the legacy of the Bhopal disaster.

Making Contacts

Examples of organisations that may be approached to provide help include:

- Environmental Agency.
- National Resources Wales.
- Environmental Campaign groups.
- Local industry (e.g. nuclear, steel, oil).
- Construction companies involved in redeveloping brownfield sites.
- Local authorities responsible for managing land fill sites.

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks

Environmental Chemistry Colin Baird (Useful as a teacher resource)

Websites

Environmental Law

<http://www.ukela.org/rte.asp?id=25>

<http://www.ukela.org/rte.asp?id=35>

Environmental contamination

<http://www.environment-agency.gov.uk/research/library/position/41233.aspx>

<http://www.environment-agency.gov.uk/research/library/position/41233.aspx>

<http://www.environment-agency.gov.uk/business/topics/pollution/36564.aspx>

<http://www.environment->

[agency.gov.uk/static/documents/Leisure/dealing_with_contaminated_land_i.pdf](http://www.environment-agency.gov.uk/static/documents/Leisure/dealing_with_contaminated_land_i.pdf) (reference)

<http://a0768b4a8a31e106d8b0->

[50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho1108bozd-e-e.pdf](http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho1108bozd-e-e.pdf) (metal mining river sediments)

<https://www.geolsoc.org.uk/~-/media/Files/GSL/shared/pdfs/education%20and%20careers/contaminated.ashx> (contaminated land-very useful document)

http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&ved=0CC0QFjAA&url=http%3A%2F%2Fwww.welshcopper.org.uk%2Fen%2Fworldofcopper_workshops_santiago.htm&ei=8ISpUt3qBcPS0QXbpoGQAQ&usq=AFQjCNHK2q8j_ggCaa97RyTedpp5UTmqYA&bvm=bv.57967247,d.d2k (Contaminated land and reclamation Swansea Lower Valley)

<http://www.hants.gov.uk/rh/hep/copper-levels-hamble-estuary.pdf> (copper in the Hamble Estuary)

<http://a0768b4a8a31e106d8b0->

[50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho0508bnzt-e-e.pdf](http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho0508bnzt-e-e.pdf) (mine water)

http://www.hsph.harvard.edu/mining/files/Acid_mine_drainage_remediation_options_-_a_review_JOHNSON_20.pdf (remediation mine works)

Encyclopaedia Environmental Science

<http://espere.mpch-mainz.mpg.de/documents/pdf/Encyclopaediamaster.pdf>

Environmental Chemistry

<http://textbook.s-anand.net/ncert/class-11/chemistry/14-environmental-chemistry>

Soil guideline values

<http://www.environment-agency.gov.uk/research/planning/64015.aspx>

Significance physical-chemical data

http://www.reach-serv.com/index.php?option=com_content&task=view&id=59&Itemid=129

Drinking water standards

<http://dwi.defra.gov.uk/consumers/advice-leaflets/standards.pdf>

Factors affecting pesticide behaviour

<http://www.gpnmag.com/factors-affecting-pesticide-behavior>

<http://longbeach.wsu.edu/cranberries/documents/howlongdoinsecticideresiduespersist.pdf>

Pesticide properties

<http://npic.orst.edu/ingred/ppdmove.htm>

Nuclear power

<http://www.world-nuclear.org/Nuclear-Basics/How-does-a-nuclear-reactor-make-electricity/>

<http://www.need.org/nuclear>

Case Study

<http://www.geologywales.co.uk/cwmrheidol.htm>

Unit 6 Climate change

Option unit: *Candidates follow unit 6 or 7*

WJEC unit entry code

Guided learning hours 100

Aim and purpose

This unit develops knowledge and understanding of the principles of meteorology. Learners will use this information to analyse, assess and report on the potential impact of climate change. The unit will enable the learners to gain the knowledge, understanding and skills to assess the potential impact of climate change and communicate their findings in writing (e.g. via magazine articles) to a variety of audiences.

Unit introduction

How do meteorologists forecast the weather? What skills do they need? How are weather maps produced and what do they show? What observations can be made to predict the weather? Are computer predictions of the weather reliable? What is the difference between weather and climate? Why does the Earth's climate vary? What causes climate change, and do human practices influence it? Should we care about climate change? What are the economic, environmental and social impacts of climate change?

Meteorologists use information gathered from the land, sea and the upper atmosphere to study the causes of particular weather conditions. Some meteorologists work within the environmental science sector, using computerised and mathematical models to make both long and short term forecasts about the impact of the weather on climate patterns. They work closely with environmental scientists and conduct research into weather patterns, climate change and its possible effects upon the environment.

This unit is designed to help you understand the basic principles of meteorology and how these are used in forecasting the weather. You will be taught how to use meteorological data, together with information about weather patterns over time scales ranging from months to centuries, to assess and report upon the potential impact of climate change that might occur. You will analyse the effect of human practices upon climate change. You will develop the skills necessary to process and analyse data obtained from a variety of sources and report upon its potential impact on climate change. You will communicate your findings, in writing, to both general and scientific audiences.

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 understand the principles of meteorology	AC1.1 explain the meaning of terms used in meteorology	Meteorological terms <ul style="list-style-type: none"> • weather, climate • air masses • anticyclone, depressions, weather fronts • isobars • Jet stream • humidity (relative and specific) • potential temperature • air pressure, density • atmospheric layers (troposphere, stratosphere, mesosphere, thermosphere, exosphere)
	AC1.2 explain the difference between weather and climate	Weather and climate <ul style="list-style-type: none"> • definitions • popular ways differentiating • difference in terms of <ul style="list-style-type: none"> ○ duration ○ statistical information
	AC1.3 explain planetary temperature using physical laws and models	Physical Laws and models <ul style="list-style-type: none"> • Earth as a black body • Wien's Law • Kirchhoff's Law of thermal radiation • Stefan Boltzmann's Law • Diurnal temperature change • Greenhouse effect

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 <i>continued</i>	AC1.4 explain the conditions necessary to produce different types of weather	Types of weather <ul style="list-style-type: none"> • frost • fog • precipitation (rainfall, snow) • thunderstorms • strong winds • tropical storms
	AC1.5 compare different methods of measuring meteorological data	Data <ul style="list-style-type: none"> • rainfall <ul style="list-style-type: none"> ○ radar ○ ground measurements • temperature measurements <ul style="list-style-type: none"> ○ ground stations ○ satellite measurements ○ tree rings • atmospheric carbon dioxide measurements <ul style="list-style-type: none"> ○ instrumental methods ○ ice core measurements

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 understand factors that can change climate	AC2.1 explain ways in which oceans affect climate	Ways oceans affect climate <ul style="list-style-type: none"> • heat sink - energy stored in oceans • carbon sink • ocean currents e.g. Gulf Stream • El Niño phenomenon
	AC2.2 explain how natural factors affect climate	Factors <ul style="list-style-type: none"> • latitude, altitude • distance from sea/oceans • Jet streams • direction of prevailing winds • topography of the land (height mountains, North, South facing) • volcanic and meteorite activity Solar activity <ul style="list-style-type: none"> • variation in the Earth's orbit and orientation of its axis
	AC2.3 assess the impact of human activity on the Earth's climate	Human activity <ul style="list-style-type: none"> • fossil fuel combustion • industrial processes • agriculture and forestry-related activities Impacts <ul style="list-style-type: none"> • enhanced greenhouse effect
	AC2.4 explain historic variations in the Earth's climate	Historic variations in climate <ul style="list-style-type: none"> • ice ages • Medieval warm period • Little ice age

Learning outcomes	Assessment criteria	Content
<i>The learner will:</i>	<i>The learner can:</i>	
LO3 understand potential impacts of climate change	AC3.1 assess the impact of climate change	<p>Economic and social e.g.</p> <ul style="list-style-type: none"> • raised sea levels and flooding • economic impact flooding on homes, industry and agriculture • loss of land • population displacement • droughts <p>Environmental impacts e.g.</p> <ul style="list-style-type: none"> • heat and carbon stored in oceans • acidity of oceans • extreme weather conditions • loss of habitat • loss of species

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to investigate climate	AC4.1 evaluate information on climate change	Evaluation <ul style="list-style-type: none"> • type of source • authorship • accuracy • credibility • peer reviewed • evidence • date
	AC4.2 process meteorological information	Meteorological information e.g. <ul style="list-style-type: none"> • carbon dioxide levels • humidity, temperature, rainfall, wind speed, air pressure Processes <ul style="list-style-type: none"> • calculations • graphical methods Graphical methods <ul style="list-style-type: none"> • using software Graphs <ul style="list-style-type: none"> • linear and log axis • trend lines Calculations <ul style="list-style-type: none"> • Manipulation of relevant equations

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 <i>continued</i>	AC4.3 interpret meteorological data	Meteorological data e.g. <ul style="list-style-type: none"> • carbon dioxide levels • humidity, temperature, rainfall, wind speed, air pressure Weather charts <ul style="list-style-type: none"> • pressure charts Sources <ul style="list-style-type: none"> • ground measurements • satellites • historic data

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO5 be able to communicate scientific and technical information to different audiences	AC5.1 communicate in writing to different types of audiences	Written communication methods <ul style="list-style-type: none"> • written (blogs, formal and popular reports, magazine style articles) Language skills <ul style="list-style-type: none"> • technical and scientific language • spelling, punctuation and grammar • clarity • language style • relevance of included material • structure of report Audiences <ul style="list-style-type: none"> • scientific and technical • semi technical • non-technical`
	AC5.2 support information using diagrams and graphs	Supporting diagrams/graphs <ul style="list-style-type: none"> • suitability (type of graph/diagram) • clarity (information conveyed clearly by graph/diagram) • presentation (labelling, scale, size, use trend lines in graphs) • relevance to written information

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO1 understand principles of meteorology	AC1.1 explain the meaning of meteorological terms	Gives an explanation of some significant terms relating to meteorological 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of significant terms relating to meteorological 3-4	Gives an accurate and coherent explanation showing detailed reasoning of the significant terms relating to meteorological terms 5-6
	AC1.2 explain the difference between weather and climate	Gives an explanation of the difference between weather and climate <i>Low level explanations may not always clearly show reasoning</i> 1	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the difference between weather and climate 2	Gives an accurate and coherent explanation showing detailed reasoning of the difference between weather and climate 3
	AC1.3 explain planetary temperature using physical laws and models	Gives an explanation of planetary temperature with some relevant use of physical laws and models <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation showing some detailed reasoning of planetary temperature with relevant use of the significant physical laws and models 3-4	Gives an accurate and coherent explanation showing detailed reasoning planetary temperature in terms of relevant physical laws and models 5-6
	AC1.4 explain the conditions necessary to produce different types of weather	Gives an explanation of some conditions to produce different types of weather <i>Low level explanations may not always clearly show reasoning</i> 1-3	Gives a mainly accurate and coherent explanation showing some detailed reasoning of the conditions to produce to produce different types of weather 4-6	Gives an accurate and coherent explanation showing detailed reasoning of the conditions necessary to produce different types of weather 7-9
	AC1.5 compare different methods of measuring meteorological data	Makes a comparison with some valid points of methods of measuring some meteorological data 1-2	Makes a mostly valid comparison with some reasoning of methods of measuring some relevant meteorological data <i>Some parts are in detail</i> 3-4	Makes a detailed and valid comparison with reasoning of methods of measuring relevant meteorological data 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO2 understand factors that can change climate	AC2.1 explain ways in which oceans affect climate	Gives an explanation of some significant ways in which oceans affect climate <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of significant ways in which oceans affect climate 3-5	Gives an accurate and coherent explanation with detailed reasoning of significant ways in which oceans affect climate 6-7
	AC2.1 explain how natural factors affect climate	Gives an explanation of some significant factors that can affect climate <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of significant factors that can affect climate 3-4	Gives an accurate and coherent explanation with detailed reasoning of the significant factors that can affect climate 5-6
	AC2.2 assess the impact of human activity on the Earth's climate	Gives an assessment of the impact of human activity on the Earth's climate, with reference to a limited range of relevant factors, with some reasoned judgements 1-2	Gives an assessment of the impact of human activity on the Earth's climate, with reference to a range of mainly relevant factors with mainly reasoned judgements <i>Some parts are in detail</i> 3-4	Gives a detailed assessment of the impact of human activity on the Earth's climate with reference to a range of relevant factors with reasoned judgements 5-6
	AC2.3 explain historic variations in the Earth's climate	Gives an explanation of historic variations in the Earth's climate <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of relevant historic variations in the Earth's climate 3-4	Gives an accurate and coherent explanation with detailed reasoning of relevant historic variations in the Earth's climate 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO3 understand potential impacts of climate change	AC3.1 assess the impact of climate change	<p>Gives an assessment of the environmental, economic and social impact of climate change with reference to a limited range of factors, making some reasoned judgements</p> <p><i>Evidence is mainly descriptive but with some reasoning to support judgements</i></p> <p><i>Evidence may be weighted to one of the three aspects (environmental, economic or social)</i></p> <p>1-4</p>	<p>Gives an assessment of the environmental, economic and social impact of climate change with reference to the significant factors making reasoned judgements</p> <p><i>Evidence may be weighted to two of the three aspects</i></p> <p>5-8</p>	<p>Gives an assessment of the environmental, economic and social impact of climate change with reference to a range of relevant factors making judgements with detailed reasoning</p> <p><i>All three aspects are covered</i></p> <p>9-12</p>

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>			
LO4 be able to investigate climate	AC4.1 evaluate information on climate change	Makes some valid judgements about climate change with some reasoning 1-2	Makes mainly valid judgements showing clear reasoning based on a range of criteria. <i>Some aspects of the reasoning may be in detail</i> 3-4	Makes valid judgements with detailed reasoning based on a range of criteria 5-6
	AC4.2 process meteorological information	Uses some suitable methods to process meteorological data Some aspects of graphs/calculations are clearly presented 1-2	Uses suitable methods to mostly accurately process data Graphs/calculations are mostly clearly and logically presented 3-4	Consistently uses suitable methods to accurately process data Graphs/calculations are clearly and logically presented 5-6
	AC4.3 interpret meteorological data	Draws some valid inferences from meteorological data 1-2	Draws some valid inferences with reasoning from meteorological information 3-4	Draws valid inferences with clear and detailed reasoning from meteorological information 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO5 be able to communicate scientific and technical information to different audiences	AC5.1 communicate in writing to different types of audiences	Communicates some information from the investigation Uses some appropriate scientific and technical language Uses some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Mostly clearly communicates information from the investigation Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Clearly communicates information from the investigation Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9
	AC5.2 support information using diagrams and graphs	Uses some suitable and relevant graphs/diagrams to support argument Presents some diagrams and graphs clearly 1-2	Uses mostly suitable and relevant graphs/diagrams to support argument Presents most diagrams and graphs clearly and to appropriate scale with correct labelling 3-4	Consistently uses suitable and relevant graphs/diagrams throughout to support argument Consistently presents all diagrams and graphs clearly and to appropriate scale and with correct labelling 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging talks by visiting speakers from Environmental/Geography departments at local Universities.
- arranging visits to Met Office, European Centre for Medium-Range Weather Forecasts, local University departments.
- arranging talks by visiting speakers from Met Office, Environmental Agency, National Resources Wales to discuss the potential impacts on the UK and Globally.

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of climate change.

Example 1

A member of an environmental agency could describe changes in recent climatic conditions. Learners could be set task to research impacts of further potential climate change on the locality.

Example 2

Local farmer/producer could describe how weather impacts on their operations and ability to grow and harvest different crops. Learners could look at different scenarios of climate change and how it could influence /affect the crops grown.

Example 3

Candidates could be given the task of writing a magazine style article for a general audience which analyses the evidence for climate change and its potential impact on a named region. This could be helped by the task been set by an Editor from a local newspaper/magazine.

Making Contacts

Examples of organisations that may be approached to provide help include:

- Met Office
- European Centre for Medium-Range Weather Forecasts
- Local University departments
- National Resource Wales
- Environmental Agency

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Volcanic activity and climate

New Scientist 19 October 2013 Blast from the Past

Websites

http://www.diffen.com/difference/Climate_vs_Weather

<http://www.theweatherclub.org.uk/>

<http://climatescience.tv/>

<http://www.metoffice.gov.uk/climate-guide>

http://www.wmo.int/pages/index_en.html

<http://www.theguardian.com/environment/climate-change>

http://royalsociety.org/events/2005/chaotic-climate/?gclid=CNfp3OXq_bsCFZGWtAodRBoA7A

Climate changes and potential impacts – Country guides

<http://www.metoffice.gov.uk/climate-guide/science/uk/obs-projections-impacts>

<http://www.bgs.ac.uk/discoveringGeology/climateChange/general/coastal.html>

Meteorological maps for the all parts of the world (current analyses and forecasts)

<http://wxmaps.org/>

Unit 7 Transport systems and the environment

Option unit: *Candidates follow unit 6*

WJEC unit entry code

Guided learning hours 100

Aim and purpose

This unit develops knowledge and understanding of how transport systems can impact on the environment and explores strategies to reduce the environmental impact of transport systems.

Unit introduction

How does using a transport system impact on the environment? How can the pollution associated with the transport of people or goods be minimised? How do transport systems affect the health of individuals? What is the difference in the impact of a petrol or diesel engine on an environment?

With an ever increasing reliance on transport systems, the impact which cars, lorries, trains, aircraft and other forms of transport are having on our environment is of increasing concern. Across the UK and globally there is a need to develop an integrated transport policy that will reduce the effect on the environment. The UK Government estimates that 55% of all private car journeys' are less than 5 miles - could these journeys have been made by public transport? By cycling? be walking? There is much talk about "active transport" improving walking and cycling routes - is this really happening in all areas?

This unit is designed to help you to understand the ways transport systems can impact on the environment and individuals, together with ways to minimise the impact of these systems. You will learn how to make effective strategies to help reduce this impact could be reduced.

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO1 understand how transport systems can impact on the environment</p>	<p><i>The learner can:</i></p> <p>AC1.1 describe current transport systems</p>	<p>Transport systems</p> <ul style="list-style-type: none"> • road: private cars, freight, buses, coaches, taxis • rail: over ground, underground, metro systems • air: passenger and cargo • sea • cycling • walking
	<p>AC1.2 explain how the combustion of fossil fuels by transport systems produces air pollutants</p>	<p>Fossil fuels</p> <ul style="list-style-type: none"> • petrol • diesel • LPG <p>Combustion products</p> <ul style="list-style-type: none"> • primary pollutants (typical combustion products, particulate emissions)
	<p>AC1.3 explain how weather conditions can affect pollution from transport systems</p>	<p>Pollution</p> <ul style="list-style-type: none"> • formation of secondary pollutants – particulate and gaseous <ul style="list-style-type: none"> ○ photochemical and free radical reactions ○ weather conditions and smog formation
	<p>AC1.4 explain how pollution from transport systems can affect the environment</p>	<p>Transport systems</p> <ul style="list-style-type: none"> • type of transport <ul style="list-style-type: none"> e.g. <ul style="list-style-type: none"> ○ air; rail, bus; car; air; ship • based upon fuel types <ul style="list-style-type: none"> e.g. <ul style="list-style-type: none"> ○ carbon (e.g. petrol, diesel engines, LPG) ○ non-carbon (e.g. electricity, hydrogen) <p>Pollution</p> <ul style="list-style-type: none"> • noise pollution • exhaust emissions (gaseous and particulate) <p>Effect on:</p> <ul style="list-style-type: none"> • biotic environment (e.g. ‘acid rain’ and vegetation) • atmosphere (e.g. ozone layer depletion and consequential impacts on biosphere) • hydrosphere

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 <i>continued</i>	AC1.5 assess the impact of transport systems on the climate	Assessment e.g. In terms of: <ul style="list-style-type: none"> • anthropogenic greenhouse gases from transport systems • carbon footprint • contribution of transport to carbon footprint • relative impact of different vehicle emissions on greenhouse effect • potential impact of increasing carbon footprint on climate
	AC1.6 explain how transport systems affect the health of individuals	Effect on health <ul style="list-style-type: none"> • effects of noise pollution • accidents • long term exposure to air pollutants (increased risk of chronic disorders) • air pollution related morbidity and mortality • beneficial effects of active forms of transport (walking and cycling) <ul style="list-style-type: none"> ○ improved physical health ○ improved mental health ○ prevention of chronic diseases • reduced risk of premature death

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 be able to investigate environmental impact of transportation systems	AC2.1 describe methods to measure the impact of transport systems on the environment	Methods <ul style="list-style-type: none"> • air sampling • soil sampling • surveys (e.g. noise levels, transport usage)
	AC2.2 analyse data on transportation systems	Data e.g. <ul style="list-style-type: none"> • concentrations of air pollutants (e.g. ozone) • noise levels • car emissions • carbon dioxide equivalent factors • car usage, public transport usage • transport survey data (e.g. single car usage) • engine efficiency data • weather patterns Analysis of data <ul style="list-style-type: none"> • graphical • statistical • valid inferences from data
	AC2.3 evaluate data on the impact of transport systems on the environment	Data <ul style="list-style-type: none"> • quantitative • qualitative Evaluate <ul style="list-style-type: none"> • validity • repeatability • accuracy • source • date

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 understand ways to reduce the environmental impact transport systems	AC3.1 describe transport policies that reduce the environmental impact of transportation systems	Policies <ul style="list-style-type: none"> • national regulation (e.g. taxation based upon fuel, carbon emissions; subsidies for new technologies in transport systems) • local regulation e.g. <ul style="list-style-type: none"> ○ bus lanes ○ vehicle charging ○ vehicle restrictions
	AC3.2 explain how technological solutions in transport systems can reduce environmental impact	Technological solutions e.g. <ul style="list-style-type: none"> • catalytic convertors • particle filters • bio fuels • hydrogen fuel cells • electric vehicles • hybrid vehicles • fuel economy • vehicle manufacture
	AC3.3 explain how behavioural solutions in transport systems can reduce environmental impact	Behavioural solutions e.g. <ul style="list-style-type: none"> • vehicle occupancy: car sharing, car clubs • use of public transport • alternative forms of travel: walking, cycling • eco-driving techniques

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to propose strategies to reduce environmental impact of transport systems	AC4.1 assess transport systems likely to be used within a particular setting	Particular setting <ul style="list-style-type: none"> • urban • rural
	AC4.2 propose strategies to reduce impact of transport systems within a particular setting	Strategies to reduce impact e.g. <ul style="list-style-type: none"> • decarbonisation of road transport • decarbonisation of rail • innovative vehicle technologies • sustainable biofuels • improved transport infrastructure • improved public transport • legal incentives—reduced tax for low carbon vehicles • eco-driving techniques • behavioural strategies: car clubs, car sharing
	AC4.3 justify the effectiveness of proposed strategies	Effectiveness of strategies <ul style="list-style-type: none"> • based on impact, cost, effectiveness

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO1 understand how transport systems can impact on the environment	AC1.1 describe current transport systems	Gives a description of some current transport systems 1	Gives a mainly clear description of current transport systems <i>Some parts are in detail</i> 2-3	Gives a clear and detailed description of current transport systems 4
	AC1.2 explain how the combustion of fossil fuels by transport systems produces air pollutants	Gives an explanation of how combustion of fossil fuels by transport systems produces air pollutants <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of how combustion of fossil fuels by transport systems produces air pollutants 3-4	Gives an accurate and coherent explanation with detailed reasoning of how combustion of fossil fuels by transport systems produces air pollutants 5-6
	AC1.3 explain how weather conditions can affect pollution from transport systems	Gives an explanation how weather conditions can affect pollution from transport systems <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, how weather conditions can affect pollution from transport systems 3-4	Gives an accurate and coherent explanation, with detailed reasoning, how weather conditions can affect pollution from transport systems 5-6
	AC1.4 explain how pollution from transport systems can affect the environment	Gives an explanation how pollution from transport systems can affect the environment <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a mainly accurate and coherent explanation, with some detailed reasoning, how pollution from transport systems can affect the environment 3-4	Gives an accurate and coherent explanation, with detailed reasoning, how pollution from transport systems can affect the environment 5-6
	AC1.5 assess the impact of transport systems on the climate	Gives an assessment of how transport systems impact on the climate with some reasoned judgements 1-2	Gives an assessment of how transport systems impact on the climate with mainly reasoned judgements <i>Some parts are in detail</i> 3-4	Gives a detailed assessment of how transport systems impact on the climate with reasoned judgements 5-6

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>			
	AC1.6 explain how transport systems affect the health of individuals	Gives an explanation of transport systems can affect the health of individuals with some reasoned judgements <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives an explanation of how transport systems can affect the health of individuals with mainly reasoned judgements <i>Some parts are in detail</i> 3-4	Gives a detailed explanation of how transport systems can affect the health of individuals with reasoned judgements 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO2 be able to investigate environmental impact of transportation systems	AC2.1 describe methods to measure the impact of transport systems on the environment	Gives a description of methods to measure the impact of transport systems on the environment 1-2	Gives a mainly clear description of a range of methods to measure the impact of transport systems on the environment <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description of a range of methods to measure the impact of transport systems on the environment 5-6
	AC2.2 analyse data on transportation systems	Draws some valid inferences of data using some appropriate processing techniques 1-3	Draws mostly valid inferences from a range of data using appropriate processing techniques <i>Some parts are in detail</i> 4-6	Draws valid inferences using detailed reasoning from a range of data using appropriate processing techniques 7-9
	AC2.3 evaluate data on the impact of transport systems on the environment	Makes some suitable judgements about the validity of data on some criteria 1-2	Makes mainly suitable judgements showing clear reasoning about the reliability of data against a range of criteria 3-4	Makes suitable judgements showing clear and detailed reasoning about the reliability of data against a range of criteria 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO3 understand ways to reduce the environmental impact transport systems	AC3.1 describe transport policies that reduce the environmental impact of transportation systems	Gives a description of some transport policies that support environmental sustainability 1-2	Gives a mainly clear description of a range of transport policies that support environmental sustainability <i>Some parts are in detail</i> 3-4	Gives a clear and detailed description of a range of transport policies that support environmental sustainability 5-6
	AC3.2 explain how technological solutions in transport systems can reduce environmental impact	Gives an explanation of how technological solutions in transport systems can reduce environmental impact <i>Low level explanations may not always clearly show reasoning</i> 1-3	Gives a mainly accurate and coherent explanation, with some detailed reasoning, of how technological solutions in transport systems can reduce environmental impact 4-6	Gives an accurate and coherent explanation with detailed reasoning of how technological solutions in transport systems can reduce environmental impact 7-9
	AC3.3 explain how behavioural solutions in transport systems can reduce environmental impact	Gives an explanation of how behavioural solutions in transport systems can reduce environmental impact <i>Low level explanations may not always clearly show reasoning</i> 1-2	Gives a clear explanation of how behavioural solutions in transport systems can reduce environmental impact 3-4	Gives an accurate and coherent explanation with detailed reasoning of a range of behavioural solutions in transport systems can reduce environmental impact 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO4 be able to propose strategies to reduce environmental impact of transport systems	AC4.1 assess transport systems likely to be used within a particular setting	Gives an assessment of transport systems likely to be used within a particular setting with some reasoned judgements 1-2	Gives an assessment of how transport systems are likely to be used within a particular setting with mainly reasoned judgements 3-4	Gives a detailed assessment of how a range of transport systems are likely to be used within a particular setting with reasoned judgements 5-6
	AC4.2 propose strategies to reduce impact of transport systems within a particular setting	Propose some suitable strategies to reduce impact of transport systems within a particular setting 1-3	Propose a range of mainly suitable strategies to reduce impact of transport systems within a particular setting 4-6	Propose a range of suitable strategies to reduce impact of transport systems 7-9
	AC4.3 justify the effectiveness of proposed strategies	Provides a justification of the effectiveness of proposed strategies with some reasoning 1-3	Provides a reasoned justification of the effectiveness of proposed strategies <i>Some parts are detailed</i> 4-6	Provides justification of the effectiveness of proposed strategies with detailed reasoning 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise the knowledge and understanding they develop is vocationally relevant. There are a number of ways in which this can be achieved by:

- arranging visits to universities with transport management/planning courses
- visits to and from companies, agencies and organisations involved with reducing the environmental impact of transport systems
- carrying out activities based around scenarios that involve transport and the environment
- providing work experience with a relevant workplace, such as a council transport planning department

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of the impact of transport systems on the environment.

Example 1

Council representatives (e.g. from the transport planning departments) could be invited to speak about transport planning and management within the local area. They could focus on the role of the council in considering transport implications for any new development. Discussion could focus around the need to balance the requirements for the new development, attitudes of people towards the development and the requirement for an integrated transport policy. Learners could then be given a case study, for example, building the M4 relief road around Newport and its impact on the environment, or the introduction of a tram system within a city centre.

Example 2

A representative from a local transport pressure group could be invited to speak about issues associated with transport and the environment within the local area. For example the introduction of cycle to work schemes (<http://www.cyclesolutions.co.uk/?gclid=CICKpo204rwCFZMbtAodwxAAXA>). This could be followed up by learners presenting arguments for and against such schemes.

Example 3

Learners could be asked to take on the role of a journalist who has been asked to prepare an article on active transport within the local area. What provision is being made for cycling and walking routes? Are these routes being improved? Are they being promoted?

Making Contacts

Examples of organisations that may be approached to provide help include:

- Local councils
- Environmental studies departments at universities
- Conservation organisations (local and national)
- Specialist environmental laboratories

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks

Environmental Chemistry Colin Baird (Useful as a teacher resource)

Websites

Pollutants and transport systems

<http://people.hofstra.edu/geotrans/eng/ch8en/appl8en/ch8a2en.html>

<http://www.environmental-protection.org.uk/committees/air-quality/air-pollution-and-transport/car-pollution/>

Campaign group

<http://www.transportenvironment.org/campaigning-smarter-and-more-sustainable-transport>

European Communities booklet

http://www.transport-research.info/Upload/Documents/200908/20090818_124030_53136_TRKC_Transport_and_the_Environment.pdf

Transport for London

<http://www.tfl.gov.uk/corporate/about-tfl/8817.aspx>

Transport energy and environment statistics

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/8947/energy-2011.pdf

United Nations environment programme <http://www.unep.org/transport/>

Reference list for Welsh policy and strategy on transport

<http://www.planethealthcymru.org/page/47271>

<http://www.thepep.org/CHWebSite/chviewer.aspx?cat=c8>

Unit 8 Managing agriculture for a sustainable future

WJEC unit entry code

Guided learning hours 100

Aim and purpose

This unit develops knowledge and understanding of sustainable agriculture. Whilst agriculture has in the main, managed to keep pace with population growth, it has often been at the expense of the natural resource base, both through over use and pollution. This unit focuses on optimum approaches to enable agriculture to provide sufficient food but not at the expense of the natural resources on which it relies.

The unit will enable the learners to provide advice on how agriculture can rise to the environmental challenge, to achieve a balance between productivity and sustainability.

Unit introduction

With an ever increasing human population, how can the need to produce more food be balanced against conservation? The use of pesticides and fertilisers has improved crop yield, but at what cost to the environment? How can we ensure that the countryside remains a place for future generations to enjoy?

Many farmers and commercial growers are now rising to the environmental challenge. There have in recent times been many improvements to reduce the impact of agricultural systems have on the environment. The Environment Agency reports that the levels of pesticides detected in rivers have declined and the numbers of some farmland wildlife have begun to stabilise and recover. There have been a number of schemes, regulations and incentives to support farmers and growers to rise to this environmental challenge. There is however still much to do; understanding how agriculture can impact on the environment is the first step to then developing plans and strategies to achieve the right balance between productivity and sustainability. Environmental scientists can help us deal with these environmental challenges by providing information and informing the strategies that should be taken to minimise the impact of agriculture on the environment.

This unit is designed to help you to understand the ways in which agriculture can impact on the environment, so that you will be able to use science to provide advice and propose strategies to reduce any negative impacts whilst maintaining the requirement for productivity.

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO1 understand the importance of soil ecosystems	AC1.1 describe the key features of ecosystems	Ecosystems <ul style="list-style-type: none"> • soil ecosystems • unmanaged ecosystems • agroecosystems Key features <ul style="list-style-type: none"> • community of living organisms (plants, animals, micro-organisms) • habitats and populations • interaction: competition, predation, cooperation, symbiosis • energy flow • ecosystem diversity • stable and unstable ecosystems
	AC1.2 describe the key features of soil	Key features <ul style="list-style-type: none"> • soil as a living system • soil profile • soil composition • soil structure • chemical composition
	AC1.3 describe the services provided by soil	Services <ul style="list-style-type: none"> • transformation of carbon • cycling of nutrients • maintenance of structure and fabric of soil • biological regulation of soil properties
	AC1.4 explain the benefits of maintaining soil ecosystems	Soil health <ul style="list-style-type: none"> • concept Ecosystems <ul style="list-style-type: none"> • soil ecosystems • unmanaged ecosystems • agroecosystems Benefits e.g. <ul style="list-style-type: none"> • fertility • crop yield • biodiversity

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 understand the principles of genetic manipulation in agriculture	AC2.1 explain principles of methods used to improve organisms used in agriculture	Methods used to improve organisms <ul style="list-style-type: none"> • artificial selection <ul style="list-style-type: none"> ○ choosing organisms showing desirable characteristics ○ inbreeding ○ outbreeding ○ implications of inbreeding and outbreeding ○ examples of use artificial selection • artificial insemination • embryo transfer • cloning • genetic modification <ul style="list-style-type: none"> ○ transgenic organisms/GM organisms, those with an altered genotype ○ examples of transgenic organisms
	AC2.2 explain the principles involved in micro-propagation	Micro-propagation <ul style="list-style-type: none"> • plant tissue culture • totipotent cells • advantages over more traditional methods of propagation

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 understand the impacts of agriculture	AC3.1 explain how agriculture affects soil health	Agriculture <ul style="list-style-type: none"> • agricultural systems <ul style="list-style-type: none"> ○ classed by product (arable farming (monoculture, multi crop); pastoral (sheep, chicken, beef, dairy)); mixed farming • classed by type <ul style="list-style-type: none"> ○ conventional, organic, intensive, • agricultural techniques e.g. <ul style="list-style-type: none"> ○ ploughing; use artificial fertilisers, manure; pesticides; use of GM methods Soil health <ul style="list-style-type: none"> • ecosystems • physical structure and composition
	AC3.2 explain how agricultural systems affect crop yield	Systems <ul style="list-style-type: none"> • agricultural systems <ul style="list-style-type: none"> ○ classed by product (arable farming (monoculture, multi crop); pastoral (sheep, chicken, beef, dairy)); mixed farming • classed by type <ul style="list-style-type: none"> ○ conventional, organic, intensive, GM methods Crop yield <ul style="list-style-type: none"> • short term yield; long term yield
	AC3.3 explain how agricultural systems contribute to greenhouse gas emissions	Agriculture and greenhouse gas emission <ul style="list-style-type: none"> • worldwide and UK contribution of agriculture • use of energy: fossil fuels, renewable energy, transport emissions (food miles) • livestock emissions and crop production emissions • storing carbon Measuring emissions <ul style="list-style-type: none"> • measures of carbon footprint • amount of greenhouse gases produced by particular activities • units (tons of per year) of carbon dioxide • conversion of methane and nitrous oxide to units of carbon dioxide

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 <i>continued</i>	AC3.4 evaluate the impacts of agriculture	<p>Agriculture</p> <ul style="list-style-type: none"> • agricultural systems <ul style="list-style-type: none"> ○ defined in ASC3.2 • agriculture techniques e.g. <ul style="list-style-type: none"> ○ ploughing ○ fertiliser use (artificial and manure) ○ pesticide use ○ hedgerow removal ○ forest clearance ○ monoculture ○ mixed farming ○ embryo transfer ○ use of GM modified organisms <p>Impacts</p> <ul style="list-style-type: none"> • environment <ul style="list-style-type: none"> ○ habitat ○ ecosystems ○ aquatic systems • economic • social

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 understand ways to reduce the environmental impact of agricultural systems	AC4.1 propose strategies to support biodiversity	Supporting biodiversity <ul style="list-style-type: none"> • management e.g. <ul style="list-style-type: none"> ○ integrated farm management ○ integrated pest management systems ○ manure management plan ○ sustainable soil management ○ economic incentives (e.g. Environmental Stewardship –England) • specific activities e.g. <ul style="list-style-type: none"> ○ maintaining grassy margins and hedgerows ○ reduced use of pesticides/fertilisers ○ hedge row management ○ permanent grassland – low input ○ buffer strips with waterways ○ ditch management ○ birds seeds
	AC4.2 propose strategies to reduce the greenhouse gas emissions used by agriculture	Strategies to e.g. <ul style="list-style-type: none"> • improve fuel efficiency • reduce greenhouse gas emissions from livestock • lock carbon into soil and vegetation • improve waste management • optimising application of fertilisers and manures • reduce nitrogen fertiliser • reduce transportation

Learning outcomes	Assessment criteria	Content
<i>The learner will:</i>	<i>The learner can:</i>	
LO4 <i>continued</i>	AC4.3 assess how regulation can help to reduce negative environmental impacts	<p>Regulation</p> <p>Intergovernmental protocols and panels e.g.</p> <ul style="list-style-type: none"> • International panel on climate change (IPCC) • Kyoto protocol <p>European directives e.g.</p> <ul style="list-style-type: none"> • Common Agricultural Policy • EU standards <p>UK legislation and directives e.g.</p> <ul style="list-style-type: none"> • Climate Change Act 2008 • Environment Act 1995 • Environmental Impact Assessments (EIAs) • Defra guidance • UK government policy • Greenhouse gas action plan <p>Regional initiatives e.g.</p> <ul style="list-style-type: none"> • Rural development Plan for Wales • Environmental Stewardship (England)

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO5 be able to communicate strategies for sustainable agricultural production systems	AC5.1 plan to provide information on strategies	Plan <ul style="list-style-type: none"> • identify requirements • actions • timelines • sequencing • priorities • milestones • monitoring • planned outputs
	AC5.2 support strategies using published information	Use <ul style="list-style-type: none"> • variety • quantitative & qualitative information • source of information: validity, bias, reliability • references information (e.g. Harvard System)
	AC5.3 communicate information using appropriate methods	Communication methods <ul style="list-style-type: none"> • presentations, podcasts, blogs, videos Communication <ul style="list-style-type: none"> • use ICT software (e.g. presentation software) • use of diagrams and images • clarity of language, tone and style • pace of delivery • organisation of information • consideration of audiences

Learning Outcome	Assessment criteria	Performance Bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO1 understand the importance of soil ecosystems	AC1.1 describe the key features of ecosystems	Gives a description of some key features of ecosystems 1-2	Gives a mainly clear and accurate description of key features of ecosystems 3-4	Gives a clear, accurate and detailed description of the key features of ecosystems 5-6
	AC1.2 describe the key features of soil	Gives a description of key features of soil <i>The description may be weighed towards two or three key features</i> 1-2	Gives a mainly clear and accurate description of key features of soil <i>Some parts are in detail</i> 3-4	Gives a clear, accurate and detailed description of key features of soil 5-6
	AC1.3 describe the services provided by soil	Gives a description of services provided by soil <i>The description may be weighed towards two or three key services</i> 1-2	Gives a mainly clear and accurate description of services provided by soil 3-4	Gives a clear, accurate and detailed description of services provided by soil 5-6
	AC1.4 explain the benefits of maintaining soil ecosystems	Gives an explanation of the benefits of maintaining soil ecosystems <i>Low level explanations may not always clearly link ideas</i> 1-2	Gives an mainly accurate and coherent explanation of the benefits of maintaining soil ecosystems 3-4	Gives an accurate, detailed and coherent explanation of the benefits of maintaining soil ecosystems 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
<i>The learner will:</i>	<i>The learner can:</i>	Band 1	Band 2	Band 3
LO2 understand the principles of genetic manipulation in agriculture	AC2.1 explain principles of methods used to improve characteristics of organisms used in agriculture	Gives an explanation of methods used to improve characteristics of organisms used in agriculture <i>Low level explanations may not always clearly link ideas</i> 1-2	Gives a mainly accurate and coherent explanation of methods used to improve characteristics of organisms used in agriculture with some detail 3-4	Gives an accurate, detailed and coherent explanation of methods used to improve characteristics of organisms used in agriculture 5-6
	AC2.2 explain the principles involved in micro-propagation	Gives an explanation of principles involved in micro-propagation <i>Low level explanations have some breadth but may have not always clearly link ideas</i> 1	Gives a mainly clear and accurate explanation of the principles involved in micro-propagation 2-3	Gives an accurate, detailed and coherent explanation of the principles involved in micro-propagation 4

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO3 understand the impacts of agriculture	AC3.1 explain how agriculture affects soil health	Gives an explanation of how agriculture affects soil health 1-2	Gives a mainly clear and accurate explanation of how agriculture affects soil health 3-4	Gives an accurate, detailed and coherent explanation of how agriculture affects soil health 5-6
	AC3.2 explain how agricultural systems affect crop yield	Gives an explanation of how agricultural systems affect crop yield <i>Low level explanations may not always clearly link ideas</i> 1-2	Gives a mainly clear and accurate explanation of how agricultural systems affect crop yield 3-4	Gives an accurate, detailed and coherent explanation of how agricultural systems affect crop yield 5-6
	AC3.3 explain how agricultural systems contribute to greenhouse gas emissions	Gives an explanation of how agricultural systems contribute to greenhouse gas emissions <i>Evidence is mainly descriptive with limited reference to scientific principles</i> 1-2	Gives a mainly clear and accurate explanation of how agricultural systems contribute to greenhouse gas emissions 3-4	Gives an accurate, detailed and coherent explanation of how agricultural systems contribute to greenhouse gas emissions 5-6
	AC3.4 evaluate the impacts of agriculture	Gives an explanation of the impact of agriculture, covering a range of possible impacts <i>Evidence may be mainly descriptive but with some reasoning to support conclusions</i> 1-3	Gives a mostly clearly reasoned and appropriate evaluation covering a range of possible impacts of the impact of agriculture on the environment 4-6	Gives a clearly reasoned and appropriate evaluation covering a wide range of possible impacts of agriculture covering a wide range of possible impacts showing 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO4 understand ways to reduce the environmental impact of agricultural systems	AC4.1 propose strategies to support biodiversity	Proposes a limited range of relevant strategies to support biodiversity. Proposal has some detail but may be limited in justification 1-3	Proposes a limited range of relevant strategies to support biodiversity. Proposal has some detail and some justification 4-6	Proposes a range of relevant strategies to support biodiversity. Proposals are detailed with clear justification 7-9
	AC4.2 propose strategies to reduce the greenhouse gas emissions by agriculture	Proposes a limited range of strategies to reduce greenhouse gas emission in agricultural production systems Proposal has some detail but may be limited in justification 1-2	Proposes a limited range of strategies reduce greenhouse gas emission in agricultural production systems Proposal has some detail and some justification 3-4	Proposes a range of relevant strategies reduce greenhouse gas emission in agricultural production systems Proposals are detailed with clear justification 5-6
	AC4.3 assess how regulation can help to reduce negative environmental impacts	Assesses how regulations can help to reduce negative environmental impacts <i>Evidence may be weighed to a few regulations Evidence is mainly descriptive but shows some reasoning to support judgements</i> 1	Assesses how a range of regulations can help to reduce negative environmental impacts with mainly clear reasoning and some detail to support judgements 2-3	Assesses how a range of regulations can help to reduce negative environmental impacts with clear and detailed reasoning to support judgements 4-5

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO5 be able to communicate strategies for sustainable agricultural production systems	AC5.1 plan to provide information on strategies	Produces a plan to provide information which may contain some omissions in content 1-2	Produces a mainly valid plan to provide information which may contain minor omissions in content 3-4	Produces a valid, detailed, well sequenced plan 5-6
	AC5.2 support strategies using published information	Uses a limited range of published information sources Some information may be of limited relevance Some sources referenced 1	Uses a range of published information sources Information sources are mainly relevant Sources mostly referenced using a suitable method 2-3	Uses a range of relevant published information sources Consistently and accurately references sources using a suitable method 4
	AC5.3 communicate information using appropriate methods	Makes some appropriate use of mostly suitable diagrams and graphs to support information Uses some appropriate scientific and technical language Use some appropriate styles and structure Uses some accurate spelling, punctuation and grammar 1-3	Makes mostly appropriate use of suitable diagrams and graphs to support information Mostly uses appropriate scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar 4-6	Makes an appropriate use of suitable diagrams and graphs to support information Consistently uses appropriate scientific and technical language Uses appropriate style and structure Uses accurate spelling, punctuation and grammar 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This unit is internally assessed and externally moderated through a summative controlled assessment. All assessment must be conducted under controlled assessment conditions. **Section 3.2** of the specification details the principles involved in internal assessment. WJEC has produced a model assignment for this unit which is available through the WJEC secure website.

Guidance for Delivery

Making teaching vocationally relevant

It is important that learners recognise that the knowledge and understanding they develop is vocationally relevant. There are a number of ways in which this can be achieved:

- arranging visits to farms, horticultural nurseries and commercial growers to see examples of environmental strategies in action.
- arranging talks by visiting speakers from agencies and organisations involved with managing the environment and environmental issues: e.g. Governmental and non-governmental agencies linked to AONBs (Areas of Outstanding Natural Beauty), National Parks, Nature Reserves, SSSIs (Sites of Special Scientific Interest), and the Environmental Agency.
- carrying out activities based around scenarios that involve agriculture and the environment.
- providing work experience in a relevant workplace, such as a farmer who is undertaking environmental activities, an organisation that monitors pollution/effects on biodiversity or a university undertaking environmental research.

The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of the impact of agricultural systems on the environment.

Example 1

Learners could be provided with a case study of an agricultural production system. One group of learners could be given the role of the "farmer"; the other group would take on the role of a local conservation group who are concerned about the impact the agricultural production system is having on the local and global environment. Learners in each group are then asked to present cases on the impact of the agricultural system on the environment and what they are/aren't doing to reduce this impact.

Example 2

A local farmer could ask the group what could be done to improve biodiversity on his farm while maintaining yields and profitability. The farmer would need to describe farming methods used. Working in small teams, the learners could analyse the current impact of farming on biodiversity and make proposals to modify practice to improve biodiversity while maintaining profitability

Example 3

Learners could be asked to take on the role of a journalist who has been asked to prepare an article on the use of genetically modified organisms and the potential environmental impacts. The article is for the New Scientist magazine, so must be an evidence based piece of writing that covers the scientific principles, as well as outlining some of the potential environmental impacts

Making Contacts

Examples of organisations that may be approached to provide help include:

- Farming organisations: such as National Farmers' Union (NFU) and National Farmers' Union Cymru
- Environment Agency
- Local Councils
- Environmental studies departments at Universities
- Conservation organisations (local and national)
- Specialist Environmental laboratories

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

Resources

Textbooks

There are a number of A-level Biology textbooks that can be used as a resource for this unit.

Examples include

New Understanding Biology for Advanced Level (G Toole and S Toole) (4th Edition)
Advanced Biology (G Monger, M Reiss and M Roberts)
WJEC A2 Biology (Gareth Rowlands)

Websites

Linking Environment and Farming (LEAF): promoting sustainable food and farming:
<http://www.leafuk.org/leaf/home.eb>

Farming and Countryside Education: <http://www.face-online.org.uk/resources/factsheets/discovering/Sustainable%20agriculture.pdf>

Environment Agency report: Good Farming, better environment:
<http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geho0406bkep-e-e.pdf>

GOV.UK website: publications page, related specifically to agriculture: very useful for facts/figures
https://www.gov.uk/government/publications?keywords=agriculture+environment&publication_filter_option=all&topics%5B%5D=all&departments%5B%5D=all&world_locations%5B%5D=all&direction=before&date=2013-11-01

BBSRC (Bioscience for the future): range of topic based publications
<http://www.bbsrc.ac.uk/publications/topic/topic-index.aspx>

Natural England: Government's advisor on the natural environment
<http://www.naturalengland.org.uk/>

Guardian newspaper: sustainable farming

<http://www.theguardian.com/sustainable-business/blog/farming-system-principles-based-sustainable>

<http://www.theguardian.com/guardian-professional/video/2013/oct/16/food-security-future-sustainable-farming-video>

University of Leeds: farm management and hedgerow diversity

<http://homepages.see.leeds.ac.uk/~lecac/ejournal/Issue%208%20articles/8,%20180-209.pdf>

Natural England

<http://www.naturalengland.org.uk/ourwork/farming/funding/es/els/usefuldocuments.aspx>

Welsh government: The Code of Good Agricultural Practice

<http://wales.gov.uk/docs/drah/publications/110420cogapwales2011introen.pdf>

British Society of Soil Science

<http://www.soils.org.uk/pages/home>

Royal Society: Soil Health

<http://rstb.royalsocietypublishing.org/content/363/1492/685.full#sec-6>

Soil ecology and management

<http://www.safs.msu.edu/soilecology/index.htm>

Embryo transfer – developing world

<http://www.ilri.org/ilrinews/index.php/archives/tag/embryo-transfer>

Unit 9 Environmental Impact Analysis

WJEC unit entry code

Guided learning hours 60

Aim and purpose

This unit is a synoptic assessment unit which requires candidates to identify and apply a selection of skills, techniques, concepts, theories and knowledge from across the qualification content in order to complete the required assessment. The assessment provides an integrated and purposeful context in which candidates can demonstrate the knowledge, understanding and skills they have developed through all other units within the qualification.

The unit will enable the learners to produce an evidence based environmental statement which will propose strategies to improve the environment or minimise damage to the environment in a particular location.

Unit introduction

What effect will the development of a new shopping centre have on the environment? What has been the lasting effect on the environment of a now disused chemical works?

Environmental scientists are often employed to undertake an environmental impact analysis to identify, predict or evaluate the effects that a particular project or activity will have or has had on the environment. Environmental impact analysis is a key aspect of many planning applications, where possible environmental threats will be assessed. In order to complete such an analysis, environmental scientists need to plan what needs to be assessed in a particular location, the testing methods, equipment and sequence of activities that are required. Data collected from investigations needs to be processed, so that this can be used to propose evidence based strategies to improve the environment or minimise environmental damage. It is important that on completion of an environmental impact analysis that strategies can be communicated to both a technical audience and a general audience.

This unit requires you to use the knowledge, understanding and skills that you have developed through all the other units to undertake an environmental impact analysis for a particular location. Having completed this analysis, you will communicate proposed strategies to improve the environment or minimise environmental damage, to both a technical audience and general audience.

Learning outcomes	Assessment criteria	Content
<p><i>The learner will:</i></p> <p>LO1 understand impact of change on an environment</p>	<p><i>The learner can:</i></p> <p>AC1.1 describe an environment</p>	<p>Environment</p> <ul style="list-style-type: none"> • biological (e.g. habitat, biodiversity, ecosystems) • chemical (e.g. pH water systems, soil, metal/nitrate ion concentrations) • physical <p>Requires learners to apply knowledge and understanding developed in units 2, 4, 5, 6/7 and 8</p>
	<p>AC1.2 assess the impact of change on an environment</p>	<p>Assessment</p> <p>Impact on</p> <ul style="list-style-type: none"> • biological environment • chemical environment • physical environment <p>Impact of changes as a result of</p> <ul style="list-style-type: none"> • human activity • natural factors <p>Human factors</p> <ul style="list-style-type: none"> • development • reclamation <p>Requires learners to apply knowledge and understanding developed in units 1, 2, 4, 5, 6/7 and 8</p>

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO2 be able to plan an environmental analysis	AC2.1 plan an environmental analysis	Plan to include <ul style="list-style-type: none"> • SMART objectives • information required • activities - testing methods • equipment • timescales <p>Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 4, 5 and 6/7</p>
	AC2.2 draw up a risk assessment	Health and safety <ul style="list-style-type: none"> • identify risks to health and safety • assess likelihood of harm • suggest suitable control measures Risk assessment documentation <ul style="list-style-type: none"> • complete risk assessment documentation
	AC2.3 justify plan for environmental analysis	Justification Reasoned arguments for objectives and procedures selected in terms of: <ul style="list-style-type: none"> • environmental threats • information required to make judgements • methods used – suitability and health & safety considerations • sampling – access, health and safety considerations <p>Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 4 and 6/7</p>
	AC2.4 describe assessment methods used in environmental analysis	Assessment methods <ul style="list-style-type: none"> • biological • chemical • physical <p>Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 4, 5 6/7 and 8</p>

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO3 be able to obtain data that will support the environmental analysis	AC3.1 obtain data from scientific investigations	Data <ul style="list-style-type: none"> • primary data • secondary data • qualitative, quantitative • biological, physical Requires learners to apply skills developed in units 1, 2, 3, 4, 5, 6/7 and 8
	AC3.2 record data from investigations	Recording data <ul style="list-style-type: none"> • appropriate formats • use of tables • clear and legible recording • accurate recording • appropriate use of units • appropriate use of figures Requires learners to apply knowledge and understanding developed in units 1, 2, 3, and 4
	AC3.3 process data	Process data <ul style="list-style-type: none"> • mathematical methods e.g. statistical methods • graphical methods • correct use of significant figures Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 4, 5, 6/7 and 8
	AC3.4 evaluate data and procedures	Evaluates <ul style="list-style-type: none"> • quality of data; effectiveness of procedures Evaluates in terms of <ul style="list-style-type: none"> • repeatability, reliability • outliers, bias • sufficiency of data (number of readings) • limitations of data & procedure • sources of error • resources, cost, time • further work needed Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 4, 6/7 and 8

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 be able to propose strategies to protect the environment	AC4.1 propose strategies to protect an environment	<p>Protect environments</p> <ul style="list-style-type: none"> • minimise environmental damage • improve environments <p>Strategies</p> <ul style="list-style-type: none"> • focussed on specific actions to <ul style="list-style-type: none"> ○ minimise environmental damage ○ improve environments • Strategies may consider e.g. <ul style="list-style-type: none"> ○ planning changes ○ changing practices that impact on the environment ○ waste management ○ clean-up of polluted environments <p>Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 5, 6/7 and 8</p>
	AC4.2 justify proposed strategies	<p>Justification</p> <ul style="list-style-type: none"> • use of evidence to support proposed strategies • strategies based on appropriate scientific understanding/concepts • appropriate use of data <p>Requires learners to apply knowledge and understanding developed in units 1, 2, 3, 4, 5, 6/7 and 8</p>

Learning outcomes <i>The learner will:</i>	Assessment criteria <i>The learner can:</i>	Content
LO4 <i>continued</i>	AC4.3 communicate strategies to an audience	<p>Communication method</p> <ul style="list-style-type: none"> • presentation to an audience, written report, leaflet, magazine article <p>Language</p> <ul style="list-style-type: none"> • technical and scientific • spelling, grammar and punctuation • appropriateness of language to audience • clarity of communication <p>Organisation</p> <ul style="list-style-type: none"> • presentation <ul style="list-style-type: none"> ○ presentation slides (use of images, text) ○ supporting notes to presentation • report <ul style="list-style-type: none"> ○ structure ○ layout ○ sections of report • magazine article <ul style="list-style-type: none"> ○ structure ○ layout ○ use images • references (using e.g. Harvard system) cited works <p>Audience</p> <ul style="list-style-type: none"> • technical • non-technical

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO1 understand impact of change on an environment	AC1.1 describe an environment	Gives a description of some aspects of an environment 1-3	Gives a mainly clear and accurate description of the significant aspects of an environment with some parts in detail 4-6	Gives a clear, accurate and detailed description which includes the significant aspects of an environment 7-9
	AC1.2 assess the impact of change on an environment	Provides a brief assessment of some impacts of change on an environment with some accuracy Draws upon limited skills/knowledge/understanding from other units in the qualification 1-3	Provides a largely accurate assessment with some reasoning of significant impacts of change on an environment Draws upon some relevant skills/knowledge/understanding from other units in the qualification 4-6	Provides an accurate and detailed assessment with reasoning of significant impacts on an environment Draws upon relevant skills/knowledge/understanding from other units in the qualification 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO2 be able to plan an environmental analysis	AC2.1 plan an environmental analysis	<p>Plan has some SMART relevant objectives</p> <p>Identifies some information to collect and identifies some appropriate ways to collect information</p> <p>Identifies some suitable activities to collect information</p> <p>Identifies some equipment to execute the plan</p> <p>Sets some achievable times to complete some aspects of the plan</p> <p><i>The plan draws upon limited skills/knowledge/understanding from other units in the qualification</i></p> <p style="text-align: center;">1-3</p>	<p>Plan has some relevant SMART objectives linked to the planned tasks</p> <p>Identifies most information to collect and identifies mostly appropriate ways to collect information</p> <p>Identifies mostly suitable activities to collect information</p> <p>Identifies most equipment to execute the plan</p> <p>Sets mostly achievable times to complete all aspects of the plan</p> <p><i>The plan draws upon some relevant skills/knowledge/understanding from other units in the qualification</i></p> <p style="text-align: center;">4-6</p>	<p>Plan has SMART objectives that are relevant to the investigation and are linked to the planned tasks</p> <p>Identifies the information to collect and appropriate ways to collect the information</p> <p>Identifies suitable activities to collect information</p> <p>Identifies the equipment to execute the plan</p> <p>Sets achievable times to complete all aspects of the plan</p> <p><i>The plan clearly draws upon relevant skills/knowledge/understanding from other units in the qualification</i></p> <p style="text-align: center;">7-9</p>
	AC2.2 draw up a risk assessment	<p>Identifies some significant hazards and risks associated with activities</p> <p>Suggests some suitable control measures</p> <p style="text-align: center;">1-2</p>	<p>Identifies most significant hazards and risks associated with activities</p> <p>Suggests some suitable and sufficient control measures for most of the hazards identified</p> <p style="text-align: center;">3-4</p>	<p>Identifies all significant hazards and risks associated with activities</p> <p>Suggests suitable and sufficient control measures for each of the hazards identified</p> <p style="text-align: center;">5-6</p>

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO2 continued	AC2.3 justify plan for environmental analysis	Provides a justification which covers some of the following elements: <ul style="list-style-type: none"> • SMART objectives • potential environmental change • information required to make judgements • methods used – suitability and health & safety considerations • sampling – access, health and safety considerations 1-3	Provides a justification which covers most of the following elements: <ul style="list-style-type: none"> • SMART objectives • potential environmental change • information required to make judgements • methods used – suitability and health & safety considerations • sampling – access, health and safety considerations 4-5	Provides a justification which covers the following in detail: <ul style="list-style-type: none"> • SMART objectives • potential environmental change • information required to make judgements • methods used – suitability and health & safety considerations • sampling – access, health and safety considerations 6-9
	AC2.4 describe assessment methods used in environmental analysis	Gives a mainly accurate description of some assessment methods used Draws upon some relevant skills/knowledge/ understanding from other units in the qualification 1-2	Gives a mainly clear and accurate description of most assessment methods used with some parts in detail Clearly draws upon relevant skills/knowledge/ understanding from other units in the qualification 3-4	Gives a clear, detailed and accurate description of assessment methods used Clearly draws upon relevant skills/knowledge/ understanding from other units in the qualification 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO3 be able to obtain data that will support the environmental analysis	AC3.1 obtain data from scientific investigations	Obtains suitable data from a limited range of investigations Some data is obtained is within expected tolerance of procedures used to obtain data 1-3	Obtains suitable data from a range of scientific investigations Most data is obtained is within expected tolerance of procedures used to obtain data 4-6	Consistently obtains suitable and sufficient data a range of scientific investigations Consistently obtains data within expected tolerance of procedures used to obtain data 7-9
	AC3.2 record data from investigations	Records some data accurately to appropriate precision in a mostly suitable format. 1	Mostly records data accurately to suitable precision in a clear and suitable format <i>Mostly correctly quotes units and data heading in records</i> 2-3	Consistently data outcomes accurately to suitable precision in a clear and suitable format <i>Consistently and correctly quotes units and data heading in records</i> 4
	AC3.3 process data	Processes data from some scientific investigations using appropriate techniques Some aspects of graphs/calculations are clearly presented Makes a limited use of significant figures 1-3	Accurately processes data from a range of scientific investigations using appropriate techniques Graphs/calculations are mostly clearly and logically presented Makes some appropriate and accurate use of significant figures 4-6	Consistently, systematically and accurately processes data from a range of scientific investigations using appropriate techniques Graphs/calculations are clearly and logically presented Consistently makes appropriate and accurate use of significant figures 7-9
	AC3.4 evaluate data and procedures	Gives an appropriate evaluation of some aspects of the data and procedures <i>Evaluation may be weighed towards data or procedures</i> 1-2	Gives a mostly clear and accurate evaluation of a range of aspects of the data and procedures 3-4	Gives a clear, detailed and accurate evaluation of a range of aspects of the data and procedures 5-6

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Learning Outcome	Assessment criteria	Performance bands		
		Band 1	Band 2	Band 3
<i>The learner will:</i>	<i>The learner can:</i>			
LO4 be able to propose strategies to protect the environment	AC4.1 propose strategies to protect an environment	Proposes some suitable strategies 1-3	Proposes a range of suitable strategies <i>Some aspects may be in detail</i> 4-6	Proposes in detail a range of suitable strategies 7-9
	AC4.2 justify proposed strategies	Provides a justification of some proposed strategies 1-2	Provides a mostly clear and appropriate justification of proposed strategies <i>Some parts are in detail</i> 3-4	Provides a clear, detailed and appropriate justification of all proposed strategies 5-6
	AC4.3 communicate strategies to an audience	Communicates some information from the investigation Uses some scientific and technical language appropriate to the audience Use some appropriate styles and structure Uses some accurate spelling, punctuation and grammar References some cited work 1-3	Mostly clearly communicates information from the investigation Mostly uses scientific and technical language Uses mostly appropriate styles and structure Uses mostly accurate spelling, punctuation and grammar References cited work 4-6	Clearly communicates information from the investigation Consistently uses scientific and technical language appropriate to the audience Uses appropriate style and structure Uses accurate spelling, punctuation and grammar References cited work fully and correctly 7-9

Zero marks to be awarded where there is insufficient evidence to achieve a mark at band 1

Assessment

This is an externally assessed **synoptic** unit which is assessed through an original, extended investigation involving an environment impact analysis of a particular location. The investigation set and marked by WJEC. Further information on the assessment of unit 9 can be found in **section 3.1.4** of the specification. The extended investigation will require approx. 6 weeks to complete and 24 hours of direct supervision.

Guidance for delivery

It is important that learners and assessors recognise that this unit draws on knowledge, understanding and skills developed in the other units of this programme of study. This is a synoptic unit and should only be delivered once units **1** to **8** have been completed.

Making teaching vocationally relevant

It is important that learners recognise that the knowledge and understanding they develop are vocationally relevant. There are a number of ways in which this can be achieved:

- arranging talks by visiting speakers from local planning agencies, environmental agencies to discuss how environmental impact surveys are carried out for new developments etc.
- arranging a visit to areas where planning has been applied for and arrange for talk to various parties for and against the development

Learners need to gain the opportunity to **integrate** the knowledge, skills and understanding they have developed from the qualification. The following are examples of approaches to delivery which could be used to enhance the learners' understanding of the vocational importance of the unit.

Example 1

Allow learners to work in small teams to investigate the potential impact on a local environment of proposals to develop a green field site. Learners could then prepare a strategy to minimise the impact which could be reported to a non-technical audience in the form of a presentation and magazine article.

Example 2

Learners could use a study of unregulated development in a third world country and suggest strategies that could be implemented to improve the environment. The strategies could be presented as formal report

Example 3

A Greenkeeper from a local golf club could be invited to describe their work and could ask learners to suggest strategies to improve biodiversity on the golf course while maintaining its integrity as a sporting venue.

Making Contacts

Examples of organisations that may be approached to provide help include:

- Local authorities
- Environmental agencies and organisations
- Local campaign groups

Skills

This unit provides opportunities for learners to develop a range of skills. Appendix 3 in the specification shows the links to Personal, learning and thinking skills (PLTS), Key Skills and Essential Skills (Wales).

6. ENTRY PROCEDURES

WJEC Level 3 Applied Extended Diploma in Environmental Science will be available for certification from June 2017.

Thereafter, the qualification will be available for certification each June.

Centres planning to offer this qualification must be registered as an accredited WJEC centre. For details on the application and accreditation, centres should contact WJEC.

Entries for the June series must be submitted no later than 21 February.

Candidates may resit internally assessed units **once only, and externally assessed units twice**. The best grade will be used for aggregation. If a candidate wishes to resit an internal unit more than once or an external unit more than twice, no results from units taken previously may be used in aggregating the new grade and all units in the qualification must be taken again.

Unit entry

Entry for individual units must be made by submitting the relevant unit codes as indicated on each unit of the specification. Entries can be made for units in the following sessions:

Unit	January 2016	June 2016	January 2017 and thereafter	June 2017 and thereafter
1.	✓	✓	✓	✓
2.		✓		✓
3	✓	✓	✓	✓
4		✓		✓
5				✓
6			✓	✓
7			✓	✓
8			✓	✓
9				✓
Certification (qualification award)				✓

Qualification entry

Learners will be entered for the qualification when entering for aggregation (cash-in). Aggregation does not take place automatically: it is necessary to enter the relevant code for aggregation to take place.

7. EXTERNAL MODERATION

The consistency of assessment practices and decisions across centres will be assured through the external moderation of a sample of work.

Each centre will have access to a consultative moderator. The consultative moderator will be available to discuss assessment requirements with centres.

Postal moderation will take place each year in June. For each series where learners are entered, centres will submit a sample, according to the formula below.

<i>Total number of candidates</i>	<i>Work to be submitted (Numbers relate to alphabetical order)</i>
1 – 10	All
11 - 19	1 st and every second (1, 3, 5, 7 etc.) plus the lowest scoring* folder and additional folders as necessary (reflecting the spread of marks) to make a total sample of 10
20 - 45	1 st and every fifth (1, 6, 11, 16 etc.) plus the lowest scoring* folder and additional folders as necessary (reflecting a spread of marks) to make a total sample of 10
46 - 99	1 st and every eleventh (1, 12, 23, 34 etc.) plus the lowest scoring* folder and additional folders as necessary (reflecting a spread of marks) to make a total sample of 10

** The score is based upon the marks the learners obtain for each of the units being submitted for moderation.*

Centres should ensure they keep all learner portfolios not sent to the moderator in their possession for two months after the closing date for sending samples for moderation. WJEC may require all portfolios for moderation and centres must be able to comply immediately with such a request.

Centres should submit a sample for **each unit** that includes:

- the controlled assignment brief used to set the assessment activity;
- a controlled assessment activities sheet completed and signed by the assessor to confirm that the controls for the unit, including authenticity of evidence, have been applied;
- completed mark record sheets outlining which performance bands are met by the evidence;
- all evidence produced by learners in completion of the controlled assessment, annotated appropriately by the assessor.

Moderators will review all evidence presented to ensure standards are aligned. Evidence will be judged against the following criteria:

- Task setting – were tasks set within the controls set by WJEC in the model assignment?
- Task taking – is there evidence that tasks were completed under the controlled conditions set out in the model assignment?
- Performance bands – does the evidence support assessor's judgement of a learner against national standards?
- Annotation – is the evidence produced by learners appropriately annotated?
- Authentication- is it clear that the evidence submitted was authentically produced by the learner?
- Standardisation – is there evidence of effective standardisation/internal quality assurance within the centre?

Timetable

Samples of work must be submitted for external moderation, and related mark sheets returned to WJEC by 15 May for the June series. Centres will need to ensure that internal submission dates are set sufficiently in advance of this to allow for authentication, assessment and standardisation.

Feedback

The outcome of moderation will be to either accept or amend a centre's assessment decisions. Guidance on actions needed before re-sitting of specified units at a subsequent moderation series will be also be provided.

Feedback will be provided through a centre moderator's report for each certification title, covering the units entered by the centre and will be accessible through WJEC secure website. The report will address the criteria referred to above.

A Principal Moderator's report will be provided for each series.

8. AWARDING AND REPORTING

Awarding and reporting of results in WJEC Level 3 Applied Extended Diploma in Environmental Science will take place in August of each year.

A **Qualification Certificate**, issued at a later date, will confirm the

- Title
- Level
- Grade of qualification (Pass, Merit, Distinction, Distinction*)
- Unit titles contributing to the qualification

Individual unit results are reported on a uniform mark scale (UMS) with the following grade equivalences:

Unit	UMS mark	UMS grade boundaries		
		D	M	P
1	120	96	72	48
2	120	96	72	48
3	120	96	72	48
4	140	112	84	56
5	120	96	72	48
6 or 7	120	96	72	48
8	120	96	72	48
9	140	112	84	56

9. ACCESS ARRANGEMENTS

Qualifications at this level often require assessment of a broad range of competencies. This is because they are vocational qualifications and prepare candidates for a wide range of occupations and higher level courses.

This specification has been designed to offer fair access for all and to minimise the need to make reasonable adjustments for learners who have particular requirements. It is expected that normally, individual learners' abilities, interests and needs will be appropriately catered for by centres through:

- (a) the choice of units and qualifications available;
- (b) the potential for personalisation of controlled assessment.

If there are any queries about the use of this flexibility inherent in the specification to meet learners' needs, or about the use of reasonable adjustments, centres should contact WJEC.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Regulations and Guidance Relating to Candidates who are eligible for Adjustments in Examinations*. This document is available on the JCQ website (www.jcq.org.uk).

10. POST-RESULTS SERVICES

If a centre wishes to query the outcome of the moderation and/or examination process this must be done formally by the head of the centre, notifying WJEC within 21 days of the publication of results.

The sample of work submitted for moderation will be reviewed by a moderator/examiner not involved in the original process, and the centre informed of the outcome.

Should the centre not be satisfied with the outcome of the review, there is provision for an appeal to WJEC.

11. CLASSIFICATION CODES

Every specification is assigned a national classification code (discounting code) indicating the subject area to which it belongs. The classification code for this specification is QA3.

Centres should be advised that where learners take two qualifications with the same classification code, performance indicators for the centre will show that they have only achieved one of the two qualifications. The same view may be taken if learners take two specifications that have different classification codes but have significant overlap of content. The discounting system affects the calculation of performance measures for a school in the performance tables. It does not alter the awards an individual learner has achieved or limit the qualifications they can take.

Learners who have any doubts about their subject combinations should check with the institution to which they wish to progress before embarking on their programmes.

Information on performance points can be obtained from (www.education.gov.uk) and/or DAQW (www.daqw.org.uk).

12. THE WIDER CURRICULUM

Opportunities for use of technology

Candidates need to be both effective and confident users of technology in order to move on to a more advanced study of environmental science. This specification allows candidates to develop ICT skills in a wide range of different contexts.

There are numerous opportunities to use ICT throughout all units. Examples include:

- gathering data from sensors linked to data-loggers or directly to computers data logging e.g.; capturing pH and other environmental data;
- finding data on weather;
- analysing data – e.g. use of spreadsheets to present graphs and calculate lines of best fit;
- using presentation software e.g. to assist in giving a presentation to an audience;
- using word processing packages to present written reports;
- using blogging software to share information to a world-wide audience
- making videos or podcasts;
- designing leaflets to communicate information.

Spiritual, Moral, Ethical, Social and Cultural Issues

The specification provides a framework and includes specific content through which individual courses may address spiritual, moral, ethical, social and cultural issues. It aims to show how science can be used to assist in the monitoring and protection of the environment. Learners will be confronted with the need of balancing human activity against potential environmental consequences. These impacts may have a local or more global impact on the environment and people.

Examples of issues which can be addressed through the specification are listed below.

- The sustainable use of energy (unit 1).
- The impacts of human activity on biodiversity (unit 2).
- Consequences of contaminating waterways (unit 3).
- Impact of pollution on the environment and human health (unit 5).
- Consequences of climate change on food production (unit 6).
- Impacts of transport systems on local and global human populations (unit 7).
- The impacts of different forms of agricultural practice on the environment (unit 8).
- Impact of development on the local environment (unit 9).

Citizenship

The applications and implications of science dealt with in meaningful environmental contexts, encourage the development of a responsible attitude to citizenship. An understanding that individuals have a collective responsibility is fostered in relation to various ethical issues included in the specifications such as land use, sustainable energy use, food production, waste disposal. The consequences of human activity on the environment are also examined throughout the qualification in a number of different contexts.

Environmental Issues

The qualification deals with environmental science in meaningful contexts. The whole qualification therefore highlights how science is used in aid of observing, monitoring and protecting the environment. Each unit will outline the environmental context of the science that is to be delivered. Learners are also made aware of legislation that is in place governing activities that have a potential environmental impact.

Health and Safety Consideration

Under UK law, health and safety is the responsibility of the employer. There are a number of regulations (notably Management of Health and Safety at Work Regulations 1999 and COSHH Regulations 2002 (as amended)) that require the completion of a risk assessment before commencing a procedure or activity that uses microorganisms or chemicals.

There are opportunities for learners to develop their own risk assessments when carrying out laboratory and field work in almost all units. Throughout the qualification there are also many opportunities to underscore the requirement to work in compliance with risk assessments in order to safe guard the health and safety of workers and members of the public.

The European Dimension

Environmental issues can be rarely confined to a particular place since human actions in one country can also impact another. Challenges to the environment need to be dealt with at national, European and global levels. This specification should make learners aware that environmental scientist need to cooperate with scientist from other countries. In addition, since environmental issues cannot be restricted to national boundaries, politicians from national and European governments will often seek to implement a common policy towards issues that impact on the environment.

The context led nature of the units will give centres the opportunity of examining environmental issues at a European level. Examples where a European dimension can be underscored includes international protocols and European legislation relating to climate change, a comparison of agricultural policy in different European countries and the impact on biodiversity, cooperation and legislation on emissions from e.g. coal-fired power stations, pollution control etc.

Appendix 1 Unit structure

Unit title

The title summarises in a concise manner the content of the unit.

Guided learning hours

Guided learning time represents only those hours in which a tutor is present and contributing to the learning process. In some organisations this is known as 'contact time'. This time includes lectures, supervised practical periods and supervised study time.

Aim and purpose

The aim and purpose provides a brief and clear summary of the unit. It also indicates the applied purpose for the unit.

Unit Introduction

This is written to the learner and gives a summary of the unit content. It sets the vocational context of the unit and highlights the purpose of the learning in the unit.

Learning outcomes

Learning outcomes state what the learner should know, understand or be able to do as a result of completing the learning in the unit.

Assessment Criteria

The assessment criteria specify the standard a learner is expected to meet to demonstrate that the learning outcomes of that unit have been achieved.

Unit content

The indicative content defines the breadth and depth of learning for each assessment criteria. It is expected that all the indicative content will be delivered during the programme of learning. It is not required to assess every aspect of the content when assessing the unit. Learners will be expected to apply the knowledge, understanding and skills acquired through the learning to the specifics of the assessment context.

Performance Bands

These are used to determine the overall unit mark. Performance bands do **not** add additional requirements to the assessment criteria.

Assessment

WJEC Level 3 Applied Extended Diploma in Environmental Science is assessed through both controlled assessment and external assessment. This section of the unit summarises the form of assessment used.

Guidance for delivery

This gives the tutor some ideas on how to deliver the unit in a vocational setting consistent with the philosophy of the qualifications and intent of the unit. Three sample contexts are provided for each unit. The guidance also gives ideas of vocational settings for the unit and suggests possible contacts that could be made in the delivery of the learning. This section also includes details of how the unit supports the development of PLTS, Wider Key Skills and Essential Skills (Wales).

Resources

This identifies useful resources to help in the delivery of the learning. Many of the resources listed are suitable for using with learners.

Appendix 2 Grade Descriptors

Grade descriptors are used by WJEC to set grade boundaries for each unit. Grade descriptors give a general indication of the levels of attainment likely to be shown by a representative learner performing at each boundary. An Award meeting involving experienced examiners and teachers will be required to set the following grade boundaries for each unit. The following grade boundaries will be set at the Award meeting:

- Distinction/Merit;
- Merit/Pass;
- Pass/ungraded

Grade descriptors are interpreted in relation to the content outlined in the specification; they are not designed to define that content. Once grade boundaries have been set by WJEC learner marks are then converted to UMS marks.

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Knowledge and understanding of environmental science	<p>Demonstrate detailed knowledge and understanding of most principles, concepts and facts from the specification.</p> <p>Consistently selects and uses relevant information from the specification.</p> <p>Consistently organises and presents information clearly, logically and in suitable structure.</p> <p>Use appropriate scientific terminology and conventions from the specification.</p>	<p>Demonstrate detailed knowledge and understanding of most principles, concepts and facts from the specification.</p> <p>Select and use relevant information in most cases from the specification.</p> <p>Organise and present information clearly and logically.</p> <p>Uses mostly appropriate scientific terminology and conventions from the specification.</p>	<p>Demonstrate knowledge and understanding of some principles and facts from the specification.</p> <p>Select and use some relevant information from the specification.</p> <p>Present some information in a clear format.</p> <p>Use some appropriate terminology and conventions from the specification.</p>

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Application of skills, knowledge and understanding in appropriate environmental contexts	<p>Apply principles and concepts from the specification in familiar and new contexts involving several steps in the argument.</p> <p>Describe significant trends and patterns, with clear explanations, shown by complex data presented in tabular or graphical form.</p> <p>Interpret qualitative and quantitative data accurately; and present arguments and evaluations clearly.</p> <p>Evaluate critically the statements, conclusions or data.</p> <p>Carry out accurately complex calculations specified for environmental science.</p> <p>Translate successfully data presented as prose, diagrams, drawings, tables or graphs, from one form to another.</p> <p>Select a wide range of facts, principles and concepts from the specification.</p> <p>Link together appropriate facts principles and concepts from different areas of the specification.</p>	<p>Apply principles and concepts from the specification in familiar and new contexts involving a few steps in the argument.</p> <p>Describe most significant trends and patterns with some clear explanations, shown by complex data presented in tabular or graphical form.</p> <p>Interpret some qualitative and quantitative data without significant errors; and present arguments and evaluations clearly.</p> <p>Evaluate critically some statements, conclusions or data.</p> <p>Carry out accurately some complex calculations specified for environmental science.</p> <p>Translate most data presented as prose, diagrams, drawings, tables or graphs, from one form to another.</p> <p>Select a range of facts, principles and concepts from the specification.</p> <p>Link together some facts principles and concepts from different areas of the specification.</p>	<p>Apply given principles or concepts from the specification in familiar and new contexts involving a few steps in the argument.</p> <p>Describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form.</p> <p>Interpret some qualitative and quantitative data.</p> <p>Identify, when directed, inconsistencies in conclusions or data.</p> <p>Carry out some steps within calculations specified for environmental science.</p> <p>Translate data successfully from one form to another, in some contexts.</p> <p>Select some facts, principles and concepts from the specification.</p> <p>Put together some facts, principles and concepts from different areas of the specification.</p>

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Use of practical skills within environmental contexts	<p>Devise and plan suitable experimental and investigative activities, selecting appropriate techniques.</p> <p>Consistently demonstrates safe and skilful use of practical techniques to produce data within the expected range of tolerance for the technique.</p> <p>Make observations and measurements with appropriate precision and record these methodically.</p> <p>Interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.</p>	<p>Devise and plan mostly suitable experimental and investigative activities, selecting appropriate techniques.</p> <p>Demonstrates skilful and safe use of practical techniques to produce data mostly within the expected range of tolerance for the technique.</p> <p>Make observations and measurements with largely appropriate precision and record these methodically.</p> <p>Interpret, explain, evaluate and communicate most aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.</p>	<p>Devise and plan some aspects of experimental and investigative activities.</p> <p>Demonstrate safe use of practical techniques to produce some data within expected range of tolerance for the technique.</p> <p>Make observations and measurements and record them.</p> <p>Interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.</p>

Area	Distinction/Merit	Merit/Pass	Pass/Ungraded
Reporting environmental information	<p>Make a clear and accurate use of English (styles, spelling, punctuation and grammar) to communicate ideas and structure arguments.</p> <p>Produce logical and well-structured reports, showing a detailed scientific understanding of their work.</p> <p>Logically organise work in a coherent structure linking conclusions to supporting evidence with clarity.</p> <p>Clearly communicate with few minor errors in the use of technical terms, spelling, punctuation and grammar.</p>	<p>Make a mostly clear and accurate use of English (styles, spelling, punctuation and grammar) to communicate ideas and structure arguments.</p> <p>Produce mostly logical and well-structured reports, showing a mostly detailed scientific understanding of their work.</p> <p>Mostly logically organise work in a coherent structure linking conclusions to supporting evidence with clarity.</p> <p>Communicate with some clarity. There are no significant errors or omissions in the use of technical terms, spelling, punctuation and grammar.</p>	<p>Make some appropriate use of English (styles, spelling, punctuation and grammar) to communicate ideas and structure arguments.</p> <p>Produce a mostly clear report, showing some understanding of their work.</p> <p>Some organisation and structure with some valid evidence.</p> <p>Communicate some suitable information without significant errors.</p>

Appendix 3 Skills Mapping

PERSONAL, LEARNING AND THINKING SKILLS (PLTS)

PLTS	Unit								
	1	2	3	4	5	6	7	8	9
Independent enquirers	✓	✓	✓	✓	✓	✓	✓	✓	✓
Creative thinkers	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reflective thinkers	✓	✓	✓	✓	✓	✓	✓	✓	✓
Team workers	✓	✓	✓	✓	✓	✓	✓	✓	✓
Self-managers	✓	✓	✓	✓	✓	✓	✓	✓	✓
Effective participators	✓	✓	✓	✓	✓	✓	✓	✓	✓

KEY SKILLS AND ESSENTIAL SKILLS (WALES)

Application of Number

	Unit								
	1	2	3	4	5	6	7	8	9
Understand numerical data	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carry out calculations	✓	✓	✓	✓	✓	✓	✓	✓	✓
Interpret results and present findings	✓	✓	✓	✓	✓	✓	✓	✓	✓

Communication

	Unit								
	1	2	3	4	5	6	7	8	9
Speaking and listening	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reading	✓	✓	✓	✓	✓	✓	✓	✓	✓
Writing	✓	✓	✓	✓	✓	✓	✓	✓	✓

ICT

	Unit								
	1	2	3	4	5	6	7	8	9
Use ICT systems	✓	✓	✓	✓	✓	✓	✓	✓	✓
Find, select and exchange information, using ICT	✓	✓	✓	✓	✓	✓	✓	✓	✓
Develop and present information, using ICT	✓	✓	✓	✓	✓	✓	✓	✓	✓

Improving own learning and performance

	Unit								
	1	2	3	4	5	6	7	8	9
Set targets using information from appropriate people and plan how these will be met	✓	✓	✓	✓	✓	✓	✓	✓	✓
Take responsibility for your learning, using your plan to help meet targets and improve your performance	✓	✓	✓	✓	✓	✓	✓	✓	✓
Review progress and establish evidence of your achievements	✓	✓	✓	✓	✓	✓	✓	✓	✓

Problem solving

	Unit								
	1	2	3	4	5	6	7	8	9
Explore a problem and identify ways of tackling it	✓	✓	✓	✓	✓	✓	✓	✓	✓
Plan and implement at least one way of solving the problem	✓	✓	✓	✓	✓	✓	✓	✓	✓
Check if the problem has been solved and review your approach to problem solving	✓	✓	✓	✓	✓	✓	✓	✓	✓

Working with others

	Unit								
	1	2	3	4	5	6	7	8	9
Plan work with others	✓	✓	✓	✓	✓	✓	✓	✓	✓
Seek to develop co-operation and check progress towards your agreed objectives	✓	✓	✓	✓	✓	✓	✓	✓	✓
Review work with others and agree ways of improving collaborative work in the future	✓	✓	✓	✓	✓	✓	✓	✓	✓