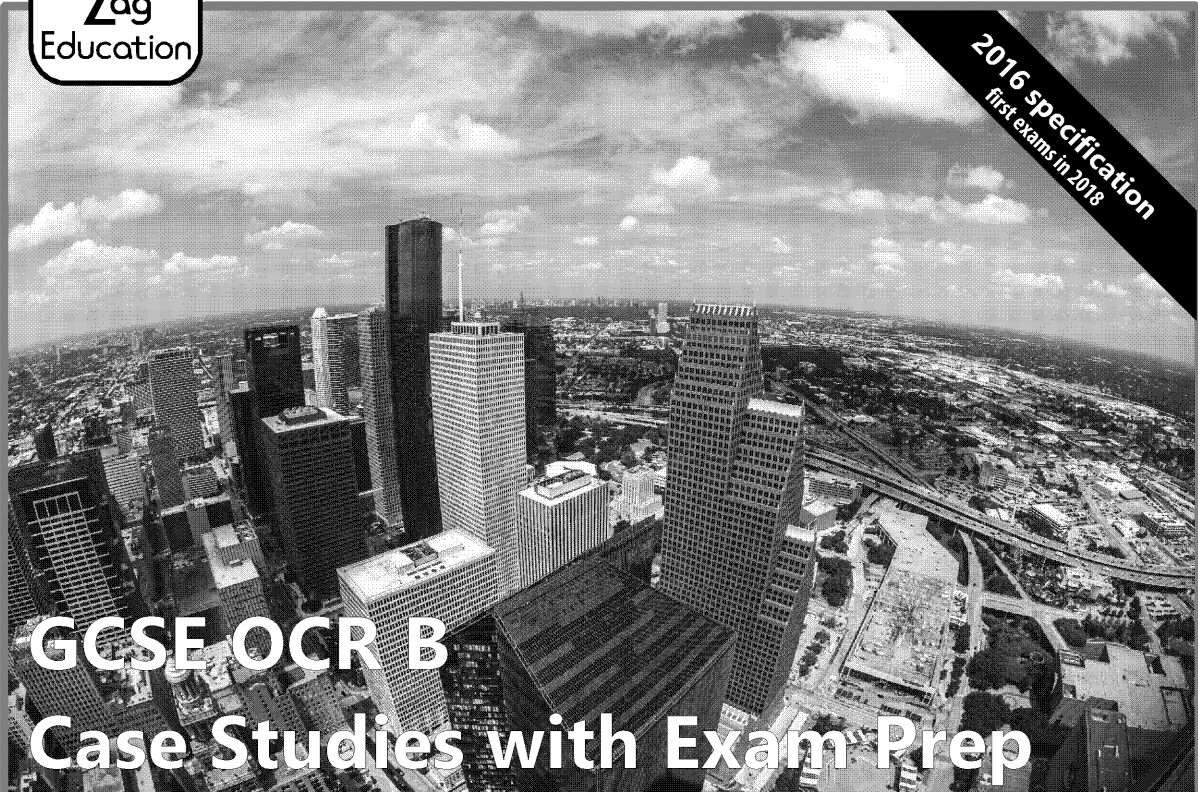Zig Zag Education

2016 specification
first exams in 2018

GCSE OCR B
Case Studies with Exam Prep

Global Hazards: Weather

Texas and Oklahoma Floods (2015)

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Contents

Teacher's Introduction

This resource has been developed to provide case studies and exam preparation material to support the GCSE OCR B specification (J384) **Topic 1: Global Hazards: Weather.**

This detailed case study is on **The Texas and Oklahoma Floods, USA (2015)** representing a non-UK **flash flooding event**.

The case study includes a main content section which can be used as part of a lesson plan or distributed to students for self-guided research; a selection of ICT interactive links to further students' research around each topic and a set of Springboard Images and discussion questions (also available as a PPT file accessible by digital download) which makes a fantastic starter activity.

*A webpage containing all the links listed in this resource is conveniently provided on ZigZag Education's website at **zzed.uk/8842***

You may find this helpful for accessing the websites rather than typing in each URL.

The exam preparation section which follows the case study contains a summary table, bringing together all of the key facts and figures relating to the case study; rapid-fire revision questions (with answers) to help recall and retention of the main points; and an exam-style question and mark scheme, written in the style of the OCR B sample material, so that students can practice answering questions relating to case studies and applying relevant knowledge in their answers.

The resource may be used as a source of reference for the required case studies for individual study, or for group work leading to discussion or debate. Subheadings in the information sections are designed to enable tabulated comparisons of social, economic and environmental impacts.

Other detailed case studies are available for this topic area representing contrasting natural weather hazard events arising from extreme weather conditions (tropical storms, flash flooding, heatwaves, and drought) in the UK and globally:

- Hurricane Sandy, USA (2012)
- Tropical Storm Chedza, Madagascar (2015)
- Flooding, Morpeth, UK (2008)
- Heat wave, UK (2015)
- Heat wave, Pakistan (2015)
- Drought, UK, (2004–2006)
- Drought, Brazil (2014–2016)
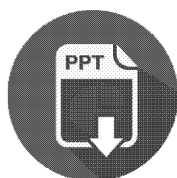
A PowerPoint presentation containing the Springboard Images starter activity to accompany this resource is available as a free digital download. Just register for free updates using the link below to download all available content for your school or purchasing site.

November 2018

Free Updates!

Register your email address to receive any future free updates* made to this resource or other Geography resources your school has purchased, and details of any promotions for your subject.

* resulting from minor specification changes, suggestions from teachers and peer reviews, or occasional errors reported by customers

Go to **zzed.uk/freeupdates**

Part 1: Case Study

Acronyms and Useful Terms

Antecedent
Electrical Storm
Flash Flood
Low Pressure
Overland F
River Flo
Tornado
Watershed

Content

Causes and Prior Weather Conditions

Both river and flash floods spread through the states of Texas and Oklahon
throughout the three-day period. Surrounding states also experienced high
normal rainfall in some areas – which meant that water flowed overland in
place during the Memorial Day weekend.

Flooding was caused by a slow-moving storm   er   id low was high bec
– the preceding weather had been we   lt   in saturated soil and alrea

The storms were caus   t   vel, very moist, south-easterly air brough
This moist   se   y (a low-pressure
weather sy   which caused
atmospheric instability. At height (called
'aloft') the air combined with cold air and
diverged, spreading out over a large area.
As the warm, moist air ascended, it cooled,
and the moisture condensed to form
clouds and rainfall. This is why the
flooding affected such a wide area, and
slow-moving downpours affected the
same areas over again, and were, in effect,
mini tropical revolving storms. The storm
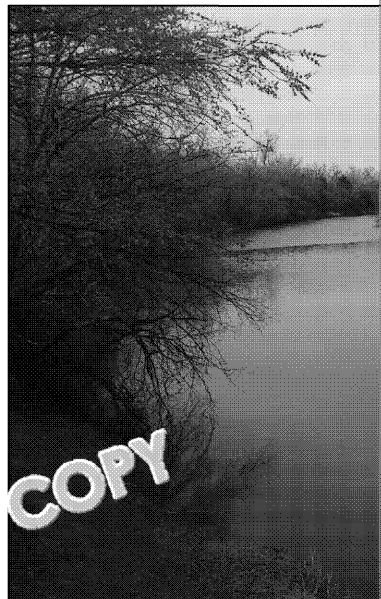produced electrical activity, as well as
tornados.

* 75 tornados formed
* Both riv   nc   oding
  occurr

*Figure 1: The Blanco River and N
tributary of*

* Northe   exas saw 510 mm rainfall.
  Overnight between 25 and 26 May, Houston saw 280 mm and 300 mm
  Watershed.
* Water levels in rivers rose rapidly – the Blanco River rose 5 feet (1.5 m
  between 10.45pm and 11.45pm on 25th May. This meant that residents

next morning to flooding. The river reached the highest level on record high being in 1929 at 8.9 metres.

- On 26th May, the Wichita River was predicted to reach a height of 7.8 m
- Sewer systems were overloaded, and released sewage into the floodwa

Social Impact

Overall, the death toll and housing damage include

- 31 deaths from flooding (Texas: 27, Oklahoma: 4)
- 16 deaths from tornados (Texas: 1, Oklahoma: 1, Mexico: 14)
- One death was caused by a traffic accident from driving in the poor weather conditions
- 11 people were reported missing
- Thousands of houses were damaged, including entire 'blocks'
- Internal damage was caused to house interiors and contents from water damage, and a thin film of silt was deposited inside houses

The impacts are now divided into the states of Texas and Oklahoma.

Texas:

- 4,000 houses damaged in Houston, and up to 400 in Wimberley. Mobile homes also damaged
- 390 houses flooded at Wichita Falls
- 100,000 customers lost electric
- 2,500 cars were abandoned in Houston, as motorists and passengers sought high ground. Some motorists, who w sleep in their cars.

Figure 2: The

Oklahoma:

- Flash floods occurred on 23rd May.
- 30 people were displaced in Elk City.
- Thousands of people were without electricity in Oklahoma and Del cities.
- Transport was difficult because some roads were 9 inches (almost 23 cm) under water; 15 'highways' were closed.
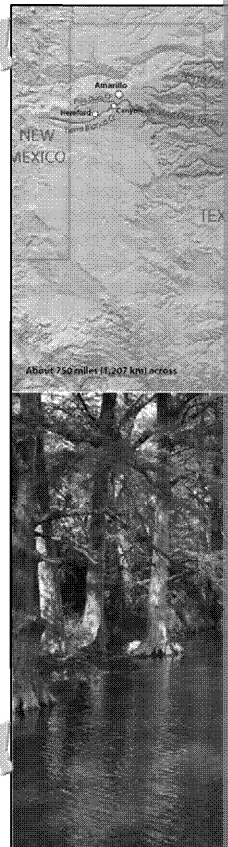- Mobile homes were damaged destroyed.
- A music festival was cancelled.

Figure 3: Floode

Economic Impact

In early June it was announced that May had been the wettest month on record in both Texas and Oklahoma. The extreme weather was predicted to cause $3 billion of economic damage, and that at least a further $1 billion would be paid out by the insurance industry. The Governor of Texas said that the flood damage was the 'worst ever'. In Houston, some areas of the city were completely shut down.
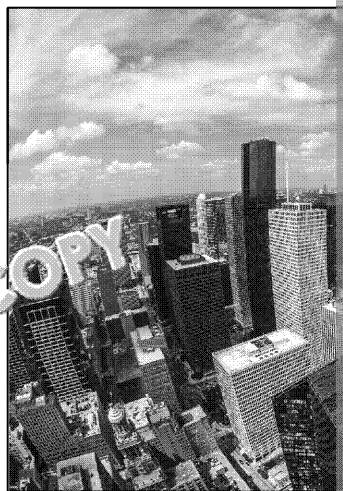

Figure 4: Houston

Damage to property, infrastructure and utilities needed to be repaired, and commercial buildings were also damaged, resulting in a loss of trade. It is also worth n insurance industry were likely to be lower than they could have been, beca out a policy!

Specific examples of the storm damage are listed below:
- Interstate 35 was just one of the roads closed by the storms – the Blanc debris, including whole trees. Transport was affected in 162 of Texas' 2 also destroyed.
- The Dallas/Fort Worth International Airport was temporarily closed fo opened up by the runway.
- Agricultural equipment, barns and crops were damaged by the ext
- Schools and churches were damaged.
- Shops and shopping malls were damaged.
- Other commercial buildings damaged included a flower nursery and p
- Cars and buses were damaged.
- Power lines were damaged.
- Mobile phone masts were damaged.

Environmental Impact
- Trees were damaged and downed by the flooding and tornados.
- When the floodwater receded, the areas flooded were covered in silt, d

Management to Reduce Risk
- The National Weather Service issued **flood warnings** for both river flo
- The warnings were later upgraded to **emergency flood warnings**.
- Social media (such as Twitter) was used by the National Weather Servi emergency planners. Posts included infographic showing the most li safety advice was also provided.
- In Austin and San Antonio, a Flood Watch was set up.
- States of emergency were declared in Texas – in 37 (of 254) counties, an
- President Obama stepped in, promising funds to be available for Texas declaration was signed for Oklahoma.
- In Houston, over 500 residents were rescued by firefighters.
- One firefighter drowned during the rescues.
- On 24th May, 2,177 households voluntarily evacuated near the Wichita forced to evacuate.
- 1,000 people evacuated in Central Texas.

Evidence for More Extreme Weather

Since pre-industrial times, the number of land-based extreme precipitation
human-increased warming – by around 18%. El Niño has also has an effect
(internal variation), but estimates suggest that this phenomenon could be i
result of climate change.

It has also been suggested that eastern Texas has wi essed a 10% increase
years, at the expense of western Texas ic as experienced long and s

Maximum increase in rainfall:	300% (in some are
Number of tornados:	75
Rainfall in northern Texas:	510 mm
Height of River Blanco:	12 m
Height of Wichita River:	8.9 m
Number of deaths from flooding:	31
Number of deaths from tornados:	16
Number of people reported missing:	11
Number of houses damaged in Houston:	1,000
Number of houses flooded in Wichita Falls	390
Number of Texan customers wit electricity:	100,000
Number of cars ab ec in Houston:	2,500
Inches of covered roads in Oklahoma:	9
Estimated economic damage:	$3 billion
Estimated cost to the insurance industry:	>$1 billion
States of emergency declared in which counties:	37 Texan counties, counties

ICT Interactive Page

Videos and photos

Texas weather for May 2015:
- https://weather.com/forecast/regional/news/plains-rain-flood-threat-

Photographs of the flood:
- https://www.theguardian.com/us-news/gallery/2015/may/26/flash-flo
  pictur

Footage of the flood:
- https://www.youtube.com/watch?v=h2UJwlc8obk
- https://www.youtube.com/watch?v=K8uIAjU3vIw

News Stories

BBC:
- http://www.bbc.co.uk/news/world-us-canada-32867226
- http://www.bbc.co.uk/news/world-us-canada-32888733

Rebuilding after the flood:
- https://www.theguardian.com/us-news/2015/.../3.../texas-floods-dan

The flood events:
- https://weather.com/.../severe/news/flood-fatigue-2015-2016-texa
- https://www.theguardian.com/world/2015/may/25/texas-oklahoma-st

$3 billion in damages:
- http://www.chron.com/news/houston-texas/texas/article/texas-flood-
  el-ni-o-6594008.php

24-hr Precipitation (in.) Ending at 7:00 A.M. E.S.T.

May 24

24-hr Precipitati

Monthly Precipitation for Dallas/Fort Worth,
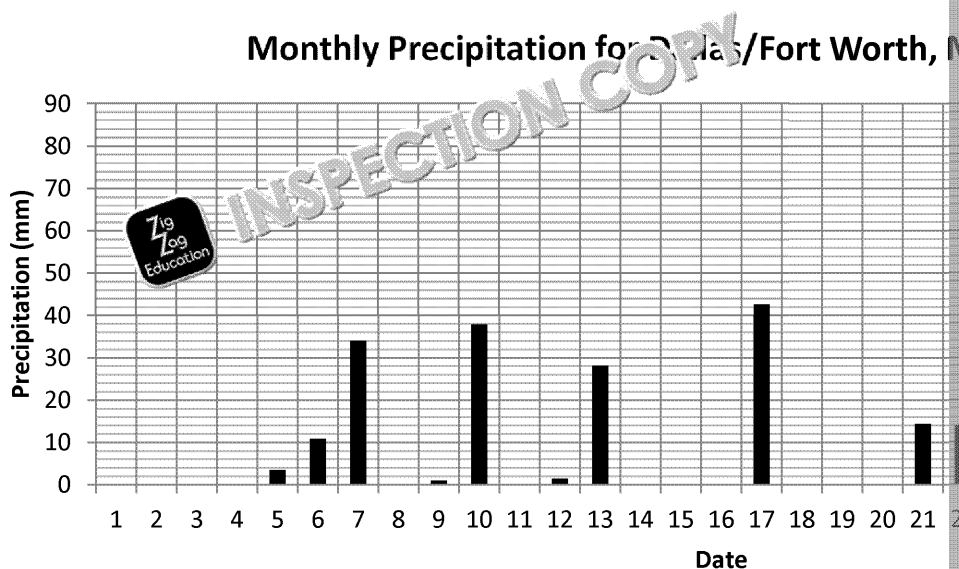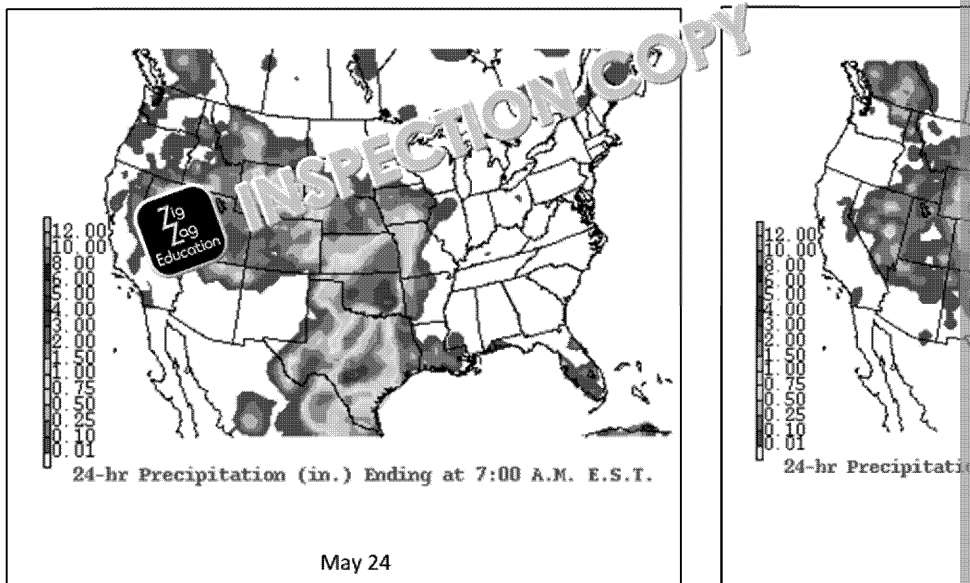

1. Describe the distribution of rainfall over 24–25 May shown on the map
2. Using the rainfall graph, describe the prior conditions.
3. Using the weather chart and graph, explain why flash flooding occurred

1. Suggest how the city could have been affected by the storms.
2. Why do you think that the economic cost of the storm was so large at a further billion expected to be paid out by insurance companies?
3. How could warnings about the storm be issued?

Springboard 1

1	• On 24 May, the major rainfall fell in ___ ___ Texas and eastern Ok___ purple and blue shading, re___ ___ rainfall between 4 and 8 i___ periods. Intensity dr___ ___ radiates away in bands of lower i___ affected. • ___ M___ the most rainfall fell over south-eastern Oklahoma – ___ ___ the whole of Oklahoma received some rainfall, only east___ the most received was less than 1.5 inches. Northern Mexico rem___ small showers.
2	• In the three weeks leading up to the 23–25 May event, four days ___ rainfall – 7th, 10th, 13th and 17th, receiving between 28 and 43 mm___ before the 23rd received just less than 15 mm each.
3	• Rainfall on 24 May across central Texas and Oklahoma was inten___ 20 cm. This is likely to have caused overland flow because the w___ soil quickly. • The preceding precipitation events would have increased the so___ increased river flow.

Springboard 2

1	• Flooding and s___ ___ age to buildings and infrastructure, suc___ n___ ___ rk___ ___ mmunications services. Homes were also floode___ ___ ___ Houston). Cars and other property were damaged; 2,500___ r___ ___ s.
2	• The United States is a developed country – therefore, there is a s___ infrastructure that could be damaged. • The flooding and disruption covered a huge area too. • River levels were incredibly high – meaning that large areas wer___ • Thousands of properties and commercial ventures were damage___
3	• News and TV, other media such as radio and newspapers. • Social media. • Door-to-door warnings / enforce evacuation.

Summary

Texas and Oklahoma Flash Floods

Question	
Which states and counties were affected by the flooding?	USA – Texas and Oklahoma Mexico
What percentage of normal rainfall fell in some areas?	300%
What was the weather like prior to the storms?	Wet – rainfall in early May and soils were saturated.
Where did the warm, moist air originate?	The Gulf of Mexico
Why was the weather system a low-pressure weather system?	The warm air rose aloft
Other than the rainfall, what were the other weather events?	Lightning and tornados
How much rain fell in northern Texas?	510 mm
Between 10.45pm and 11.45pm, how fast did the Blanco River rise?	5 feet every 15 minutes – 5
How many deaths were caused by the flooding?	31
Where did most of those deaths occur?	Texas
Where did tornadoes cause the most fatalities?	Mexico
How many people were reported missing?	11
What was left behind when the floodwater inside houses dropped?	A thin film of silt
How many homes were damaged in Houston?	4,000
How many customers lost electrical power?	100,000
Why were 2,500 cars abandoned in Houston?	Their drivers and passengers
What was the level of water that flooded some roads in Oklahoma?	9 inches (approximately 23
What was the estimated economic cost of the flooding and tornados?	$3 billion
How much did the extreme weather affect the insurance industry?	At least $1 billion
Who said that the flooding in Texas was the 'worst ever'?	The Governor of Texas
Why was the Dallas/Fort Worth International Airport closed for several hours?	A sinkhole opened up near t
How was agriculture damaged?	Crops were damaged. Equip damaged.
How was infrastructure damaged?	Roads, power distribution a damaged by the flood.
What type of warnings were issued?	Flood warnings, followed by
Who used social media to inform the public and planners?	The National Weather Serv
How many people were rescued in Houston?	Over 500
In how many counties was a state of emergency declared?	37 in Texas, and all 77 in O
How many households were evacuated from near the Wichita River?	2,177 voluntary, 400 enforce

1	Describe the conditions which led to the flooding in late May	
2	Where was the source of the moisture that caused the flooding?	
3	Why was the flooding so severe?	
4	'The death toll varies by country and cause' – what do you think is meant by this statement?	
5	Suggest the social effects caused by the damage to property.	
6	Why were cars abandoned on roads?	
7	Suggest the estimated damage of $3 billion is a surprising figure.	

8	Why was transport affected?	
9	Why was the government involved?	
10	How did the National Weather Service assist?	
11	To what extent do you think that the evacuations and rescues were successful?	
12	Why do you think that some people may argue that the flooding was in part enhanced by climate change?	

1	Des___e p___ conditions which led to the flooding in late May___	The weeks preceding that the soil was alre quickly flowed acros more water.
2	Where was the source of the moisture that caused the flooding?	The moisture came f Mexico. As the air a
3	Why was the flooding so severe?	The weather system for a very long time. divergence. The wea Oklahoma, as well a
4	'Th___ to ___ed by country and cause' – what do you think is m___ that statement?	The majority of fata Mexico). However, N tornados. In the Uni only two from the to
5	Suggest the social effects caused by the damage to property.	Inconvenience and s and cleaned, and rej been damaged for so
6	Why were cars abandoned ___ ?	Drivers escaped to h come to a standstill.

| 7	Suggest whether the estimated damage of $3 billion is a surprising figure.	*No – the United States is a developed country and, therefore, has a lot of infrastructure. The flooding w... Texas and Oklahoma.*
8	Why was transport affected?	*Many roads were flooded or d... When the water receded, silt a... Furthermore, air transport wa... Dallas/Fort Worth Internation...*
9	Why was the g...nn... ...ved?	*To provide funding for the reb...*
10	How did the National Weather Service assist?	*By providing emergency flood... emergency planners.*
11	To what extent do you think that the evacuations and rescues were successful?	*While thousands of people wer... were also 31 flooding-related d... need to decide, trading off the...*
12	Why do you think that some people ma... ...u... ...the flooding was in part enhanced by climate ... nge...	*Warmer ocean temperature co... however, changes could be due... existing weather patterns. Oth... yet being seen.*

1. Suggest why the flooding was a surprise to some residents.

2. 'The flooding between 23–26 May w~~~ in ~~~~~.' Suggest why this s~~ correct.

3. Evalua~~~~ ~~~~~ can determine that the flooding has been caused chang~~~

Figure 1: Weather maps showing daily rainfall. Note that Texas received further rainfall on 26 May.
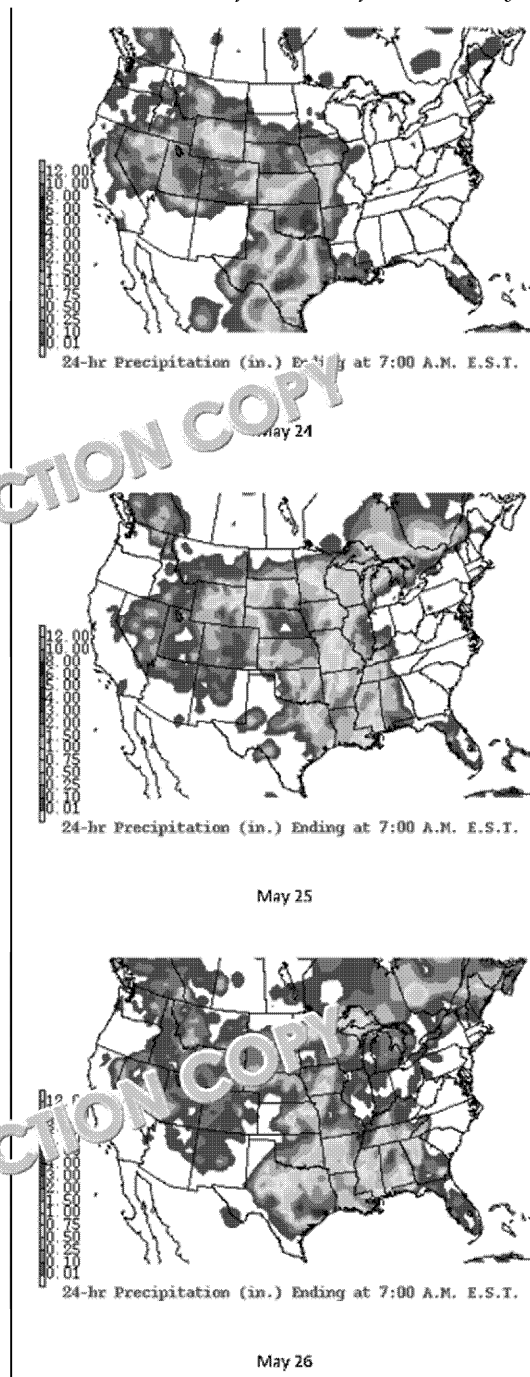
1. While warning was given and maps were provided by the National Weather ⬚ quickly – for example, 5 feet in 15 minutes. Therefore ⬚ ⬚ ⬚ le people were sur⬚ when they woke up the next morning.

2. This statement relates to the ⬚ ⬚ ⬚ ⬚ conditions – the wet start of the mon⬚ already saturated an⬚ ⬚ ⬚ ⬚ ⬚ full. This decreased the soil's capacity to a⬚ overlan⬚ ⬚ ⬚ ⬚ ⬚ component of flow. Rainfall was also very heavy a⬚ of wat⬚ ⬚ ⬚ ⬚ that water would not be able to quickly infiltrate the surface. ⬚ full als⬚ ⬚ ⬚ eased the risk of flooding, because there was less room in the ch⬚ Therefore, given the severity of the event, and the underlying conditions, it ⬚ major flooding.

3. While some people may argue that the effects of climate change are unlikely ⬚ that in the future, weather patterns may shift, and extreme events are likely ⬚ addition, some models have indicated an 18% increase in extreme precipitat⬚ times. Furthermore, over the past century, rainfall patterns do appear to hav⬚ seen in eastern Texas, with drier periods in the west.

Question 1

Case study – extreme weather event in a UK and non-UK location

Explain how the consequences of extreme weather events differ in two contrasting countries.

Level Marking

Level	Mark	Description
1	1-2	• The student evidences basic knowledge • The student evidences limited understan exist between places, environments and • The ideas expresse by the student are • A named ex~ ~' ~ provided but place
2	3-4	• The ~tu~er~ ~vidences some knowledge • T~ ~.udent evidences good understand ~between places, environments and proc • The ideas expressed by the student are • A named example is provided with som

3	5-6	• The student evidences thorough knowle
		  (AO1)
		• The student evidences a firm understan
		  exist between places, environments and
		• Ideas expressed by the student are in-d
		• A named example and place-specific de

Suggested Content

Name of UK extreme weather event: Heatwave, 1ˢᵗ July 2015
Name of non-UK extreme weather event: Texas and Oklahoma Floods, 20

- As the two weather events are different and in contrasting countries, th events are also different. The table below demonstrates the difference and environmental consequences.

	Texas and Oklahoma floods	
Social Consequences	• 31 deaths ~o ~h ~ ~ing, 16 deaths fr~ ~ ~.~s. • ~ ~ople were reported missing. • Thousands of houses were damaged, including houses contents by floodwater. • 10,000 customers were without electricity. • Severe disruption to transport.	• There were unli associated with were a variety o poor air quality, • The issues caus not as severe as transport was af issues (rather th surfaces meltin buckled tracks. transport servic Underground) w
Economic Consequences	• The extreme weather was predicted to cause $3 billion of economic damage, and that at least a further $1 billion would be paid out by the insurance industry. • Damage to property, infrastructure and utilities needed to be repaired, and commercial buildings were al~ damaged, resulting in a lo~ ~ ~ e. • Agricultural equip~~ ~t va damaged.	• The heatwave w minimised disru • There may have spending.
Environm~~ Conseq~	• Tre~ ~ ~aged and downed ~y ~ ~ooding and tornados. • ~when the floodwater receded, the areas flooded were covered in silt, debris and branches.	• There were unli to the short dur • It was thought t at Thetford For 30 acres of fore