Tea-Composition

Structured Depth Study:
Earth and Environmental Science

Notes for Teachers

Duration	15 hours of class time. Ideally, this will take place at regular intervals across Terms 1 and 2. A mandatory field trip will support students in sampling soils and considering topographic factors that affect the properties of soils.
Module sequencing	Due to the structure of the EES course, and the longitudinal aspect of the Depth Study, it is suggested that teachers sequence their teaching in the following pattern: Term 1 – complete Module 1 and commence Module 4 Term 2 – complete Module 4 and commence Module 2 Term 3 – complete Module 2 and Module 3
Nature of the Depth Study	A depth study is any type of investigation/activity that a student completes individually or collaboratively that allows the further development of one or more concepts found within or inspired by the syllabus. It may be one investigation/activity or a series of investigations/activities. Depth studies provide opportunities for students to pursue their interests in earth and environmental science, acquire a depth of understanding, and take responsibility for their own learning. Depth studies promote differentiation and engagement, and support all forms of assessment, including assessment for, and of learning. Depth studies allow for the demonstration of a range of Working Scientifically skills. (NESA EES Syllabus, 2017, p. 22). In this Depth Study, students are given the opportunity to conduct soil research with scientists from the University of Sydney. The Tea Bag Index project, an initiative supported by the University of Sydney, provides a simple, standardised method of practical engagement with soil science that contributes to our knowledge of litter stabilisation and the decomposition of different soils. The actual procedure is quite simple and involves students weighing then burying two particular tea bags, each containing a specific type of tea housed in a biodegradable cover. After a period of three months, the tea bags are exhumed, dried and their mass remeasured, to determine the rate of decomposition. Students should select a variety of areas in which to bury their tea bags, so that microbial activity under different environmental conditions and different soil types can be considered. Detailed information about the project can be obtained at http://www.teatime4science.org/ or http://www.tern.org.au/Newsletter-2016-Nov-TeaTime4Science-pg31717.html. This component of the Depth Study enables students to work directly with researchers on an authentic project, that directly relates to content and skills considered in Module 1 – Earth's Resources, and Module 4 – Human Impacts, of the Year 11 EES course, and provides students with an excellent opportunity to expand their knowledge of how scientists research, gather and process information in order to make evidence-based conclusions. Moreover, it provides an excellent foundation for students to further their understanding of soils and soil decomposition, should they choose to undertake a more detailed study in the Science Extension Course in Year 12.

Outcomes being assessed:
A student:

- EES11/12-1 develops and evaluates questions and hypotheses for scientific investigation
- EES11/12-2 designs and evaluates investigations in order to obtain primary and secondary data and information
- EES11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information
- EES11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
- EES11/12-5 analyses and evaluates primary and secondary sources of data
- EES11/12-6 solves scientific problems using primary and secondary data, critical thinking skills and scientific processes
- EES11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose
- EES11-8 describes the key features of the Earth's systems, including the geosphere, atmosphere, hydrosphere and biosphere and how they are interrelated
- EES11-11 describes human impact on the Earth in relation to hydrological processes, geological processes and biological changes

Suggested activity – should be repeated for each soil type or soil location	**Background notes for teachers**
Soil density	• Weigh a sample of soil (grams), then pour it into a measuring cylinder, tap it down lightly and measure the volume in cm^3. Density = mass/volume in g/cm^3
Soil texture	• Soil texture refers to how coarse or fine a soil is, that is, how much sand, silt and clay it contains. Students should examine soil samples under the binocular microscope and feel the texture between their fingers.
Organic material content	• Take a 100g sample of air-dried soil and place in an evaporating basin. Heat strongly for at least 30 minutes to burn off all of the humus and other organic matter. For more accurate results repeat heating and reweigh until constant mass is achieved, and total mass of organic material lost can be calculate by difference.
Moisture content	• Weigh a metal/foil food dish and then record weight (g). Take a heaped tablespoon of soil, spread it out in the foil dish and record the weight (dish + soil). Leave the soil out to dry in a sunny spot, under a hot lamp, on a hot plate or in a slow drying oven, until the soil is quite dry. • Reweigh the dry soil sample and calculate the percentage of water in the soil sample.
Water holding capacity	• Place 100g of air-dried soil into the top end of an inverted PET bottle, then place the bottle over a measuring jug or cylinder, as shown. Use cotton wool as a plug in the opening of the bottle. https://staff.concord.org/~btinker/GL/web/geology/english/water_holding_capacity_files/image002.jpg  • Pour 1 litre of water into the bottle and measure the amount of water percolating through the soil sample. The difference between this amount and the initial volume of 1 litre is the amount of water retained by the soil sample.

pH	• On a white tile place a small amount of a soil sample, about the size of a 50c piece. Add several drops of universal indicator until the soil is moist throughout. • Gently sprinkle some barium sulfate [$BaSO_4$] powder onto the soil. $BaSO_4$ will absorb some of the indicator and show its colour. • Refer to the pH colour chart provided and determine the pH of this soil sample and any others provided. • Alternatively, a commercial soil pH probe may be calibrated and used for each sample.
Calcium content	• Add excess 5M hydrochloric acid to a small quantity of each soil sample and use arbitrary units to describe the relative vigour of the reaction. Although technically this reaction is testing for the presence of carbonate ions, it is acceptable to assume that the calcium ions occur in the form of calcium carbonate. • Retain the soil samples for testing for the presence of iron.
Iron content	• Use a dropper pipette to remove the clear liquid found above the soil sample used in calcium content test. Place it in a clear test tube and add sufficient 6M ammonia solution to register a pH of 8 or greater, using universal indicator paper. Under these conditions, any iron present should settle out as a reddish-brown residue. • Compare the residue of various samples using an arbitrary scale.
Phosphate content	• Take about 100g of soil and place into a Buchner funnel. • Wash with about 100mL of hot, distilled water and allow to cool. • Add 1mL of acidified ammonium molybdate solution and warm gently in a water bath. • The presence of a yellowish precipitate suggests phosphate ions are present. • Compare the colour of the various samples using an arbitrary scale.
Presence of chloride ions	• Take a 100g sample of soil and add about 100mL of distilled water to it. • Allow the sample to settle then extract some of the liquid above the soil using a dropper pipette. • Add this sample to a test tube, then add 2-3mL of silver nitrate solution to it. • The presence of a white precipitate suggests chloride ions are in the soil sample. • Compare the degree of precipitate across the samples using an arbitrary scale.
Presence of microbial activity	• Students should inoculate sterile agar plates with samples of their soils, then seal and incubate for 3-5 days at 25°C to 30°C. It is important that students also prepare at least one control plate. • After incubation, students can count colonies using a mini-grid and take photographs of plate growth.

Materials required for soil tests

Test	Materials
Soil density	• Electronic mass balance • Measuring cylinder
Soil texture	• Binocular microscope
Organic material content	• Evaporating basin • Heat source • Electronic mass balance
Moisture content	• Metal/foil food dish • Electronic mass balance • Teaspoon • Heat source
Water holding capacity	• PET bottle • Measuring jug or cylinder • Cotton wool • 1L water
pH	• White tile • Universal indicator/commercial soil pH probe • Barium sulfate [$BaSO_4$] powder
Calcium content	• 5M hydrochloric acid
Iron content	• Dropper pipette • Test tube • 6M ammonia solution • Universal indicator paper
Phosphate content	• Buchner funnel • 100mL of hot distilled water • 1mL acidified ammonium molybdate solution • Water bath
Presence of chloride ions	• 100mL distilled water • Dropper pipette. • Test tube • Silver nitrate solution
Presence of microbial activity	• Sterile agar plates • Incubator • Mini-grid

Task

Task number: 1	**Weighting:** 40%	**Timing:** Start date: Term 1; completion date: Term 2

Outcomes assessed:

A student:

- EES11/12-1 develops and evaluates questions and hypotheses for scientific investigation
- EES11/12-2 designs and evaluates investigations in order to obtain primary and secondary data and information
- EES11/12-3 conducts investigations to collect valid and reliable primary and secondary data and information
- EES11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
- EES11/12-5 analyses and evaluates primary and secondary sources of data
- EES11/12-6 solves scientific problems using primary and secondary data, critical thinking skills and scientific processes
- EES11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose
- EES11-8 describes the key features of the Earth's systems, including the geosphere, atmosphere, hydrosphere and biosphere and how they are interrelated
- EES11-11 describes human impact on the Earth in relation to hydrological processes, geological processes and biological changes

Nature of the task:

- This task is a structured Depth Study in which students will carry out secondary source research and fieldwork, in order to obtain detailed information about the condition and sustainability of soil samples within an area. The Depth Study will form a part of a research project, developed by the University of Sydney, with students providing important raw data to support the project.
- Students will commence their structured Depth Study in Term 1, during their study of Module 1 – Earth's Resources. The formal completion of the Study will take place at the beginning of Term 2, when students will be studying Module 4 – Human Impacts. Modules 2 and 3 will then be studied at the end of Term 2 and throughout Term 3 of the Year 11 course.
- The major components of the task include:
  a) Research about soil structure and properties. Students should use this research as a basis for developing a testable question about soils.
  b) Fieldwork during which time soil samples will be collected. Specific decomposition tea bags supplied by the University of Sydney, will be buried at marked locations.
  c) Laboratory analysis of collected soil samples.
  d) Return to the field to exhume tea bags.
  e) Tea bags will be analysed in a joint project between students and the University of Sydney.
  f) Final report write up, and discussion of results, including those supplied by the University of Sydney.

Overview of the task:

This task contributes 40% of your Year 11 Earth and Environmental Science mark, and hence you should take some time to consider, plan and conduct your investigations.

- 15 hours of class time will be allocated to work on the task.
- The task is to be carried out in a group of two or three students. The final mark awarded for this Depth Study will be the same for all group members. It is therefore important that ALL members contribute constructively to the project.
- Your group should create a video report about either the fieldwork component, or laboratory investigations conducted on specific soil samples.
- The video report should be no longer than 10 minutes and should feature all student group members explaining and conducting specific aspects of the fieldwork or laboratory investigations. Material obtained from the analysis conducted by the University of Sydney should also be included.
- Data collected (including tables or graphs) and conclusions made must be included in the video.
- The laboratory investigations carried out must be conducted safely with a risk assessment carried out beforehand.
- Data collected (including tables or graphs) and conclusions made must be included in the video.

Description of the task:

a) Research:

EES11/12-1: A student develops and evaluates questions and hypotheses for scientific investigation.

- Explain the formation of soil in terms of the interaction of atmospheric, geologic, hydrologic and biotic processes (ACSES020)
- Investigate a range of computer interactives that demonstrate the formation of soil, eg Smithsonian Environmental Research Centre – Smithsonian Institute Dig It http://forces.si.edu/soils/
- Describe the interactions resulting in the formation of soils:
    - atmospheric
    - geologic
    - hydrologic
    - biotic
- Create an infographic or flowchart to summarise the factors affecting soil formation.
- As a result of your research, develop a testable question and hypothesis related to soils. Examples could include, but are not limited to, the effect of slope and shape of land; natural drainage and overflow conditions; microbial activity within soils; the effect of rainfall, temperature and fertilisers/composts; carbon storage within soils, and factors that affect the rate and degree of soil decomposition.

ENSURE THAT YOUR TEACHER REVIEWS YOUR DEPTH STUDY QUESTION/HYPOTHESIS BEFORE YOU COMMENCE

b) Designs an investigation:

EES11/12-2: A student designs and evaluates investigations in order to obtain primary and secondary data and information.

- Assess risks, consider ethical issues and select appropriate materials and technologies when designing and planning an investigation (ACSES031, ACSES097). You will need to develop a risk assessment for both your fieldwork activities and your laboratory investigations. You must

consider all the equipment needed in the field, together with chemicals and equipment needed for the laboratory investigations.

- You should consider investigating the following factors when in the field:
    - vegetation
    - elevation
    - aspect
    - temperature of soil in situ
    - distance from urban or agricultural development
    - mass of soil sample/decomposition tea bags buried
- You should consider carrying out the following tests on your soil samples:
    - density
    - soil texture
    - organic material content
    - moisture content
    - water holding capacity
    - pH
    - calcium content
    - iron content
    - phosphate content
    - presence of chloride ions
    - presence of microbial activity
- Justify and evaluate the use of variables and experimental controls to ensure that a valid procedure is developed, that allows for the reliable collection of data (ACSES002).

c) Conducting investigations:

EES 11/12-3: A student conducts investigations to collect valid and reliable primary and secondary data and information.

Note that the exact type of investigations you conduct will depend on your research question/hypothesis. The list below contains examples only. Check with your teacher if you are unsure.

MAKE SURE YOU RECORD APPROPRIATE VIDEO FOOTAGE AND IMAGES THAT MUST BE INCLUDED IN YOUR FINAL VIDEO REPORT PRESENTATION

- Conduct a practical investigation to examine soil types and component materials (ACSES020).
- Collect soil samples from an augured hole or trench, noting the exact location and topographical features.
- Construct a soil sedimentation column. Measure the proportions of:
    - organic material
    - sand
    - clay/silt
- Compare a range of soil profiles to note similarities and differences.
- Gather evidence to show that soil is a mixture not just sediment grains.
- Test and classify soils based on their composition of:
    - clay
    - silt
    - sand
    - moisture content
    - organic content
    - pH
    - calcium content

- iron content
- phosphate content
- presence of chloride ion
- presence of microbial activity

- Weigh then bury TWO of the tea bags provided – one with a fast rate of decomposition and one with a slower rate of decomposition – in close proximity to each other. Make sure that you mark the location clearly and that you have selected at least TWO areas with different climatic and topographical features. You will need to revisit and exhume these after 3 months, however; you are strongly encouraged to check regularly that the bag area has not been disturbed or in any way compromised.

d) Processing data and information:

EES11/12-4: A student selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media.

- You will need to present your data using a range of tables and appropriate graphs or graphical organisers. You should also ensure that you take images of your results, especially those that compare soils from different areas. This material must be included in your video report presentation. If you are considering microbial activity, you should discard the agar plates appropriately, after 2 weeks of incubation, taking readings and images of numbers and types of colonies.
- You should ensure that you include data and information from the Tea Bag Index project. It is your responsibility to regularly liaise with University of Sydney staff and obtain results and information from them.

e) Analysing data and information:

EES11/12-5: A student analyses and evaluates primary and secondary data and information.

- You should derive trends, patterns and relationships in data and information. Compare your results and findings with those from your previous research and consider any anomalies or inconsistencies in the data.
- You should also assess any errors, uncertainties or limitations in the data (ACSES004, ACSES005, ACSES0033, ACSES099).
- Assess the relevance, accuracy, validity and reliability of your research, and that taken from secondary sources, and suggest possible improvements to your experimental investigation (ACSES005).

f) Problem solving:

EES11/12-6: A student solves scientific problems using primary and secondary data, critical thinking skills and scientific processes.

- Depending on your specific question or hypothesis, you may be able to use a mathematical model to describe your results and predict future phenomena. This could be highly likely if you have worked with the Tea-Composition project and you should discuss the statistical analyses, and their significance, with the team from the University.

g) Communicating:

EES11/12-7: A student communicates scientific understanding using suitable language and terminology for a specific audience or purpose.

- The marking criteria indicate the specific aspects you should include in your video report

presentation. It is important that in your report you consider the following:

- the selection and use of appropriate scientific notations, nomenclature and scientific language (ACSES008, ACSES036, ACSES067, ACSES102).
- the construction of a suitable set of evidence-based arguments, which you suggest to your peers should be reviewed by them and evaluated as needed (ACSES034, ACSES036).

- Your video report presentation will be uploaded to the school's intranet and possibly website and provided to the University of Sydney as appropriate.

Marking criteria:

Knowledge and Understanding – 5 marks (EES11-8; EES11-11)

- Describes the main features of the geosphere, atmosphere, hydrosphere and biosphere.
- Analyses the relationships between each of these spheres, with respect to soils and their properties.
- Describes how the impact of humans has affected geological processes and biological changes.

Planning and Conducting Investigations – 12 marks (EES11/12-1, EES11/12-2, EES11/12-3)

- Develops a suitable and relevant hypothesis for scientific investigation.
- Designs an investigation/series of experiments that provides valid and reliable data.

Processing and Analysing Data and Information – 13 marks (EES11/12-4, EES11/12-5)

- Correctly represents data and carries out appropriate calculations and processing of information.
- Evaluates the results of the investigation to make an appropriate conclusion.
- Assesses the accuracy, validity and reliability of primary data gathered.

Communication and Problem Solving – 10 marks (EES11/12-6, EES11/12-7)

- Uses modelling, where appropriate, to explain phenomena, make predictions and solve problems.
- Communicates scientific understanding using suitable language and terminology.
- The video presentation communicates ideas and concepts clearly.

Feedback provided:

- Written feedback on the task will be via comments on the marking guidelines.

Marking Guidelines

Knowledge and Understanding 5 marks *(EES11-8; EES11-11)*

Criteria	Marks
• EES11-8: A student describes the key features of the Earth's systems, including the geosphere, atmosphere, hydrosphere and biosphere and how they are interrelated • EES11-11: A student describes human impact on the Earth in relation to hydrological processes, geological processes and biological changes	
A student:	
• Describes the main features of the geosphere, atmosphere, hydrosphere and biosphere. • Analyses the relationships between each of these spheres, with respect to soils and their properties. • Describes how the impact of humans has affected geological processes and biological changes.	4-5
• Identifies the main features of the geosphere, atmosphere, hydrosphere and biosphere. • Describes the relationships between each of these spheres, with respect to soils and their properties. • Identifies how the impact of humans has affected geological processes and biological changes.	2-3
• Provides some relevant information about the geosphere, atmosphere, hydrosphere or biosphere OR • Identifies ways in which humans have impacted processes on the Earth.	1

Planning and Conducting Investigations 12 marks (EES11/12-1, EES11/12-2, EES11/12-3)

Criteria	Marks
EES11/12-1: A student develops and evaluates questions and hypotheses for scientific investigation	
A student:	
● Demonstrates a correct understanding of observations, research and experimentation required to construct an informed hypothesis. ● Develops a suitable and relevant testable question or hypothesis for scientific investigation. ● Identifies appropriate issues to investigate.	3-4
● Demonstrates some understanding of observations, research and experimentation required to construct an informed hypothesis. ● Develops a suitable and relevant question for scientific investigation. ● Identifies appropriate issues to investigate.	2
● States some aspect relevant to a hypothesis or scientific question OR ● Identifies an appropriate issue to investigate.	1
EES11/12-2: A student designs and evaluates investigations in order to obtain primary and secondary data and information	
A student:	
● Conducts appropriate secondary research to support an investigation. ● Correctly designs an appropriate experiment with proper experimental procedures, including the specific points: o control of variables o repetition o measurement and observation. ● Evaluates the results of an investigation to make an appropriate conclusion.	3-4
● Conducts some research on a given topic. ● Correctly describes an appropriate experiment including ONE of the specific points. ● Evaluates the results of an investigation to make a conclusion.	2
● Conducts limited research on a given topic OR ● Provides a partial description of an appropriate experiment.	1

Criteria	Marks
EES11/12-3: A student conducts investigations to collect valid and reliable primary and secondary data and information	
A student:	
● Conducts a valid investigation showing proper care and precision in collection of data and measurements. ● Conducts an appropriate amount of repetition of experiment.	3-4
● Conducts an investigation allowing collection of some data and measurements. ● Conducts some repetition during investigation.	2
● Conducts an investigation with some aspect of validity or repetition considered.	1

Processing and Analysing Data 13 marks (EES11/12-4, EES11/12-5)

Criteria	Marks
EES11/12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media	
A student:	
● Selects appropriate qualitative and quantitative data and information, representing it using a range of formats including digital technologies and graphic organisers. ● Applies correct quantitative processes and calculations. ● Makes an evaluation about the quality of the data collected.	6-7
● Uses qualitative and quantitative data and information, representing it using at least one type of format including digital technologies and graphic organisers. ● Attempts some quantitative processes, or processes with errors.	4-5
● Uses some qualitative and/or quantitative data and information, possibly incorrectly, representing them using one type of format including digital technologies and graphic organisers.	2-3
● Represents data and information using a type of format OR ● Attempts some quantitative analysis.	1
EES11/12-5 analyses and evaluates primary and secondary sources of data	
A student:	
● Correctly derives trends, patterns and relationships in data and information. ● Assesses error, uncertainty and limitations in data. ● Assesses the relevance, accuracy, validity and reliability of primary and secondary data. ● Suggests improvements to investigations; or further investigation possibilities.	5-6
● Derives trends, patterns and relationships in data and information. ● Describes the relevance, accuracy, validity and reliability of primary and secondary data. ● Suggests improvements to investigations; or further investigation possibilities.	3-4
● Describes trends, patterns and relationships in data and information. ● Suggests improvements to investigations; or further investigation possibilities.	2
● Identifies trends, patterns and relationships in data and information OR ● Suggests improvements to investigations; or further investigation possibilities.	1

Communication and Problem Solving 10 marks (EES11/12-6, EES11/12-7)

Criteria	Marks
EES11/12-6 solves scientific problems using primary and secondary data, critical thinking skills and scientific processes	
A student:	
• Presents tables with appropriate formatting, headings, units and uncertainty. • Presents graphs with appropriate axes, labels, scale, units, correctly plotted data points, and appropriate lines/curves of best fit. • Presents diagrams that are correctly drawn, and labelled with appropriate scale.	4-5
• Presents tables that have headings and units. • Presents graphs that have axes, labels, scale, units, plotted data points, and lines/ curves of best fit, but with some errors and/or inaccuracies. • Presents diagrams that are correctly drawn, possibly not showing correct scale.	2-3
• Provides some correct representation of information, but with several errors and/or inconsistencies.	1
EES11/12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose	
A student:	
• Shows a comprehensive understanding of a variety of soil properties and factors that affect soil health and sustainability. • Communicates ideas in an organised manner using appropriate terminology. • Video presentation is engaging and accurately reflects the investigation undertaken. • Links between concepts are clearly, and extensively, demonstrated.	4-5
• Shows some understanding of soil properties and factors affecting soil health. • Video presentation describes the investigation undertaken. • Provides some links between ideas.	2-3
• Shows some understanding of factors that affect soil health OR • Video presentation limited and contains incomplete and/or incorrect information and processes.	1