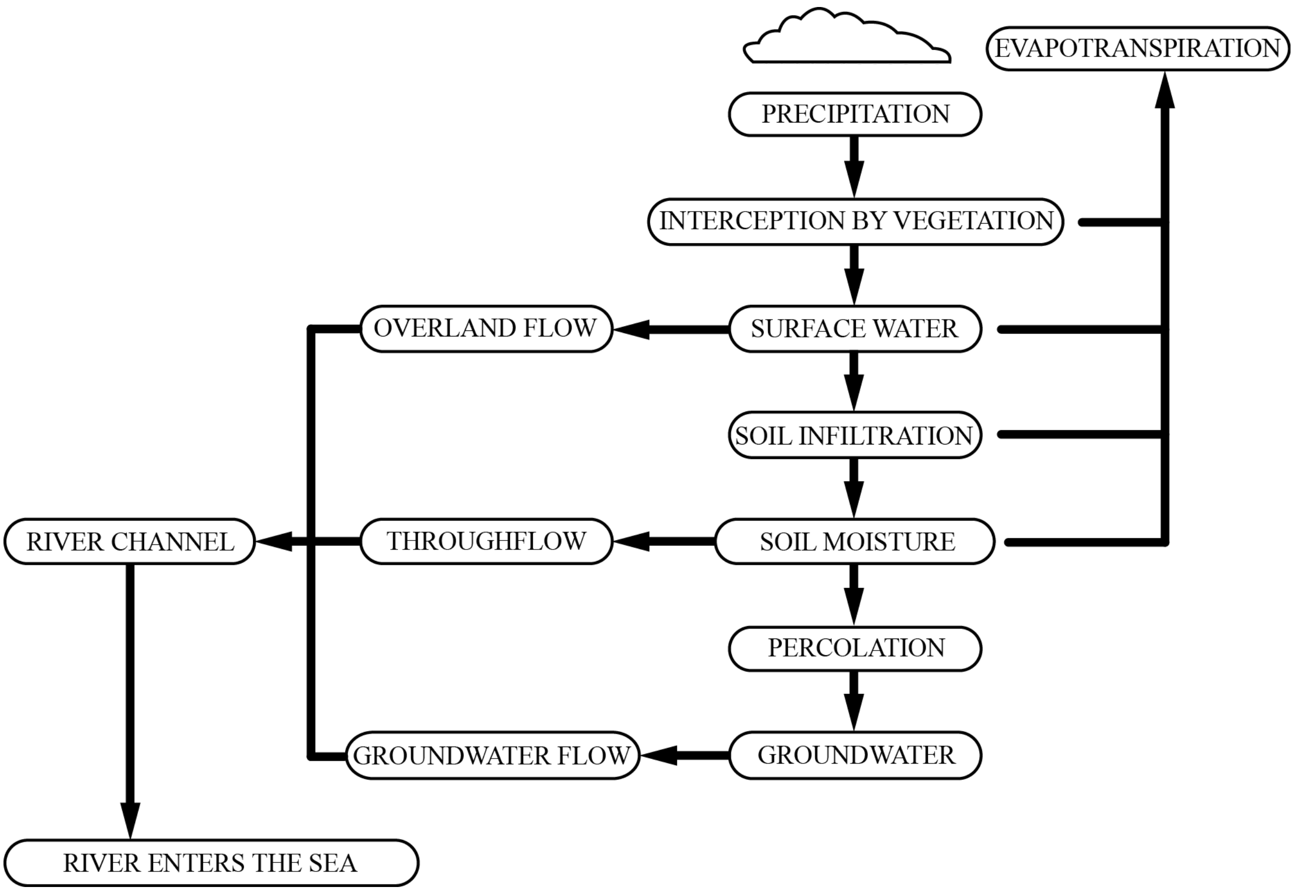
SL Paper 2

The diagram shows the inputs, outputs, stores and transfers that occur within a drainage basin as an open system.



[Source: adapted from http://www.bbc.co.uk/scotland/education/int/geog/rivers/images/basin/diag_processes.gif]

a. Identify **two** transfers and **two** stores shown in the diagram. [2+2]

b. Explain **three** ways in which human activity can reduce the time taken for water to pass through the system. [2+2+

c. Examine how an international conflict has arisen as a result of competing demands for freshwater. [10]

Markscheme

a. Award 2 marks for the correct identification of two stores (interception, surface water, soil moisture, groundwater, channel) and 2 marks for the correct identification of two transfers (soil infiltration, percolation, overland flow, throughflow, groundwater flow). No marks should be awarded for the identification of evapotranspiration or river enters the sea as a transfer.

b. Answers depend on the human activity/activities chosen which may lead to land use changes (urbanization, deforestation, agriculture), river channel modifications, drainage systems. Marks should not be allocated to “increased rainfall”.

Award 1 mark for correct identification of a relevant human activity and 1 mark for a valid explanation of how it reduces the time taken for water to pass through the system.

c. The freshwater water resource involved should be clearly identified and located, as should the countries involved in the water conflict.

Answers should clearly describe the nature of the conflict and explain why it occurs.

The associated problems for each of the countries involved should be examined. Attempts to resolve the conflict can lead to further conflict and this can be credited where relevant.

Answers that refer only to a conflict within a country should not move above band C.

Marks should be awarded according to the markbands.

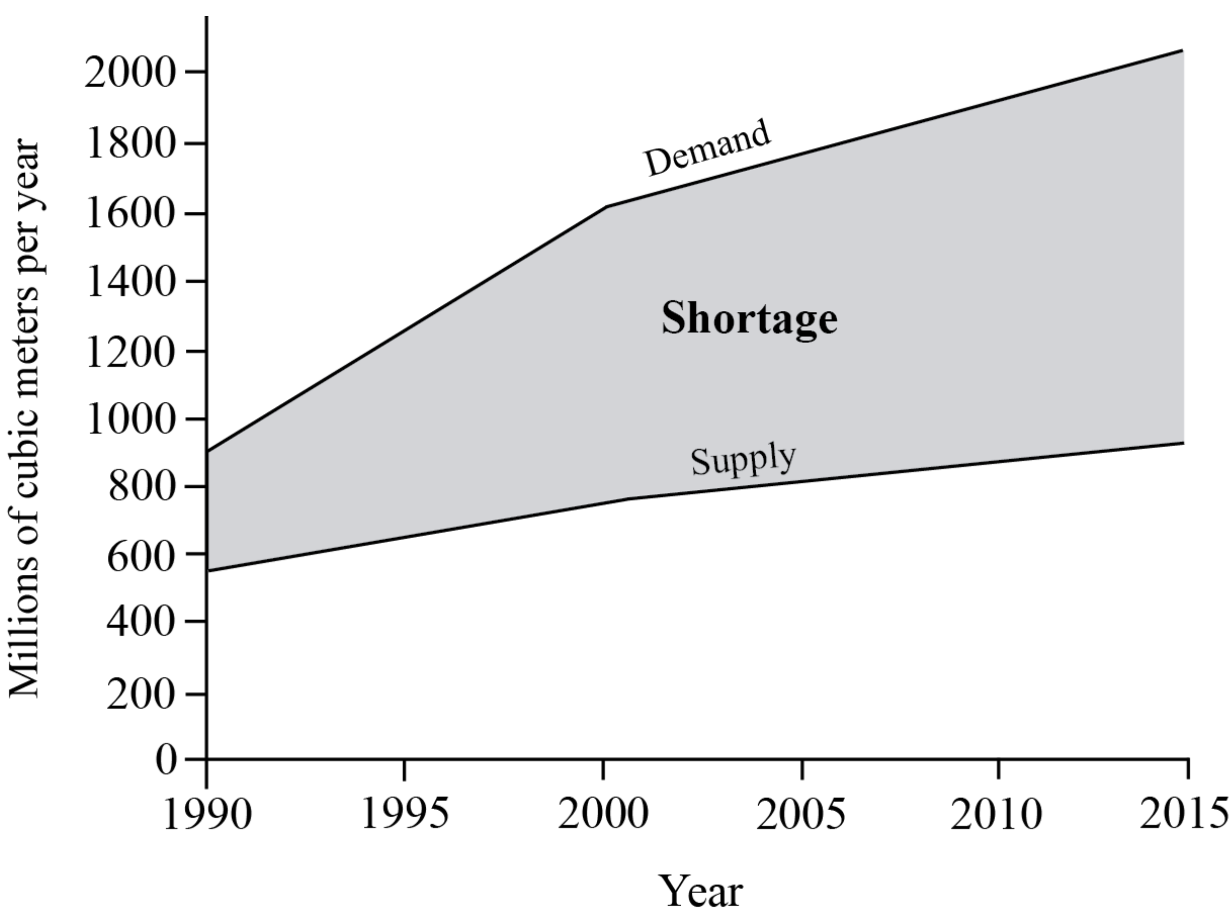
Examiners report

a. Knowledge and understanding was good.

b. Weaker candidates often failed to unpack the term "human activity". Popular choices were urbanization, deforestation and river channel modifications.

c. Many answers were based on the USA–Mexico conflict over usage of the River Colorado, but specific details of this (or other chosen examples such as the Nile basin or the Jordan) were often shaky. Some accounts were overly descriptive and insufficiently focused on the details of the conflict. Where candidates wrote about more than one example, the higher-scoring example was credited.

The graph shows the supply and demand for water in an unnamed country from 1990 to 2015.



[Source: adapted from an edited version of *Water Pollution Control – A Guide to the Use of Water Quality Management Principles* (1997), WHO/UNEP]

a. Describe the trend in water shortage between 1990 and 2015 shown on the graph. [2]

b. Suggest possible reasons for the changes in supply between 1990 and 2015 shown on the graph. [2]

c. Analyse **two** competing demands for water in a named river basin. [6]

d. Referring to **one or more** examples, examine the environmental effects of ground water abstraction and irrigation. [10]

Markscheme

a. Water shortage is increasing [1 mark], but at a decreased rate since 2000 [1 mark]. For full marks some quantification is required.

b. Possible reasons include the increased abstraction of ground water as a result of new wells, increased water from storages such as reservoirs, and from desalination plants. The suggestion that the increased supply comes from increased precipitation is not acceptable, since it would not result in such a uniform trend over the time period. Award 1 mark each for two valid reasons.

c. Competition for water is intense in many river basins. It is expected that candidates will analyse two broad categories of demand (such as residential, industrial, agricultural) and not two highly specific demands; the latter approach is likely to prove self-penalizing in the context of this question. Award 1 mark for the clear identification of two competing demands and 1 mark for the identification of a specific river basin.

   The remaining 4 marks should be reserved for the analysis of the competing demands. It is not necessary for the analysis of the two demands to be equal, but the response must make some points of comparison or contrast in order to be awarded 4 marks.

d. There are numerous environmental effects associated with ground water abstraction and irrigation. Ground water abstraction may lead to falling water tables, salt-water incursions if close to the coast, and, in extreme cases, subsidence of the ground surface. The effects of irrigation may include salinization, agro-chemical runoff, ground water pollution and the increased likelihood of the eutrophication of lakes, rivers and wetlands. Other valid ideas should also be credited.

   Candidates are expected to examine a variety of effects and both positive and negative effects are equally acceptable.

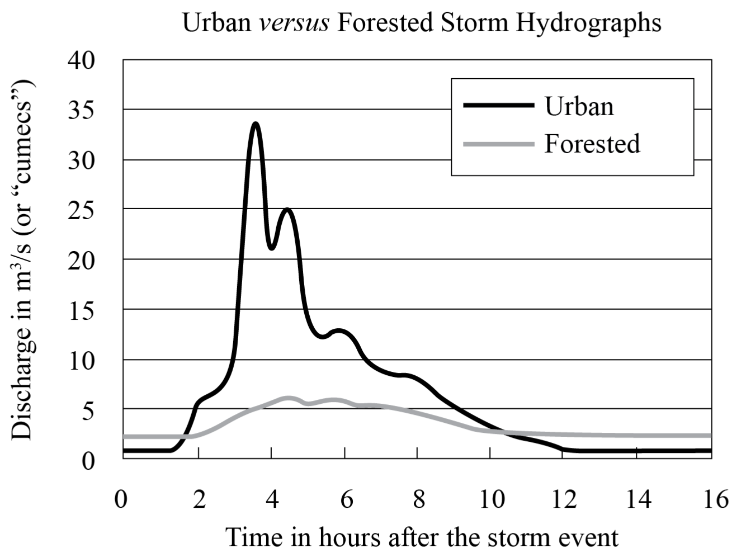
   It is not necessary for ground water abstraction and irrigation to be treated equally. Answers considering both aspects of the question in some detail are likely to be credited at bands E/F. Answers that use an appropriate example or examples are likely to be credited at band D and above.

   Marks should be allocated according to the markbands.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]

The diagram shows the response of a stream in an urban area compared with that of a stream in a neighbouring forested area after the same rainstorm event. (The basins are of similar size and drainage density.)



[Source: www.mdsg.umd.edu/images/uploads/siteimages/CQ/V07N2/urban_forest_hydrograph]

a. Describe **four** differences between the two hydrographs shown on the diagram. [4]

b. Suggest reasons why the urban and forested hydrographs show different responses to the storm event. [6]

c. With reference to a named river flood event, examine the relative importance of natural and human causes. [10]

Markscheme

a. Differences could include:

- higher peak discharge in the urban area
- shorter lag time in the urban area
- steeper rising limb in the urban area
- the longer peak discharge in the forested area
- there may be other features e.g. differences in base flow, urban hydrograph has two peaks.

Award [1 mark] for each valid difference. For full marks there should be some quantification.

b. Answers should refer to the reasons for the rapid response in the urban area due to lack of interception, impermeable surfaces (roads, roofs, paving), thereby reducing infiltration, and the presence of artificial and rapid drainage channels (drains, sewers, flood channels), explaining the rapid rising limb, high peak discharge and rapid falling limb on account of overland flow/runoff.

The slower and lower response in the forested area could be explained by higher interception, the retention of water by litter, absorption by root systems, high soil and bedrock permeability.

Award [1 mark] for each valid reason suggested and award additional marks for depth of explanation (of the operation of factors and associated processes).

c. The flood event should be located and dated by year.

Possible natural causes could be:

- excessive heavy or prolonged rainfall including flash flooding
- rapid snowmelt
- high antecedent rainfall and/or low rates of evaporation
- frozen ground preventing infiltration
- relief or basin shape conducive to flooding
- the nature of the soil/bedrock.

Possible human causes might include:

- removal of vegetation/deforestation
- urbanization of river basins
- farming methods that cause soil compaction
- river control that reduces flood arrival times downriver
- river control that results in higher peak discharge downriver
- straightening of river channels
- removal of wetland areas.

Not all of the above need to be included but the causes must be related to the named river flood event. Answers that do not refer to an actual event should not move above band C. Answers that examine the relative importance of human and natural causes are likely to be credited at bands E and F.

Marks should be allocated according to the markbands.

Examiners report

a. Generally, most candidates were able to identify four relevant differences, though the use of appropriate terms such as lag time, rising limb and base flow was frequently absent. Weaker candidates could not clearly identify the elements of the hydrograph, often leading to vague and expanded attempts to describe the differences, even merely describing the shape of the two graphs without knowing what they represented.

b. Good understanding was shown in the majority of cases although there were descriptive answers that did not focus on the stream responses of the hydrograph.

c. Many candidates who responded well to parts (a) and (b) did badly on part (c). Too many named a country but not an actual named river flood event (which needed to be located and dated). A few used outdated case studies. Bangladesh was a commonly used case study, but in many cases there was no mention of the name of the river. Some attempted to look at relative importance of the natural and human causes but tended to be descriptive and answered in general terms concentrating on the effects not the causes. In these cases, human causes were poorly covered. Good responses could succinctly analyse the various factors that supported their stance and those that did well used a wide range of factors to support their conclusion.

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a. Draw a labelled diagram to show the main features of an artesian basin. [4]

b. Explain the environmental impacts caused by groundwater abstraction. [6]

c. Evaluate the success of the management strategies used in **one** named wetland area. [10]

Markscheme

a. A diagram of a basin [1 mark], labelled aquifer [1 mark].

Two other labels (1 mark each up to a maximum of 2 marks) could include:

- impermeable strata
- source area
- artesian well
- water table
- any other relevant feature.

Alternative diagrams to conventional cross-sections are equally acceptable.

b. Answers could include: explanations of falling water tables, ground subsidence, river discharge reduction, drying up of springs and wells, effects on wetlands, changes in groundwater quality, increased toxicity (for example, arsenic), effects on natural vegetation, intrusion of sea water.

A simple list of impacts with no explanation should not be awarded more than 2 marks. A list with some explanation should be credited more than 2 marks where appropriate.

At least two impacts could be explained in detail; more impacts in less detail are acceptable.

c. Responses will depend upon the wetland area chosen.

The wetland area should be named, located and described.

The reasons why management strategies are necessary in the named wetland should be clearly outlined.

The actual management strategies employed in the named wetland should be described. Possible strategies could include: creating national parks or sites of special scientific interest, habitat conservation, wetland extension, controlling or legislating against agricultural run-off, drainage, water management schemes, tourism.

To access markbands E and F, the success or failure of the strategies should be evaluated in terms of the benefits and problems that have resulted in named wetland areas.

Marks should be allocated according to the markbands.

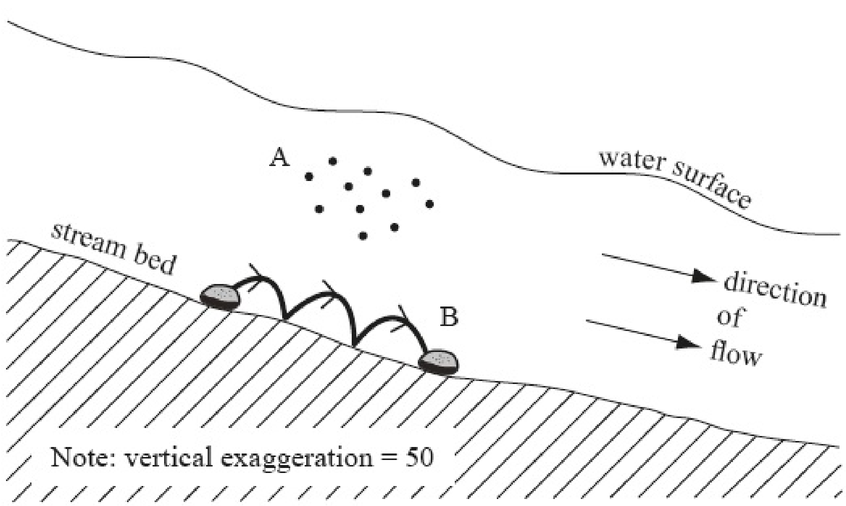
Examiners report

a. In general, this was not done very well, however, a small minority knew it very well.

b. This question was answered with great detail. Candidates knew their material and showed a wide range of support and explanation.

c. The answers to this varied from the detailed evaluation of small-scale wetlands, for example, Wicken Fen in the UK, to large-scale ones such as the Kissimee restoration scheme in Florida. There was an impressive range of knowledge and understanding shown.

The diagram shows two transport processes that operate in a river channel.



a. Identify **and** describe process A **and** process B shown in the diagram. [4]

b. Draw a labelled diagram to show the main input, outputs, transfers and stores of the hydrological cycle for an **un-vegetated** drainage basin. [6]

c. “Of all the impacts of agriculture on water quality, salinization is the most damaging.” Discuss this statement. [10]

Markscheme

a. A – Suspension ***[1 mark]*** – finer load carried along in the channel above the bed ***[1 mark]***.

B – Saltation ***[1 mark]*** – coarser material bounces along the river bed ***[1 mark]***.

b.
- Input: precipitation ***[1 mark]***.
- Outputs: evaporation/run-off/river discharge ***[1 mark]***.
- Transfers: must have at least four for two marks (or two for one mark): infiltration, throughflow, overland flow, groundwater flow/base-flow ***[2 marks]***.
- Stores: must have at least four for two marks (or two for one mark): atmosphere, soil, groundwater/water table, lakes, river water, surface store/surface depression, snow, water tanks/water butts ***[2 marks]***.

Either a systems diagram or a pictorial image of a drainage basin is acceptable.

Award up to a maximum of ***[3 marks]*** if there is no diagram.

c. Responses should show an understanding of salinization and its effects. Salinization is widespread in arid and semi-arid environments where groundwater extraction in coastal areas leads to saline incursion; salt water drawn upwards by capillary action results in salt enrichment of the soil/surface. Irrigation is another cause as, over time, levels of salt build up through repeated watering – leaching of the salts by flooding can lower water quality in rivers. Local geology can also play an important role in some contexts. Salinization damages livelihoods for farmers by limiting agriculture/reducing yields.

As the counter-argument, responses could also examine the impacts of agro-chemicals, sedimentation due to increased run-off, the effects of animal wastes, groundwater pollution and eutrophication of rivers, streams, lakes and/or wetlands where relevant. (Not all of these are required.)

Good answers may question who or what is damaged (land, incomes, ecosystems, local businesses), and should recognize it is a more serious concern in some parts of the world than in others.

Responses that are mainly descriptive and/or look only at salinization should not progress above band D.

At bands E and F responses should discuss the relative importance of at least one other agricultural impact on water quality. At band F there should be a well balanced evaluation.

Marks should be allocated according to the markbands.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

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a. (i) Define the term *stream discharge*. [5]

(ii) State **two** river transport processes **and** outline how each process operates.

b. Explain how hydrographs can be used to forecast **and** manage flooding. [5]

c. Examine the possible impacts of the mismanagement of groundwater resources. [10]

Markscheme

a. (i) The rate of stream/river flow/the volume/amount of water passing a point per unit of time (may specify hours/days – any unit of time is acceptable). Must have time.

(ii) Suspension, solution, saltation, traction, flotation.

In each case award **[1]** for naming the process and **[1]** for some specific detail of the process *eg* may quantify the particle size (accept "large" or "small"), rock type, chemical processes, or use specialist vocabulary.

For example, award **[2]** for "Some material is carried in solution, such as material dissolved by carbonation" or "suspension is when small particles are carried in the water".

Do not award more than **[1]** for an outline that does no more than define the terms ("suspension is when particles are carried in the water" or "solution is when the load is dissolved in the water").

b. Award **[1]** for the description of a hydrograph (drawn, stated or implied), for example "the hydrograph shows response of a river/stream to a precipitation event over time".

Award **[1]** for each explanation of how a hydrograph is used to help with flood management/warning. Award additional marks for any development that uses specialist knowledge of hydrographs and/or floods. There may be other valid approaches and these should be credited. Answers may focus on ideas of "archive" hydrographs, "live" hydrographs (using GIS *etc*), or both.

For example:

- historical hydrographs can be used as models for future flooding **[1]**, allowing estimate of time lag to peak discharge to be made **[1]** which provides vital information for evacuation times **[1]** or provides guide to extent of possible flooding/areas at risk **[1]**
- knowledge of rural and urban hydrographs helps us know what might happen in particular locations **[1]** because urban hydrographs are flashy **[1]**
- discharge prior to rainfall event shown on hydrograph **[1]** shows how much/little rain is needed before bankfull discharge is reached **[1]**
- return periods for high-magnitude floods **[1]** can be estimated *eg* one in a hundred year events **[1]** which may influence land-use zoning [1] and flood protection schemes *eg* size of levees **[1]**
- credit other valid points not covered by the markscheme.

c. Groundwater management may comprise over-abstraction or pollution, either of which may constitute unsustainable management depending on the scale or rate of the change. The focus may be on agriculture and groundwater pollution and may make use of a detailed local case study.

The impacts could be physical (subsidence, ecosystem damage), human (dwindling supplies, conflicts and possible attempts at resolution either locally or internationally *eg* transboundary aquifers). Mismanagement may also comprise distribution inequities or losses due to inefficient storage and transfer technology.

An entirely physical or human answer can be awarded full marks if it covers a range of (at least three) well-developed impacts.

Good answers may be carefully structured around different types of impact (either for processes, people or ecosystems), or may examine the temporal and/or spatial extent of any impacts. Another approach might be to examine different kinds of mismanagement, or contrasting views of user groups about what constitutes mismanagement (may use concept of sustainable development).

For band D, expect some description of some problems related to water quality and/or quantity.

At band E, expect <u>either</u> more detailed explanation of some impacts <u>or</u> an examination of the meaning of "mismanagement" (*eg* unsustainability).

At band F expect both of these elements.

There may be other approaches and these should be credited.

Marks should be allocated according to the markbands.

Examiners report

a. (i) Many candidates did not give a full definition of "stream discharge", omitting reference to time/cumecs.

(ii) Most candidates correctly named the river transport processes, but often failed to give descriptive detail to gain full marks.

b. Most candidates understood the concept of a hydrograph, but were often let down by the explanation of how hydrographs might be used to forecast and manage flooding. There were some very good sketches of hydrographs, although annotations would have helped answer the question more succinctly.

c. Most candidates were able to describe groundwater resources and outline some impacts of mismanagement. Many, however, were unable to develop their explanation of why mismanagement had occurred. The Aral Sea is not really considered to be a groundwater store; those that used this example told the story of mismanagement rather than focusing on the question. The very strongest responses used case studies with factual detail and figures illustrating the costs of abuse of groundwater resources to society and the environment.

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a. Draw a labelled diagram of a hydrograph. [4]

b. Explain how hydrographs are used to forecast floods. [6]

c. “Dams and reservoirs create as many problems as they solve.” Discuss this statement with reference to multi-purpose schemes. [10]

Markscheme

a. The hydrograph must include:

- Labelled axes showing time and discharge [1 mark]
- Line graph showing discharge [1 mark].

Any additional features or labels are worth 1 mark each, up to a maximum of 2 marks:

- Labelled rainfall
- Peak discharge
- Base flow
- Lag time
- Rising or falling limb.

b. There are many ways in which hydrographs are useful in forecasting floods. Answers could mention prediction of flood height and arrival time downstream using a study of lag times and stream response records. Hydrographs are also used to predict the return period of floods of different sizes through the use of hydrograph records over a long period of time. They may also be used to predict the extent of flooding and how long it will last.

At least two of these should be explained to gain 6 marks.

A strong account of one may compensate for a weaker account of another.

c. At least one example of a multi-purpose scheme should be named and located.

Solutions might include: the benefits of power generation, water supply, irrigation, transport, flood control, recreation and tourism.

These should be balanced against potential problems that could include: loss of land, displacement of population, loss of water through evaporation, silting, seismic problems, cost, diseases such as bilharzia, loss of nutrients due to flood control, salinization.

To access bands E and F, candidates should discuss both solutions and problems using at least one actual scheme.

Marks should be allocated according to the markbands.

Examiners report

a. Excellent at both levels, though a few higher level centres erroneously offered climate graphs rather than hydrographs.

b. Links to forecasting were often tenuous with few references to speed of flood onset, height, duration or return period.

c. The approach was usually sound, with some truly outstanding responses using detailed case studies and accurate supporting data.

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b. Explain **three** factors that may produce a short time lag on a storm hydrograph. [6]

c. Compare the effectiveness of alternative stream management strategies, **other than** dams. [10]

Markscheme

b. A short time lag is usually associated with overland flow linked with any of the following factors:

• the characteristics of the precipitation input (type and duration of precipitation, speed of snow melt, antecedent rainfall)
• the shape and size of the drainage basin (including tributaries / drainage network)
• characteristics of the drainage basin (land use, gradient, geology, vegetation, urbanization).

For example: Short lag time is caused by an unvegetated drainage basin **[1]** in which surface runoff is accelerated/interception does not occur **[1]**. Also linked with impermeable clay soil **[1]** and the lack of infiltration **[1]**. Also linked with drainage basins that are round **[1]** because all water reaches the measuring point at roughly the same time **[1]**.

c. There are many alternative strategies that could be examined. For example, building of dykes/flood barriers or artificial levees, channel

management (straightening, deepening, widening), flood relief channels/basins, river/wetland restoration.

Land uses strategies are acceptable if they are purposely designed to manage streams. *Do not credit indirect/unplanned impacts of urbanization, deforestation, etc*.

Good answers may focus on, and compare, the effectiveness of strategies (may look at different perspectives, user groups). Another approach might be to compare the effectiveness at different spatial/temporal scales.

At band D, expect a description of one or more stream management strategies.

At band E, expect <u>either</u> a more detailed explanation of two or more different strategies <u>or</u> a structured comparison of their effectiveness (costs, benefits and perspectives on these).

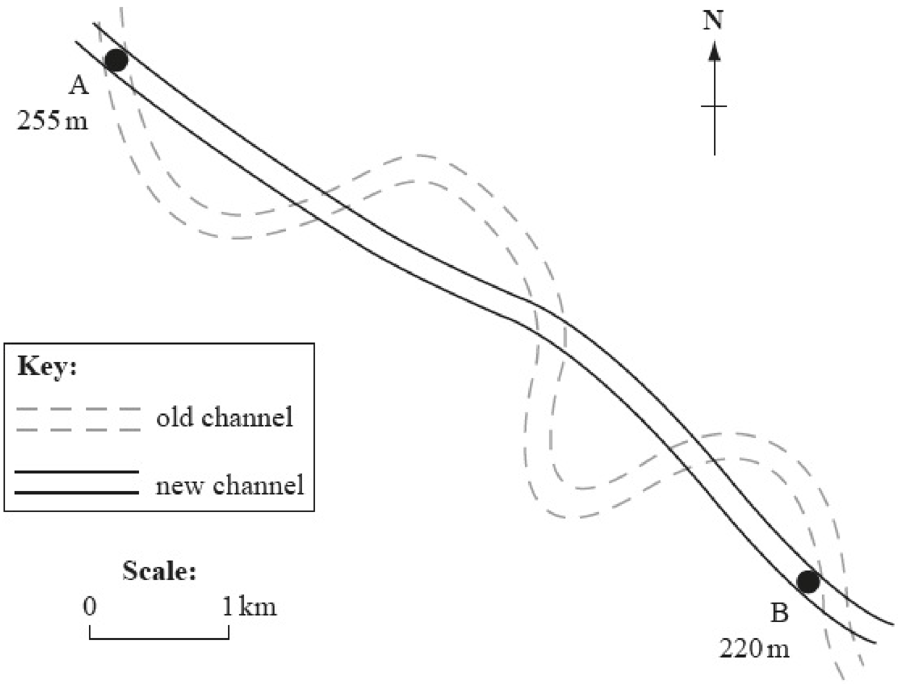
At band F, expect both of these elements.

Marks should be allocated according to the markbands.

Examiners report

b. [N/A]
c. [N/A]

The diagram shows the changes in a river channel following implementation of a management strategy.



a. Define the term *stream discharge*. [2]

b. (i) State the direction towards which the river is flowing at B. [8]

(ii) State **three** changes to the river channel that result from this management strategy.

(iii) Explain **one** benefit **and one** problem for people that might result from this management strategy.

c. Examine the benefits **and** problems of different river management strategies (**other than** that shown in the diagram). [10]

Markscheme

a. The volume/amount of water ***[1 mark]***, passing a given point in a given time ***[1 mark]***. Or also accept formula of velocity × cross-sectional area.

b. (i) South East.

(ii) The new channel is straighter ***[1 mark]***, shorter ***[1 mark]***, and has a steeper gradient ***[1 mark]***.

Accept changes to processes, such as more erosion ***[1 mark]***.

(iii) **Benefits:** better for navigation due to shortening of the channel, flood water removed more quickly.

Problems: flood moves faster downstream, flood is larger downstream, lag time downstream is reduced, navigation upstream is harder, erosive power of the river is increased.

Award ***[1 mark]*** for each correct statement and a further ***[1 mark]*** for a valid explanation.

c. Candidates should refer to at least two different strategies. (No credit should be given for strategies that look at channel straightening.)

The following approaches may be relevant:

- multi-purpose schemes (dams) that have flood control dimensions
- hard engineering approaches including levees, diversion channels, spreading grounds, walls, flood relief channels
- other approaches to stream management including river restoration schemes (restoring natural surfaces, channel shape, habitats); water quality legislation and actions (for example, nitrate control); wetland restoration.

Also accept drainage basin schemes that impact on river processes or water quality, for example, afforestation; river hazard management schemes, for example, land-use zoning that leaves unoccupied areas for river to occupy during flood.

The use of only one river management strategy which includes benefits and problems is unlikely to progress beyond the D/E border.

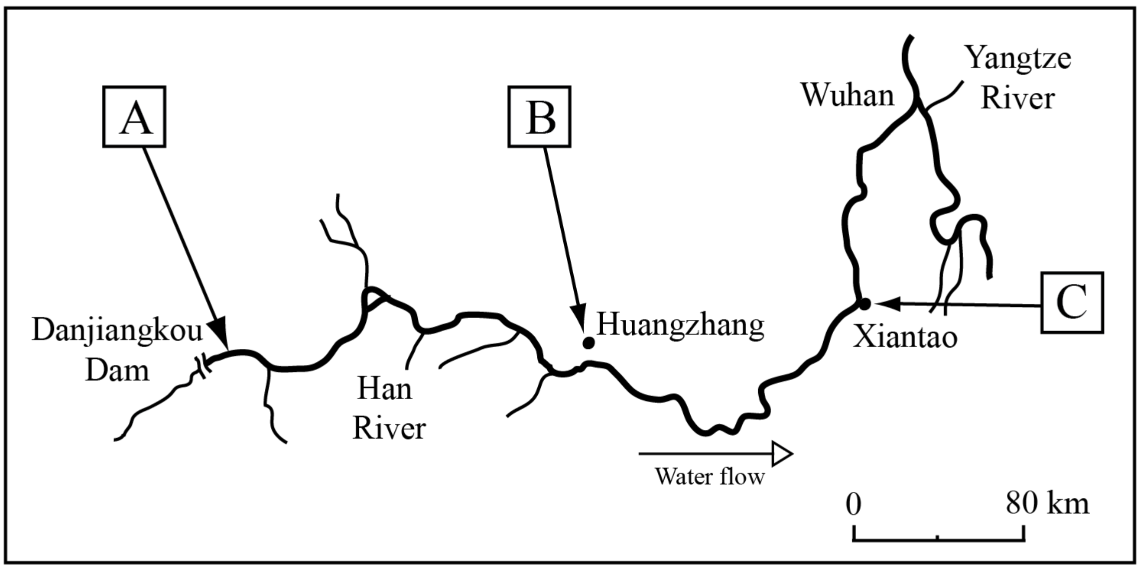
To achieve band E there must be an attempt at evaluation of two strategies. At band F expect a well balanced evaluation.

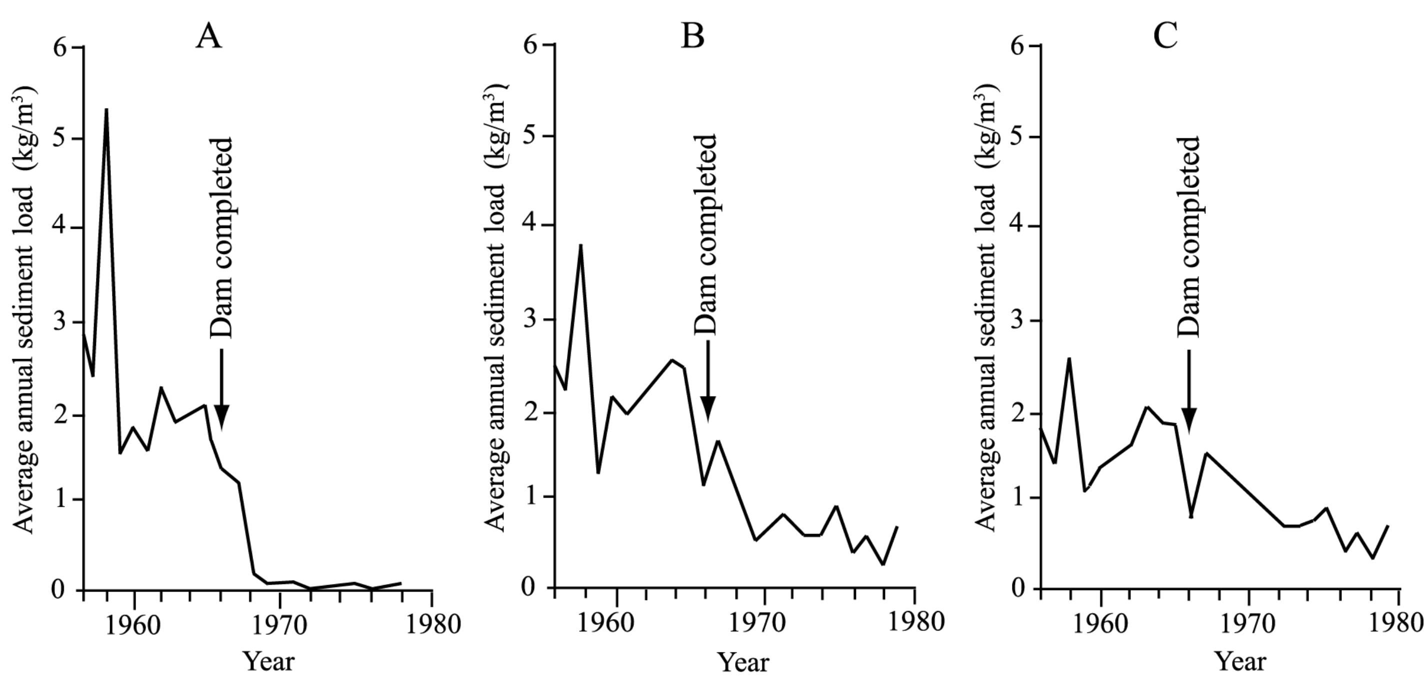
Marks should be allocated according to the markbands.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The map shows the location of the Danjiangkou Dam on the Han River in China. The graphs show the sediment loads at three places (A, B, C) downstream of the dam.





[Source: Nick Middleton (1999), *The Global Casino*, Arnold]

ai. State the year when the highest sediment load occurred. [1]

aii. State the volume of sediment load in that year at Huangzhang. [1]

b. Identify **three** ways in which the load of a river is transported and briefly describe **one** of these ways [3]

c. Referring to the map and graphs, explain how the construction of the Danjiangkou Dam affected sediment loads along the Han River. [5]

d. Examine the influences of physical factors and human activity on a specific river flood. [10]

Markscheme

ai. 1958.

aii. Accept answers from 3.7 – 3.8 kg/m^3 inclusive. Units are required.

b. Answers are likely to be solution; suspension; bed load (though it is equally acceptable for candidates to identify more than one type of bed load movement).

Award 1 mark for two correct ways, 2 marks for three correct ways, with the remaining 1 mark reserved for an appropriate description of one of the ways.

c. Candidates are expected to describe that, following construction of the dam, sediment load decreased [1 mark] and that sediment flows became less variable [1 mark]. A third mark should be awarded for any recognition that either sediment load or the variability of sediment load diminished more at sites close to the dam than further downstream. The final 2 marks should be reserved for statements explaining these trends or patterns by reference, for example, to the reduction in peak water flows following dam construction, or to the impact of the dam acting as a sediment trap.

Other valid statements can be credited.

d. Both physical factors (such as the size and shape of the drainage basin; the amount and intensity of precipitation) and human activity (such as land clearance, location of housing, dam construction, flood defences) play a part in river floods, though the balance between the two will vary, depending on the specific river flood chosen.

Answers that examine a specific river flood are likely to be credited at band D and above. It is not necessary for physical factors and human activity to be treated equally. Answers considering both aspects of the question in some detail are likely to be credited at bands E/F.

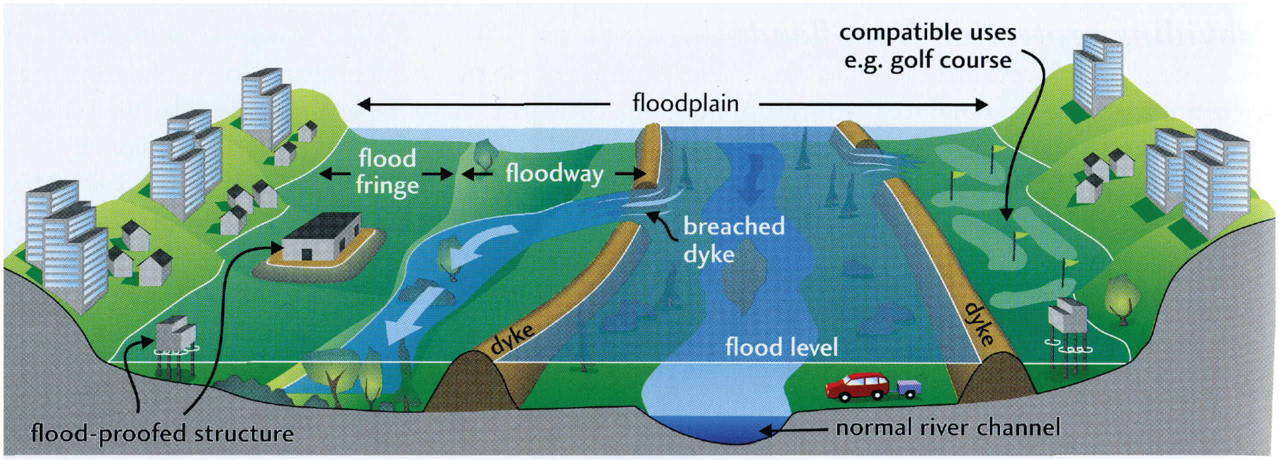
It is expected that responses will examine one specific river flood, which can be at any scale.

Marks should be allocated according to the markbands.

Examiners report

ai. [N/A]
aii. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]

The diagram shows a river floodplain.



[Source: John Clague and Bob Turner, (2003), *Vancouver, City on the Edge*, Tricouni Press, page 74]

a. Referring to the diagram, briefly describe **two** floodplain management strategies. [2+2]

b. Explain how human activities on a floodplain can increase the probability of flooding. [6]

c. “Eutrophication is the most damaging agricultural impact on water quality.” Discuss this statement. [10]

Markscheme

a. The diagram provides evidence for several floodplain management strategies, including floodplain zoning; construction and maintenance of dykes; maintenance of a floodway to channel flood waters away from settlements or valuable land; deliberate “set-aside” of floodplain as an area where no development is permitted; flood-proofing of buildings.

   Award 1 mark for each valid suggestion for a management strategy, and a further 1 mark in each case for further description or development. Some reference to the diagram is essential for the awarding of the full 4 marks.

b. Answers could refer to two human activities in detail or several in less detail. Human activities might include: urbanization, mechanized farming causing soil compaction, deforestation, removal of pastureland for arable farming, construction of artificial levees, straightening of the channel, removal of wetlands.

   A simple list with no explanation should not be awarded more than 2 marks. A list with some explanation should be credited more than 2 marks where appropriate.

c. Answers should describe how eutrophication can be caused by farming and how it impacts on water quality. It is expected that answers will examine other impacts of agriculture on water quality and compare these with the impact of eutrophication. This might include the effects of irrigation such as salinization, or the accumulation of toxins/pesticides in water bodies as well as increased water sediment content due to soil erosion following intense precipitation or exposure to wind.

   To access bands E and F, answers should include a clear evaluation of one or more agricultural impacts compared to eutrophication.

   Marks should be allocated according to the markbands.

Examiners report

a. Knowledge and understanding was reasonable though at standard level strategies were often identified but not well described with regard to their functioning.

b. This question proved harder, with few recognizing the importance of "probability". Although human activities were identified, answers rarely explained fully how they might affect flooding

c. Many discussions were strong on eutrophication, but less convincing on salinization or other impacts, so that at both levels arguments tended to unbalanced. Weaker candidates tended to write about water pollution in general.

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a. Outline how water is transferred through a drainage basin by: [4]

(i) infiltration;

(ii) throughflow.

b. Suggest how a change in the balance of water stored in oceans and ice could result in: [6]

(i) **one** environmental consequence with **positive** effects for people;

(ii) **one** environmental consequence with **negative** effects for people.

c. “The benefits gained from the construction of large dams outweigh any costs.” Discuss this statement with reference to **one or more** major dams. [10]

Markscheme

a. (i)

*Award **[1]** for a simple description and **[1]** for some development*.

For example:
Infiltration is the downward movement of water **[1]** from the surface/into the soil **[1]** / may be influenced by vegetation cover/slope angle/human impact **[1]**.

(ii)

*Award **[1]** for a simple description and **[1]** for some development*.

For example:
Throughflow is the sideways/lateral movement of water within the soil **[1]** where downward movement is restricted **[1]** / moves through pores/cracks/fissures or natural pipes in the soil **[1]**.

b. (i)

Consequences include: retreat of glaciers and ice shelves / ice caps; accessibility to more land (for farming); new sea floor resources found; increased water supply; changes in tourism; new shipping routes.

*Award **[1]** for the consequence and **[2]** for development and/or exemplification*.

For example: Arctic ice melting **[1]** is allowing the discovery of previously unknown oceanic resources **[1]**, *eg* oil **[1]**.

(ii)

Consequences include: rising sea levels caused by ice melt; flooding in low-lying areas; drowned features on coastlines or emergent features; coastal inundation; increased river flows; water insecurity; changes in tourism; environmental refugees.

*Award **[1]** for the consequence and **[2]** for development and/or exemplification*.

For example:
Ice melt is causing rising sea levels **[1]** which are inundating coastal areas/low-lying islands, *eg* Pacific atolls **[1]** leading to migration **[1]**.

c. At least one example of a major dam should be named and located. Both benefits and costs should be discussed.

Costs could include: biodiversity loss; increased siltation; changing river load downstream (and water temperature change with ecosystem impacts); loss of water through increased evaporation; increased chances of diseases (such as bilharzia); loss of nutrients due to flood control; salinization; seismic activity; increased landslides; forced migration/displacement of population; loss of farmland; loss of historic sites; drowning of settlements; disruption of transport links.

Benefits include: power generation; industrialization; economic spin-off; prestige, water supply; irrigation; transport/navigation; flood control; supplements low river levels; fishing; recreation and tourism.

Good candidates may question from whose perspective the statement is made or may apply concepts. Another approach may be to apply scale or timescale, *ie* many people benefit over a broad area while only local people lose their homes, or the benefits and costs may only become clear over time.

To access band D, there should be description of some costs and benefits – do not expect balance.

For band E, there should be <u>either</u> explanation of a greater range/depth of costs and benefits <u>or</u> some discussion of the statement (considers perspective, scale, time, etc).

For band F, expect both.

Marks should be allocated according to the markbands.

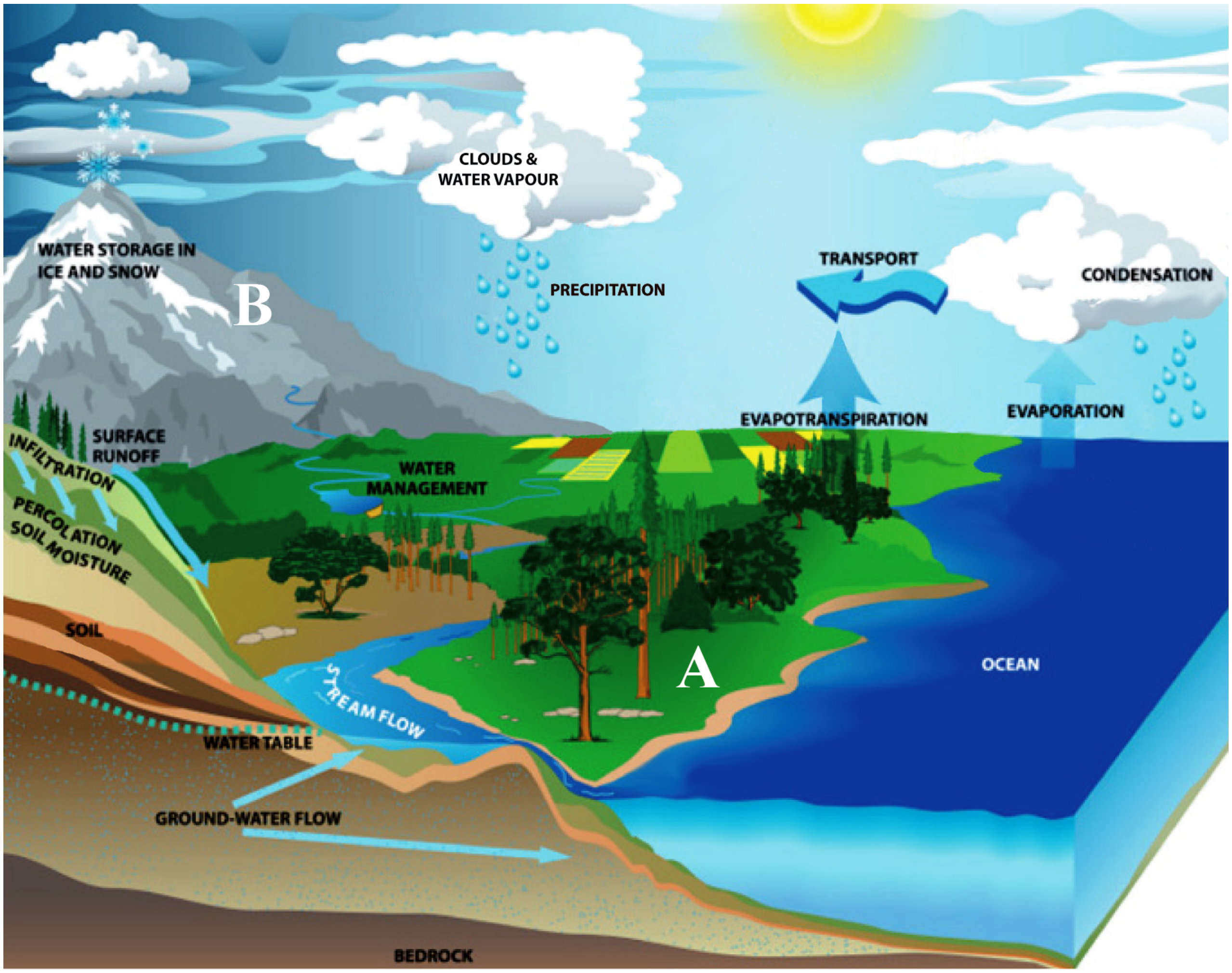
Examiners report

a. The meanings of the terms “infiltration” and “throughflow” were often imperfectly understood. The use of a diagram sometimes helped the answer, and due credit was given.

b. This was generally well answered. A variety of different consequences was acceptable, but answers were often not sufficiently developed to warrant full marks.

c. Some excellent responses, mainly using Three Gorges Dam, the Hoover Dam and Aswan Dams as examples. The best answers gave range/variety/detail of costs and benefits, in relation to the particular dams chosen, and were able to make some overall evaluation. Sometimes, however, answers were general and descriptive.

The diagram shows the main features of the hydrological cycle.



[Source: http://allritewaterconditioning.com/prosite/Whats_In_your_Water]

a. Describe **two** conditions at point A which would make infiltration rates higher than at point B. [2x2]

b. Explain the consequences of a decrease in the amount of water stored in ice in the hydrological cycle at any stage. [6]

c. “Strategies adopted to meet the competing demands for water are not always effective.” Discuss this statement with reference to **one** named river basin. [10]

Markscheme

a. Possible answers could include interception by vegetation, slope angle, snow melt, non-frozen ground, soil characteristics (soil porosity, soil infiltration capacity), water content of the soil, antecedent precipitation, intensity of the precipitation or any other logical answer.

Award 1 mark for identifying each factor and a further 1 mark for how it influences infiltration.

b. Possible consequences may be human and/or physical. The human consequences are likely to be negative: water insecurity, changes in tourism, coastal inundation, environmental refugees. There may be short-term benefits, for example, increased river flow, accessibility to more grazing lands.

Responses may mention arctic ice melt, new shipping routes, new sea floor exploitation, retreating land ice can increase agricultural land area.

Physical consequences could include: rising sea levels caused by ice melt, retreat of glaciers and ice shelves/ice caps caused by global warming, flooding in low-lying areas, drowned features on coastlines (resulting from eustatic changes in sea level) or emergent features (resulting from isostatic rebound).

At least two different consequences must be explained for the award of full marks. Candidates may choose to explain two consequences in depth or more than two in less depth.

c. Responses will depend on the river basin chosen.

The basin should be named and located (if more than one basin is used, credit should be given to the example which answers the question most effectively). The competing demands should be outlined depending on which basin is named.

The strategies (such as dams, reservoirs, water rationing, water pricing) adopted in the basin to meet the competing demands should be outlined. The successes and, if relevant, failures of the management strategies should be discussed. Discussion on whether the strategies are effective depends on the view of the stakeholder. The best responses may reflect this.

Answers that do not refer to a named river basin, or which focus on one side of the argument, should not move above band D. To access markbands E and F, the strategies should be effectively evaluated.

Marks should be allocated according to the markbands.

Examiners report

a. Some candidates overcomplicated matters by referring to rock type and permeability when there was no evidence to support this on the diagram, but the concept of infiltration capacity was well understood.

b. This was generally well answered. Candidates wrote about a range of consequences, notably flooding and sea-level change (though few referred to drowned or emergent coastal landforms that could result from consequent eustatic or isostatic changes). However, some candidates failed to go into detail – that would be alright if they had a large range of consequences.

c. There were some very good answers which dealt with a named drainage basin. However, some candidates did not identify a basin – nor a strategy – and identified conflicts over access to water, for example, Israel and Palestine. Others wrote about the advantages and disadvantages of large dams – which is relevant – but needs to go further into strategies. Competing demands could also have been explored in more detail as numerous responses did not identify these with specific reference to the chosen basin.

---

a. Describe **two** characteristics of natural levées. [4]

b(i) Define the term *wetlands.* [2]

b(ii) Explain **two** reasons why some wetlands are protected. [4]

c. “Multi-purpose schemes result in more benefits than problems.” Discuss this statement, referring to both physical **and** human impacts. [10]

Markscheme

a.
- Raised bank ***[1 mark]*** above the flood plain ***[1 mark]***
- Parallel to river channel ***[1 mark]*** so “fossil” levées may show former river channel ***[1 mark]***
- Composed of alluvium ***[1 mark]*** showing annual/periodic accumulation ***[1 mark]***
- Sorting/grading of material ***[1 mark]*** coarse material forms the levée with fine material further from river ***[1 mark]***
- Asymmetrical cross-section ***[1 mark],*** steeper facing the river channel ***[1 mark].***

b(i) Areas that are regularly saturated ***[1 mark]*** for a variety of reasons, due to groundwater or surface water (including freshwater marshes, swamps and bogs) ***[1 mark].***

- Source of freshwater

b(ii).
- Maintain water quality
- Biodiversity source (niches)
- Natural flood defence
- Tourist resource/recreation
- Food/aquaculture
- Expect other suggestions.

In each case, award ***[1 mark]*** for identifying the reason for protection and ***[1 mark]*** for further development or exemplification.

c. Multi-purpose scheme (MPS) should be named and located. Dams and reservoirs likely to be included, built for a range of purposes *eg* water supply, electricity, irrigation. MPSs may also incorporate navigation, recreation, climate regulation or may have other purposes. However, solutions may not always have been fully realized in practice *ie* problems only partially solved.

Physical and human problems often associated with MPSs include: forced migration, loss of farmland and historic features/settlements, transport interruption, biodiversity loss, increased siltation, changing river load downstream (and water temperature change with ecosystem impacts), increased evaporation, seismic activity.

To access band D, some benefits and/or problems associated with a MPS should be described. For bands E and F, discussion is provided or a conclusion arrived at.

Marks should be allocated according to the markbands.

Examiners report

a. There was a poor understanding of the characteristics of levées.

b(i). Wetlands were generally well understood, together with the reasons for their protection.

b(ii). Wetlands were generally well understood, together with the reasons for their protection.

c. There were some good responses to multi-purpose schemes, their benefits and problems, and some effective use of case studies. Again, the weaker candidates wrote all they knew about a particular scheme, such as the Three Gorges Dam, with limited reference to the question.

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a. Outline **two** ways in which sediment is transported by a river. [4]

b.i. Using **one named** example of an international conflict related to freshwater, briefly explain **one** cause of the conflict. [2]

b.ii. Using **one named** example of an international conflict related to freshwater, briefly explain **two** consequences of the conflict. [4]

c. Examine how human activity influenced the severity of **one named** river flood event. [10]

Markscheme

a. *In each case, award* ***[1]*** *for correctly identifying the term and* ***[1]*** *for including some specific detail of the process, eg may quantify the particle size (accept "large" or "small"), or use specialist vocabulary.*

For example:

- Saltation **[1]** is jumping/bouncing of small particles along the river bed **[1]**.
- Traction **[1]** is heavier material dragged or rolled along the bed **[1]**.

Other possibilities include:

- solution

- suspension
- floatation.

b.i. *Award **[1]** for identifying a named conflict and **[1]** for some specific explanation of the cause.*

For example: Sudan and Egypt had a conflict over the Nile river, as both are in need of limited water supplies **[1]** to satisfy the demands of their growing populations **[1]**.

Other possible causes might be:

- two countries both in need of limited water supplies
- population/economic pressures
- environmental/climate change
- water security/boundary dispute
- hydropower schemes along transboundary rivers
- industrial pressures.

b.ii *Award **[1]** for each consequence identified and **[1]** for some further explanation or development.*

Possible consequences could include:

- treaties/international agreement **[1]** and gives further detail (which may include quotas and water allowances) **[1]**
- escalation of international conflict **[1]** and gives a detail, *eg* political repercussions **[1]**
- one country builds a dam to maximize its supply **[1]** and gives a detail, *eg* date of construction, or ecological/economic harm downstream, or navigation issues **[1]**
- a substitution strategy, *eg* desalinization **[1]** and gives a detail **[1]**.

For example: Sudan and Egypt's conflict resulted in the Nile treaty **[1]**, which set limits for water use by each country **[1]**. As a consequence of now having access to less water, the Egyptians have tried to use desalinization to meet their water needs **[1]**. This uses a process called reverse osmosis to remove salt and produce freshwater **[1]**.

Two separate consequences are needed; do not credit multiple problems associated with dam construction.

c. Human factors that can increase flood severity include: deforestation and changing agricultural practices in the drainage basin, removal of

wetlands, urbanization/increasing concrete surfaces/drainage ditches and changes to the channel flow.

Human factors that can sometimes decrease severity include straightening, widening, building levees, *etc*.

Physical factors may be highly relevant for some case studies.

Good answers may examine how human activity can increase and/or decrease the risk of floods in complex ways (levees may reduce or increase flood risk).

Another approach may be to examine how human activities along one stretch of river have impacts for other places on the river. Rapid emergency responses might also reduce the severity of the flood.

At band D, expect a description of the ways in which human activity has caused the named flood event.

At band E, expect either a more detailed explanation of a greater range of human activities or a structured examination of how human activity has influenced flood severity.

At band F, expect both.

Marks should be allocated according to the Paper 2 HL and SL markbands.

Examiners report

a. [N/A]
b.i. [N/A]
b.ii. [N/A]
c. [N/A]

---

a. Define the terms *drainage divide* **and** *wetlands*. [4]

b. Explain how stream discharge is related to channel size **and** shape. [6]

c. Using examples, examine the hydrological impacts that can result from the construction of a dam and reservoir across a river channel. [10]

Markscheme

a. Drainage divide – the line defining the limit of a drainage basin ***[1 mark]*** separating it from neighbouring basins ***[1 mark]***. Also known as a watershed ***[1 mark]***. Credit alternative phrasing.

Wetlands – areas that are regularly saturated ***[1 mark]*** by groundwater or surface water ***[1 mark]***. These include freshwater marshes, swamps and bogs ***[1 mark]***. Credit alternative phrasing.

b.
- Award ***[1 mark]*** for defining/calculating discharge.
- Award ***[1 mark]*** for establishing a link between discharge and channel size (*eg* higher discharge in a larger/lower course channel).
- Award ***[1 mark]*** for establishing a link between discharge and channel shape (lower discharge in wide, shallow or deep, narrow channels, or equivalent point made).

The remaining ***[3 marks]*** should be awarded for explanatory points, such as:

- role of hydraulic radius
- importance of wetted perimeter
- idea of friction in relation to stream efficiency
- further development of width/depth or shape explanation.

c. Responses could cover downstream impacts such as more regular discharge, differences in seasonal flow (regime), fewer floods with longer delay and lower peaks.

Upstream impacts could include lower gradient, local base level, increased evaporation and seepage.

In extreme cases lower discharge can cause severe environmental problems *eg*, the Nile Delta erosion and red water famine at Aswan, the discharge of the lower River Colorado.

Accept references to changes in sediment transport immediately downstream or upstream, possibly causing clear water erosion and deposition and effects on fluvial landforms.

Impacts that are not hydrological should not be credited; limited credit may be given for geographical knowledge of some issues about a recognizable dam/reservoir.

At band D, responses are likely to be descriptive and at least two hydrological impacts should be related to changes resulting from dam construction.

At band E expect <u>either</u> a greater range of impacts <u>or</u> an evaluation of how impacts may vary *eg*, positive/negative, short-term/long-term.

At band F, expect both.

Marks should be allocated according to the markbands.

Examiners report

a. There were few problems with the two definitions, although the term drainage divide was less successful.

b. This question was not well understood, and there was some confusion about the meaning of the term stream discharge. Some candidates had a reasonably good idea and could relate discharge to the explanation of friction, hydraulic radius and wetted perimeter. Channel size was dealt with better than shape.

c. Generally this question was very poorly answered, with the question not being understood by many candidates. The term hydrological impacts caused significant problems. The majority of candidates either tried to relate to the hydrological cycle, or wrote an answer that focused on human and economic, rather than hydrological, impacts.

a. Briefly outline **two** processes of river erosion. [4]

b.i. Explain how irrigation can lead to salinization. [2]

b.ii. Explain **two** consequences of salinization for farmers. [4]

c. Discuss the positive **and** negative **hydrological** impacts of dam and reservoir construction. [10]

Markscheme

a. *In each case, award **[1]** for identifying the process, and **[1]** for a brief outline.*

- Hydraulic action **[1]** in which the force of water hitting the banks causes erosion **[1]**.
- Abrasion / corrasion **[1]** – wearing away of river sides and bed by the river's load **[1]**.
- Attrition **[1]** – material moved along the bed of a river collides with other material and breaks it up into smaller pieces **[1]**.
- Corrosion / solution **[1]** – depends on chemical composition with certain rocks dissolving more **[1]**.

b.i. Salinization is the build-up of salts in soil to an excessive level. It can occur when there is over-irrigation **[1]** (*ie*, where more water is added than

can be taken up by the plants). If the groundwater has a high salt content and the

water table rises, the soil in fields may have salt levels that are too high for plant growth **[1]**.

For example: As water passes over/through the soil, it dissolves various minerals and nutrients **[1]** / in some areas, naturally high levels of evaporation increase the salt content at the surface **[1]** / capillary action also brings water to the surface where evaporation leaves the salts **[1]**.

b.ii. *In each case, award **[1]** for valid consequence and **[1]** for further explanation/detail.*

Possible consequences include:

- may be very costly for farmers **[1]** as yields of crops may decrease / as may have to add expensive artificial fertilizers **[1]**
- salinity may affect the structure of the soil **[1]**, resulting in surface soil compaction **[1]**
- loss of vegetation cover **[1]** may expose the area to the effects of soil erosion **[1]**.

For example: Crops tend to have low salt tolerance **[1]** so salinization reduces crop yield/makes it less productive **[1]**.

c. Responses could cover downstream positive impacts such as more regular discharge, reduced differences in seasonal flow (regime), fewer floods

with longer delay and lower peaks. Upstream positive impacts could include lower gradient and change to local base level.

Negative downstream impacts are that lower discharge can cause severe environmental problems, *eg*, the Nile Delta erosion and red water famine at Aswan, the reduced discharge of the lower River Colorado. Negative impacts upstream could include increased evaporation and seepage.

There could also be reference to changes in sediment transport immediately downstream or upstream, with effects on fluvial landforms.

Some credit may be given for geographical knowledge of some issues about a recognizable dam/reservoir.

Good answers may discuss in detail the potential positive and negative hydrological impacts of dam construction before arriving at a final evidenced conclusion. An alternative approach would be to provide a structured discussion of the question from different perspectives, as these may differ on what constitutes positive or negative.

At band D, expect two hydrological impacts to be described and linked to dam construction.

At band E, expect <u>either</u> a more detailed explanation of greater range of hydrological impacts <u>or</u> a structured discussion of both positive and negative hydrological impacts.

At band F, expect both of these elements.

Marks should be allocated according to the markbands.

Examiners report

a. [N/A]
b.i. [N/A]
b.ii. [N/A]
c. [N/A]

---

a. Outline **two** environmental problems that may occur downstream from multi-purpose dams. [4]

b. Define the concept of “maximum sustainable yield” of freshwater. [2]

c. With reference to **one named** river basin, explain **two** strategies that have been adopted to meet competing demands for water. [4]

d. “The negative consequences of river flooding always outweigh the benefits.” Discuss this statement. [10]

Markscheme

a. *In each case, award **[1]** for a valid problem and **[1]** for development*.

For example: Reduced nutrient transport downstream **[1]**, resulting in decreased agricultural/fisheries yields **[1]**.

Problems could include:

• loss of biodiversity
• increased risk of salinization
• less water for agriculture
• clear water erosion
• decreased fish stocks
• flooding due to dam collapse

Accept other creditable suggestions as long as they are downstream from the dam.

b. *The maximum level of extraction of water **[1]** that can be maintained indefinitely for a given area **[1]***.

Alternative acceptable definitions include:

• the relationship/balance between inputs and outputs **[1]** so that water does not run out for the foreseeable future/on an annual basis **[1]**
• the largest amount of water that can be taken from a resource **[1]** without depleting the original source or potential for replenishment **[1]**.

c. *In each case, award **[1]** for a valid strategy, and **[1]** for further development.*

*Award a maximum of **[3]** if no example is given*.

One approach is to manage the conflicting needs of different user groups, *eg* farmers, industries and domestic users. Another approach is to tackle the issue of too many domestic users competing for limited water.

For example: In the Colorado River basin: state administrations impose quotas **[1]** for different user groups, *eg* casinos/golf courses **[1]**, restricting consumption in order to conserve water. At the local scale, homeowners in any city are competing for a limited amount of water and have to implement their own conservation measures, *eg* flushing the toilet less often **[1]**. This is encouraged by grants for low-flush toilets **[1]**.

Other possibilities include:

• domestic pricing
• rationing
• water metering
• conservation measures, *eg* shorter showers, re-use of grey water, replacing grass with sand and succulents, more efficient irrigation systems – drip rather than sprinkler, desalinization projects
• storage of water: *eg* dams/reservoirs
• inter-basin water transfer.

d. Answers would be expected to discuss the advantages and disadvantages of river flooding.

The benefits of flooding could include the formation of floodplains; areas of flat land; fertile alluvial soils suitable for agriculture; areas for human settlement; formation of wetland ecosystems; maintaining ecosystems; re-charging of groundwater. Opportunities may exist, for example, for aquaculture; some economies are closely connected to the flood cycles.

The negative consequences of floods may include loss of life, damage to infrastructure, housing and farmland. Economic and social losses may be substantial, especially in urban areas on floodplains.

It may also be argued that the information gained from a river flood helps guard against future inundations, and that frequent monitoring and management strategies may reduce the impact of flooding. Similarly, it may be argued that river flooding is largely beneficial and that many ancient civilizations depended on the regular flooding of rivers. However, because of climate change and other human factors, flood frequency and magnitude has increased.

Good answers would be expected to discuss in detail the potential advantages and disadvantages of flooding in a way that arrives at a final evaluation. An alternative approach would be to provide a structured discussion of the statement from different perspectives, as these may differ on what constitutes a benefit or cost.

At band D, expect a description of some consequences of river flooding.

At band E, expect <u>either</u> more detailed explanation of the advantages and disadvantages of river flooding <u>or</u> a structured discussion of the statement.

At band F, expect both of these elements.

Marks should be allocated according to the markbands.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]

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a. Describe **two** processes involved in the transport of a river's load. [2+2]

b. Explain **two** environmental impacts of agriculture on water quality. [3+3]

c. "Floodplain management strategies have more costs than benefits." Discuss this statement. [10]

Markscheme

a. Award [1 mark] for identifying the process, and [1 mark] for a brief elaboration of each process.

Suspension: particles of finer materials such as clay and silt are held up by turbulence and make up most of the total load.

Solution: the dissolved load, derived from the solution of rocks containing carbonates or salts.

Traction: the movement of the largest particles such as cobbles or boulders along the stream bed.

Saltation: the "jumping"/bouncing of medium-sized particles along the bed.

Flotation: leaves and twigs carried on the surface of the river.

b. The environmental impacts could include salinization, agro-chemical runoff, pollution of groundwater and eutrophication. For each impact award [1 mark] for use of the correct term and a further [2 marks] for development.

For example, eutrophication [1 mark] is a nutrient enrichment of streams and lakes caused by agricultural runoff from nitrate fertilizers carrying excess nutrients [1 mark]. This can cause algal blooms and reduced levels of oxygen in water [1 mark].

c. Responses should discuss how strategies may prevent or exacerbate the flood risk, or may do both depending on the hydrological conditions prevalent at the time. Possible strategies could include:

- the construction of artificial levees
- flood barriers/walls to protect settlements
- flood relief channels
- flood basins or zones to absorb floodwater
- the creation/maintenance/restoration of wetland areas
- the removal of settlements from flood prone areas
- afforestation to increase interception
- enlargement of the channel e.g. by dredging
- straightening of river channels
- terracing, soil bunds and contour ploughing to reduce runoff
- dam construction – though this not always related to floodplains.

Answers may refer to several strategies in breadth or fewer strategies in more depth. The inclusion of floodplain examples is not directly asked for but these are expected in responses reaching band D and above.

Answers that simply describe strategies without discussing whether they increase or decrease floods (or both) should not move above band C. Responses that present a balanced argument are likely to be credited at bands
E and F.

Marks should be allocated according to the markbands.

Examiners report

a. Many (succinct) correct responses. Some did not use correct terms but described the process. Some had erosion and/or transport and deposition terms.

b. Some very competent answers. Most candidates found it easy to explain one environmental benefit though many failed to find a suitable second benefit. Also, many answers tended to describe the causes of salinization and eutrophication rather than explain their impacts on water quality so an inability to elaborate cost marks. Some weaker candidates stated irrigation was an impact and also lost marks.

c. Poor answers focused on one aspect of floodplain management, for example, all that can be written about the Aswan Dam. Many listed strategies, like dams, channelization and so on but failed to evaluate them as strategies for preventing/exacerbating floods. Generally, only a limited range of floodplain management strategies were presented and few candidates were therefore able to enter a detailed discussion. Very good responses used good examples to support analysis.

The map extract shows an area in western Mexico. The scale of the map is 1:250 000 and the contour interval is 100 metres.

[Source: Extract from a map of Tepic, Mexico (F13 – 8), produced by Instituto Nacional de Estadística y Geografía (INEGI), www.inegi.org.mx
]

CONTOUR INTERVAL 100 METRES

SCALE FOR MAP 1:250 000

5 4 3 2 1 0 Kilometres 10 20

KEY/LEGEND FOR MAP

POPULATIONS

LOCALITY	○
WITH MORE THAN 500 000 INHABITANTS	CHIHUAHUA
50 001 TO 500 000 INHABITANTS	ZAMORA
15 001 TO 50 000	AGUA PRIETA
2501 TO 15 000	Nicolás Bravo
LESS THAN 2501 INHABITANTS	La Misión
TEMPORARY LOCATION OR NAME OF PLACE	□ Buenavista

TERRESTRIAL ROUTES

PAVED ROAD	
STATE OR FEDERAL ROAD NUMBER SIGNPOSTING	MEX 15 ZAC 10
UNPAVED ROAD/DIRT TRACK	
BREACH, PATH	

REPRESENTATION OF THE RELIEF

CONTOUR LINE IN METRES	2500
NORMAL CONTOUR LINE	

HYDROGRAPHIC CHARACTERISTICS

BODY OF WATER: PERENNIAL, INTERMITTENT

SPRING, DISAPPEARING CURRENT

OTHER AREAS

MARSH, LAND SUBJECT TO FLOODING

SALT MINES, MALPAIS

DUNES, SANDY AREA

DENSE VEGETATION, GREEN URBAN AREA

OTHER CULTURAL CHARACTERISTICS

RUNWAY, AIRPORT: INTERNATIONAL, NATIONAL, LOCAL

ELECTRIC TRANSMISSION LINE WITH ELECTRICITY PYLONS	EL

BRIDGE, TUNNEL

CANAL, DAM

BORDER (EARTH RIDGE FOR CONTROLLING FLOW OF IRRIGATION)

a. Describe the geographical characteristics of the Río Grande de Santiago downstream from La Presa. [4]

b. Analyse how the freshwater resources shown in box A on the map could be used for different purposes. [6]

c. “People should not try to prevent rivers from flooding.” Discuss this statement. [10]

Markscheme

a. Award 1 mark for meandering, 1 mark for south-west direction and 2 marks for other characteristics such as oxbow lake or delta.

Award a maximum 3 marks for a list of landforms with no overview/description.

Full marks should not be awarded in the absence of map evidence – names or grid references.

b. Use of the river for irrigation, navigation, domestic use.

Wetland has potential for tourism, nature reserves, farming, aquaculture.

Lakes – fish farming, tourism, sport and recreation.

At least two different types of water resource (wetlands, rivers, lakes) should be analysed.

A maximum of 4 marks should be awarded where only one resource is analysed.

Full marks should not be awarded without some use of map evidence – names or grid references.

c. There are various approaches to answering this question. Candidates could focus on avoiding the expensive consequences of river flooding, or the impacts of levée building on floodplains or alternative stream management strategies.

Answers should propose arguments for and against allowing rivers to flood. Arguments against could include the need to protect population, settlements, infrastructure, farmland crops and livestock from loss.

Mention of drawbacks of natural flooding could include loss of agricultural land, the cost of relocation of population, transport disruption, contamination of water supplies, the spread of disease and disease-carrying insects, loss of life and property. Reference could be made to flood frequency and the cost of protection from small, medium and large floods.

Counter-arguments may refer to engineering strategies that actually exacerbate flooding downstream in terms of the increased volume and reduced arrival time of a flood surge. The benefits of allowing rivers to flood naturally might include reduced costs of levée and dam construction, the accumulation of new soil thus raising fertility and reducing the need for chemical fertilizers, more organic content entrained in the river boosting the aquatic ecosystem, lower and later flood crests, and less erosion of the river bed. Answers may also refer to the benefits of the re-establishment of wetland areas to absorb floodwater, thus lowering flood peaks and reducing the risk downstream.

Good answers will probably conclude that a balance of protection in some areas and allowing floods in others is the best solution. Not all of the above is needed for an answer to reach the top bands, however, answers that present only one aspect of the argument should not be credited above band C.

Marks should be allocated according to the markbands.

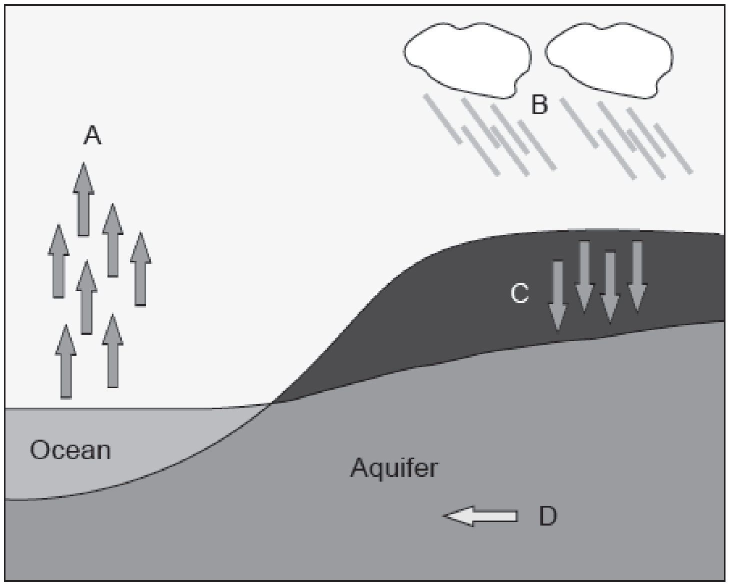
Examiners report

a. Descriptions of the "geographical characteristics" were poor and often failed to include direction of flow or to identify specific landforms that were clearly visible on the map.

b. Many attempts failed to distinguish between the different freshwater resources shown on the relevant area of the map. Some ideas (such as building a hydroelectric power station) revealed a complete lack of appreciation for scale or reality.

c. There were some strong, well-balanced responses; weaker responses tended to be purely descriptive of past flood events or flood protection strategies.

The diagram shows some possible water movements in the hydrological cycle.



[Source: © International Baccalaureate Organization 2018]

a.i. State the **four** elements of the hydrological cycle labelled A–D. [2]

a.ii. State **two** possible methods of artificially recharging the aquifer. [2]

b. Explain **three** possible ways people may modify a river channel to increase the flow of water. [6]

c. To what extent has the management of **one** major wetland area been successful? [10]

Markscheme

a.i. *Award **[2]** for all four correct answers, **[1]** for two or three correct answers.*

A = evaporation

B = precipitation (accept rainfall)

C = infiltration (accept percolation)

D = groundwater flow (accept baseflow).

a.ii. *Award **[1]** for any of the following points, up to a maximum of **[2]**:*

- the creation of recharge basin lakes
- controlled flooding/irrigation
- water pumped down the bore hole
- drainage diversion
- other valid methods.

b. *In each case, award **[1]** for correct identification of a method and **[1]** for a valid explanation of how it increases the flow of water (may make applied use of concepts such as wetted perimeter, hydraulic radius, channel efficiency).*

For example, straightening/shortening a river channel **[1]** increases the gradient and therefore the velocity **[1]**.

Other possibilities include:

- concreting the channel/decreasing the roughness
- widening/deepening/levees
- dredging.

c. Responses should clearly identify one major wetland. If more than one wetland is referred to, credit only the first.

Major wetlands include, for example, the Kissimmee, the Everglades, Norfolk Broads.

Responses should clearly outline the management with respect to why it was needed and its aims. There are numerous reasons why wetlands are managed: biodiversity issues, restoration of wetlands, ecotourism, natural flood defenses. Management can then be evaluated in terms of how successful it has been (or not).

Good answers may discuss the extent to which different stakeholders have different perspectives on whether the strategy has been successful. Another approach might be to evaluate the extent to which all aims and objectives have been met (there may be spatial and temporal dimensions to this).

At band D, responses should describe the management of a major named wetland, and may assert partial success/failure.

At band E, there should be either greater explanation of the strengths and weaknesses of the management, or a critical evaluation of the extent of success.

At band F, expect both.

Marks should be allocated according to the Paper 2 HL and SL markbands.

Examiners report

a.i. [N/A]
a.ii. [N/A]
b. [N/A]
c. [N/A]

---

a. (i) Briefly outline how the natural recharge of an aquifer takes place. [4]

(ii) State **two** methods that can be used to artificially recharge an aquifer.

b. Suggest how **three** human modifications of a floodplain can help to reduce flooding. [6]

c. Evaluate the strategies that have been used to resolve competing demands for water in **one named** river basin [10]

Markscheme

a. (i) Natural recharge happens through normal percolation after rainfall/snowfall **[1]** and/or a gradual seepage from rivers or other water bodies **[1]**.

*Credit any valid extension of either point or any comment that relates to the geology/porosity of rock **[1]** of the area that allows downward movement of water.*

(ii) Through creation of recharge basin lakes **[1]** or water pumped down the bore hole **[1]**. Credit any other logical reason why more water could be introduced to a region where an aquifer is present, *eg* drainage diversion **[1]**.

b. *In each case award **[1]** for explanation of what the modification is and **[1]** for link clearly established with flooding.*

Modifications should be exclusive of each other. Modifications could include:

- afforestation
- changing agricultural practices
- urban changes *eg* “greening”
- river management schemes *ie* any measures that decrease the flood (*eg* flood relief channels, land-use zoning/river restoration schemes, channelization, levees).

For example: Flood relief channels are artificial channels parallel to the river **[1]** which divert water away from the river in a controlled manner, reducing flood risk **[1]**.

For example: Restoration of rivers allows them to meander and deliberately flood an area **[1]**, reducing the risk of floods downstream **[1]**.

Only modifications on the floodplain may be credited.

c. Responses will depend on the river basin chosen. The river basin should be named and located.

The competing demands should be outlined and could include farming, industry, domestic supplies, recreation and power supply.

Strategies depend on the river basin selected but could include: customer metering of water, dams and reservoirs, transfer of water, zoning, water use restriction (temporary or permanent), customer advisory services, the use of incentives for installation and/or retrofitting of water efficient equipment, reduction of water use by the water utility, leakage detection and repair programmes and pressure reduction, regulation of the efficiency of water using appliances, especially in new buildings, and use of reclaimed water (*eg* waste water/grey water) to reduce the need for fresh water supplies.

Good answers may discuss the varying power and/or perspectives of different user groups in relation to how a resolution is arrived at (commercial/human need for water may ultimately take precedence over the needs of ecosystems/wetlands, for instance) Another approach might be to evaluate the importance/success of strategies/actions.

Answers that do not refer to a named river basin and focus on demands only should not move beyond band C.

At band D, expect description of some strategies used to tackle water demand problems in a recognizable river basin.

At Band E, expect <u>either</u> more in-depth explanation of strategies, <u>or</u> some critical evaluation of how successful the strategies have been.

At band F, expect both.

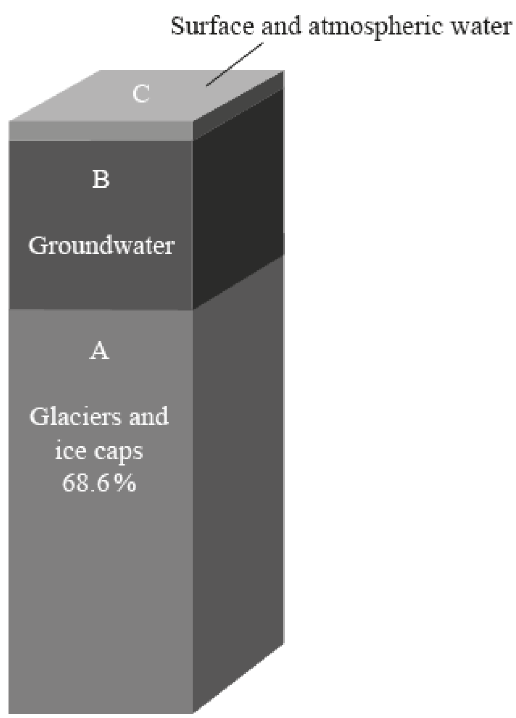
Marks should be allocated according to the markbands.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Option A — Freshwater – issues and conflicts

1. The diagram shows the three main sources of freshwater on Earth.



[Source: *Water in Crisis to the World Fresh Water Resources* by Gleick (1993) Fig. "Distribution of Earth's Water" from Chp. "World fresh water resources" by Shiklomanov. By permission of Oxford University Press, Inc.]

a. (i) Define the term *groundwater*. [2]

(ii) Estimate the percentage of groundwater shown on the diagram.

b. State **two** major types of natural surface freshwater (other than rivers). [2]

c. Explain **three** consequences of a reduction in the volume of ice caps. [6]

d. Discuss the relative importance of the factors affecting the characteristics of hydrographs. [10]

Markscheme

a. (i) Water found below the surface of the earth ***[1 mark]***.

(ii) Accept answers in the range 25–30% (inclusive) ***[1 mark]***.

b. Accept lakes, wetlands (marshes or swamps), depression storage/surface storage.

Award ***[1 mark]*** for each source identified.

c. Accept any of the following. In each case, award ***[1 mark]*** for a valid consequence and ***[1 mark]*** for a valid explanation. For example:

- coastal flooding/inundation ***[1 mark]*** due to rising sea levels/more water stored in oceans ***[1 mark]***
- relocation of coastal settlements ***[1 mark]*** due to heightened long-term flood risk ***[1 mark]*** (but do not credit suggestion that massive flooding occurs "overnight" leading to death and destruction)
- accelerated global warming ***[1 mark]*** due to albedo reduction as ice melts ***[1 mark]***
- loss of productive agricultural land ***[1 mark]*** due to saline intrusion/contamination of freshwater
- landscape changes as land-based glaciers retreat ***[1 mark]*** due to moraine deposition *etc* ***[1 mark]***
- possible river flooding ***[1 mark]*** due to melting of ice caps/glaciers ***[1 mark]***.

Credit other valid consequences and explanations.

d. *Credit all content in line with the markbands. Credit unexpected approaches wherever relevant.*

One approach would be to look at a single river: temporal variations are based on factors such as precipitation (amount, intensity, type), antecedent rainfall and seasonal changes in vegetation/interception. Another approach is to compare a different river: geology, soils and land-use (urbanization), drainage basin size and shape, relief, all play an important role.

Factors should be linked with characteristics that can include rising limb, falling limb, lag-time and peak discharge. Diagrams should be credited.

Certain domain factors could be identified such as geology (when discussing different basins), or antecedent conditions (when discussing variations in response to two similar sized rainfall events). Urbanization over time is a key factor that can transform hydrographs. Clearly, any evaluation of relative importance is context specific.

At band D, a range of factors should be described that are linked to some recognizable hydrograph characteristics.

At band E there should be either a wider or structured discussion of factors (may compare different basins, as well as considering seasonal changes or urban/rural contrasts) or a viewpoint is argued about the relative importance of factors (but for a more limited range of factors/scenarios).

At band F, expect both elements.

Examiners report

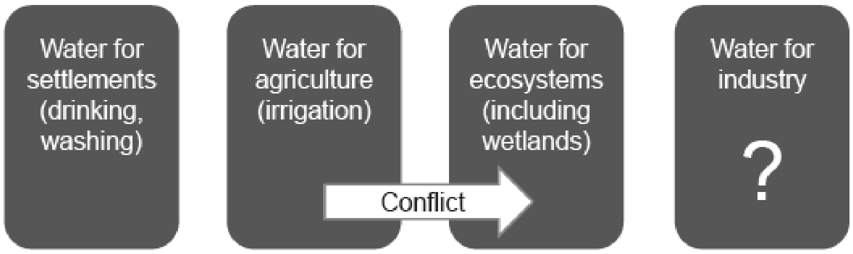
a. (i/ii) No problems encountered.

b. These had to be natural and surface, for example, lakes, springs. Too many candidates named oceans, aquifers, reservoirs and were therefore unable to identify a second type of freshwater.

c. Generally done well although the explanations were sometimes very descriptive rather than backing up the consequence.

d. There were some very good answers showing that hydrographs and the factors affecting their characteristics are being well taught. There were some good annotated diagrams and terminology was clear. The main weakness was not considering the relative importance of the factors. However, many wrote generalized answers on rivers and showed no understanding of the term hydrographs.

The diagram shows competing water demands and water conflict in a river basin.



[Source: © International Baccalaureate Organization 2015]

a. State **two** possible uses of water for industry. [2]

b. Outline **two** possible reasons for the conflict shown. [4]

c. Explain how a drainage basin functions as an open system. [4]

d. Compare the importance of river erosion and deposition in the development of floodplain landforms. [10]

Markscheme

a. Award **[1]** each for any of the following up to a maximum of **[2]**:

- electricity/HEP
- transport
- raw material
- cooling
- waste disposal
- recycling, *eg* paper
- manufacturing of goods
- cleaning (must be related to industry) – *eg* in fish factory
- other creditable suggestions.

b. The conflicts can relate to water quality or water quantity. In each case, award **[1]** for identifying a specified reason of conflict and **[1]** for some outlined development, either of why the conflict occurs, or what its impact is on ecosystems.

For example: Irrigation can lead to agricultural runoff **[1]** which pollutes rivers with nitrates leading to eutrophication **[1]**. Dam building to increase water supply for agriculture **[1]** means fish cannot migrate and breed **[1]**.

Possible reasons could include, but are not limited to:

- groundwater depletion
- salinization
- drainage diversion
- dam building
- pollution/eutrophication.

Award no more than **[1]** in total for responses that simply assert that there is not enough water to go around, unless some additional details are given.

c. Award **[1]** for identifying that the system has inputs (precipitation/rainfall) and outputs.

Award **[1]** for each of the following, up to a maximum of **[2]**:

- discharge, evaporation and/or transpiration are the outputs (must identify two)
- transfers take place, such as overland flow (must specify at least one transfer)
- stores such as soil moisture, interception storage (must specify at least one store)
- operation of feedback loops.

Reserve the final **[1]** for explicit recognition of the meaning of “open” (allows transfers across system boundary).

Up to **[4]** may be awarded for a diagram that includes specific inputs, outputs, stores, transfers and feedback related to a drainage basin. If the system diagram is not related to a drainage basin, award up to a maximum of **[2]**.

d. Key processes include erosion (abrasion, hydraulic action, corrosion) and deposition (sorted by sediment size and shape).

Landforms include floodplain, meanders, oxbow lakes, levees, braided channel, delta, river terrace, slip-off slopes, etc.

Do not expect wide coverage of landforms if the quality of the argument (compare) and detail of the process is strong. Any argument should focus on the comparative importance of erosion and deposition for individual landforms or the floodplain as a whole.

Good answers may compare the importance of different processes for different landforms on a case by case basis (*eg* compare the role that both erosion and deposition play in floodplain or meander formation). Another approach might be to offer an overview of the development of the floodplain as a whole, during times when either erosion or deposition dominates (linked to flood events perhaps).

For band D, expect some description of some landforms, with some basic link(s) with river processes (erosion and/or deposition).

At band E, expect either a more detailed explanation of landforms (*eg* different types of erosion) or a structured comparison (*eg* can group landforms into erosional and depositional types).

At band F expect both of these elements.

There may be other approaches and these should be credited accordingly.

Marks should be allocated according to the markbands.

Examiners report

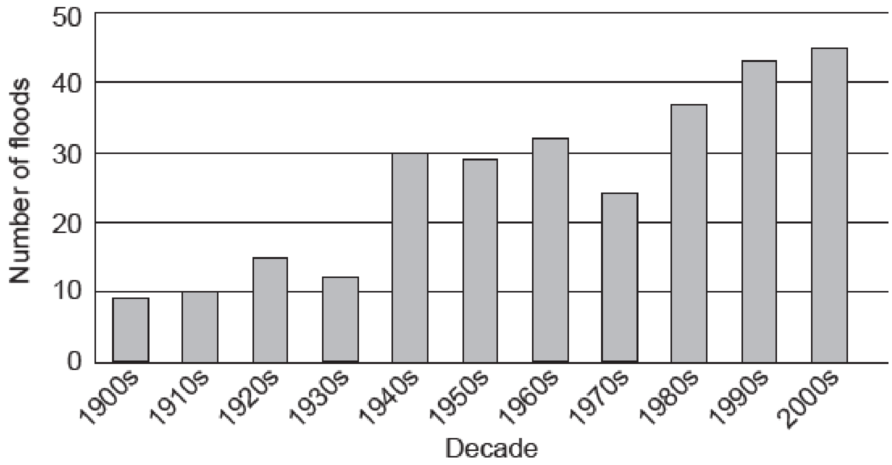
a. No problems.

b. There was some confusion over the diagram and the arrow, which showed conflict between water for agriculture and ecosystems. Reasons for conflict were stated, but often not developed sufficiently for the second mark.

c. This was generally poorly answered, with many candidates not understanding how a drainage basin functions as an open system, with inputs, outputs, stores and transfers. Many were unable to define the word “open system” beyond the fact that it has inputs and outputs.

d. There was a general lack of knowledge and understanding regarding floodplain landforms, and the contribution of erosion and deposition in their formation. Meanders, oxbow lakes and levees were popular. It was worrying that some candidates thought that waterfalls are a feature of floodplains. The command word “compare” was largely ignored, and there was little evaluation of the relative roles of erosion and deposition in the formation of landforms.

The graph shows the number of floods per decade for a river.



[Source: copyright International Baccalaureate Organization, 2016]

a. (i) Describe the changes in flood frequency shown on the graph. [4]

(ii) Estimate how many more floods occurred in the 1990s than in the 1930s.

b. Suggest **one** physical reason **and one** human reason why the risk of a river flooding can change over time. [6]

c. To what extent are floodplain landforms the result of river deposition? [10]

Markscheme

a. (i) Possibilities include:

- increasing number of floods **[1]**
- appears to be cyclical **[1]**
- there are two flood-rich periods (1940s to 1960s; 1980s to 2000s) **[1]**
- one/two flood-poor periods (1900s to 1940s; possibly 1970s) **[1]**.

*If no quantification, maximum **[2]**.*

[3 marks]

(ii) 31 ***[1]***

*Allow answers between 29 and 33 **[1]**.*

[1 mark]

b. *Award **[1]** for each valid reason and **[2]** for development/explanation/exemplification.*

Physical reasons (over different timescales) include more rainfall/storms, climate change, antecedent conditions. Human reasons include deforestation/reforestation, increase in urbanization, climate change, change in agricultural practices, river management, increased monitoring.

For example: An increase in building/urban areas leads to more impermeable **[1]** surfaces which leads to more surface run-off **[1]** and a greater amount of water entering the river **[1]**.

For example: Very intense rainstorms **[1]** caused by low pressure systems/strong monsoonal winds/La Niña, *etc*, **[1]** create flooding as river channels are unable to cope with increased water **[1]**.

[6 marks]

c. Deposition on floodplains does help explain the majority of landforms, but some are explained by a combination of erosion and deposition.

A number of various landforms should be looked at and explained. Responses are not expected to give detailed accounts of the formation of each feature but the contribution of deposition and erosion (as required) should be made clear. Not all features are expected to be covered.

Features include meanders, oxbow lakes, river terraces (formed by both erosion and deposition) and floodplains, braiding, levees, point bars and deltas (depositional only).

Good answers may be carefully structured around mainly depositional landforms and landforms formed by other processes, *eg* erosion or mass movement. Some might consider the extent to which both erosion and deposition contribute to a particular landform, *eg* meanders, or are of varying importance at different times, *eg* seasons or longer-term change, or places.

Do not credit landforms found outside the floodplain area, eg waterfalls.

At band D, expect a number of features to be described but mainly attributed to deposition.

At band E, expect either an explanation of a number of features attributed to erosion/deposition or a combination of the two or a discussion of the extent to which deposition dominates.

At band F, expect both.

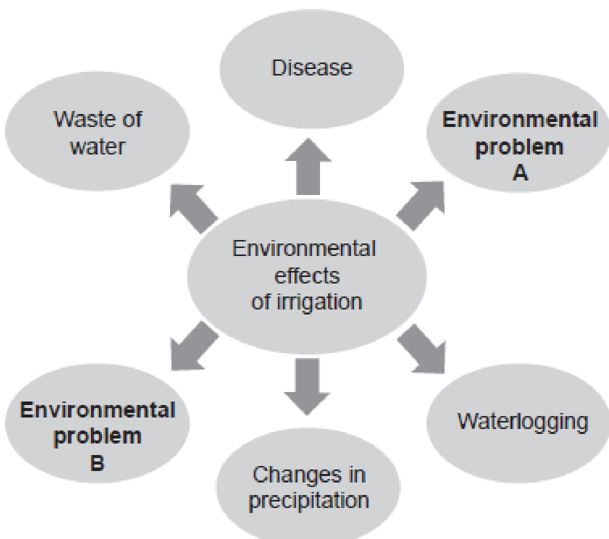
Marks should be allocated according to the markbands.

[10 marks]

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The diagram below outlines environmental problems for agriculture associated with the overuse of irrigation water.



[Source: copyright International Baccalaureate Organization, 2015]

a. State **and** briefly outline what environmental problem A **and** environmental problem B could be. [4]

b. Using **one named** example, briefly explain **one** cause and **two** consequences of an international conflict related to freshwater. [6]

c. "Natural factors are always more important than human factors in causing a river flood." Discuss this statement with reference to **one named** example. [10]

Markscheme

a. *In each case, award **[1]** for stating a valid problem and **[1]** for a relevant outline.*

Possible answers could include:

- groundwater problems – excessive use can cause rapid depletion of available supplies/subsidence of ground
- salinization – increasing concentration of salts in upper layers of soils
- pollution – irrigation run-off carries farm waste into rivers
- eutrophication – irrigation water washes fertilizers/nitrates into water bodies.

Credit any other reasonable point, such as leaching or soil erosion.

b. *For the example named, award up to **[2]** for the cause and **[2+2]** for two consequences.*

The most likely <u>cause</u> might be: two countries both in need of limited water supplies **[1]** and gives a detail, *eg* population sizes/different demands/arid climate/boundary dispute *etc* **[1]**.

Possible <u>consequences</u> could be:

- treaties/international agreement **[1]** and gives a detail *eg* date **[1]**
- escalation of international conflict **[1]** and gives a detail *eg* political repercussions **[1]**
- one country builds a dam to maximize its supply **[1]** and gives a detail *eg* date of construction, or ecological/economic harm downstream, or navigation issues **[1]**
- a substitution strategy *eg* desalinization **[1]** and gives a detail **[1]**.

For example: Sudan and Egypt had a conflict over the Nile river, as both are in need of limited water supplies **[1]** to satisfy the demands of the growing populations **[1]**. This conflict resulted in the Nile treaty **[1]** in 1959 **[1]**. Since then the Egyptians have tried to use desalinization to meet their water needs **[1]**. This uses a process called reverse osmosis to remove salt and produce freshwater **[1]**.

*Award up to a maximum of **[4]** if inappropriate or no named example.*

Two separate consequences are needed; do not credit multiple problems associated with dam construction.

If more than one example is used, mark only the first.

c. A river flood should be clearly identified and located. It is not necessary to identify an actual river, as long as a river flood is identified and located;

eg Bangladesh floods in 2005.

An account of the causes of a particular flood on the named river should be detailed. Both natural and human factors should be included (case study dependent) and good answers should include some specific details that refer to that river flood (not generalizations).

Likely human causes include urbanization, deforestation *etc.*

Physical causes may include frontal rainfall, extreme weather, steep slopes, *etc*.

Good answers may discuss how human and natural factors may interrelate: land use changes can exacerbate a natural tendency towards flashy hydrographs. A combination of urbanization and high-intensity rainfall may be the reason why extreme flooding has affected a place.

At band D, expect reference to a named river flood and a description of the natural and human causes of the flood.

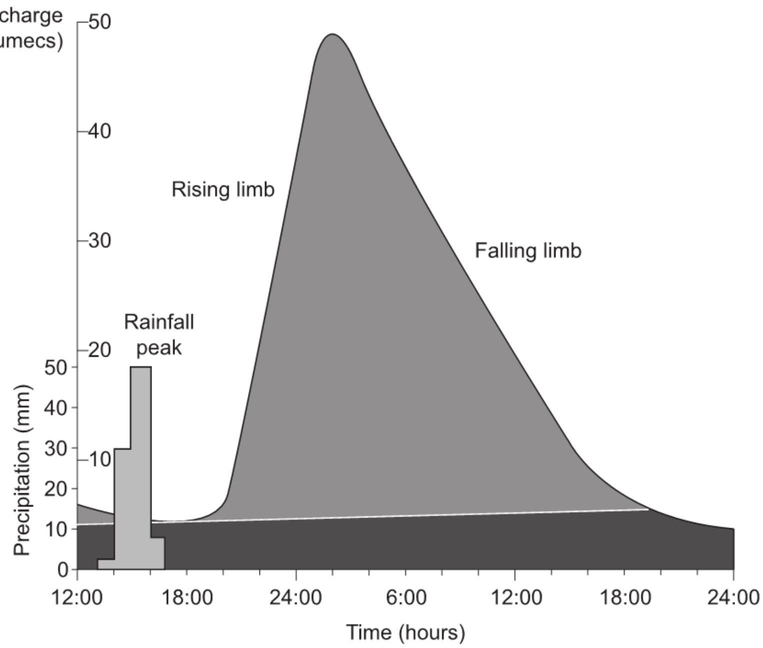
At band E, expect <u>either</u> a more in-depth explanation of the natural and human causes, <u>or</u> some critical discussion of the relative importance of natural and human factors.

At band F, expect both.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The diagram shows a storm hydrograph for a river.



[Source: © International Baccalaureate Organization 2017]

a.i. State the lag time for the storm event shown on the hydrograph. [1]

a.ii. State how many hours the discharge was over 40 cumecs. [1]

a.iii. Outline why the rising limb on this hydrograph is steeper than the falling limb. [2]

b. Explain the formation of **two** landforms on a river floodplain. [6]

c. Discuss the environmental consequences of eutrophication and the pollution of aquifers. [10]

Markscheme

a.i. 10–11 hours **[1]**

a.ii. 5 hours 30 minutes (5.5 hours) **[1]**

*Accept answers in the range 5–6 hours **[1].***

a.iii. The rising limb is steeper as it is responding to the precipitation falling in the drainage basin/rapid increase of rainwater reaching the river/rapid run-off **[1]**, whereas the falling limb still has rain reaching the river slowly/by throughflow / groundwater flow **[1]**.

b. Possibilities include, but are not limited to:

- floodplain
- meanders
- ox-bow lakes
- deltas
- levees
- terraces
- alluvial fans.

*Award **[1]** for each landform identified and **[2]** for further description/explanation of their formation.*

For example: Braiding **[1]** is a river channel with a number of interconnecting channels separating the islands or eyots **[1]**. They form when sediment-rich rivers are forced to deposit their load as discharge is reduced **[1]**.

c. Groundwater pollution and eutrophication may be caused by farming, fertilizer and waste run-off. Eutrophication occurs in a surface water store, causing algal blooms and reduced levels of oxygen in the water, whereas aquifer pollution results in the declining quality and quantity of water.

Other environmental consequences could include adverse impacts on habitats, flora and fauna, or creation of dead zones.

Good answers may compare environmental consequences on a variety of scales or from different perspectives (stakeholders). Another approach might be to compare the way eutrophication occurs at a more local scale than aquifer pollution, or the way eutrophication occurs on the surface whereas aquifer pollution occurs underground.

At band D, expect description of the two types of pollution and their environmental consequences.

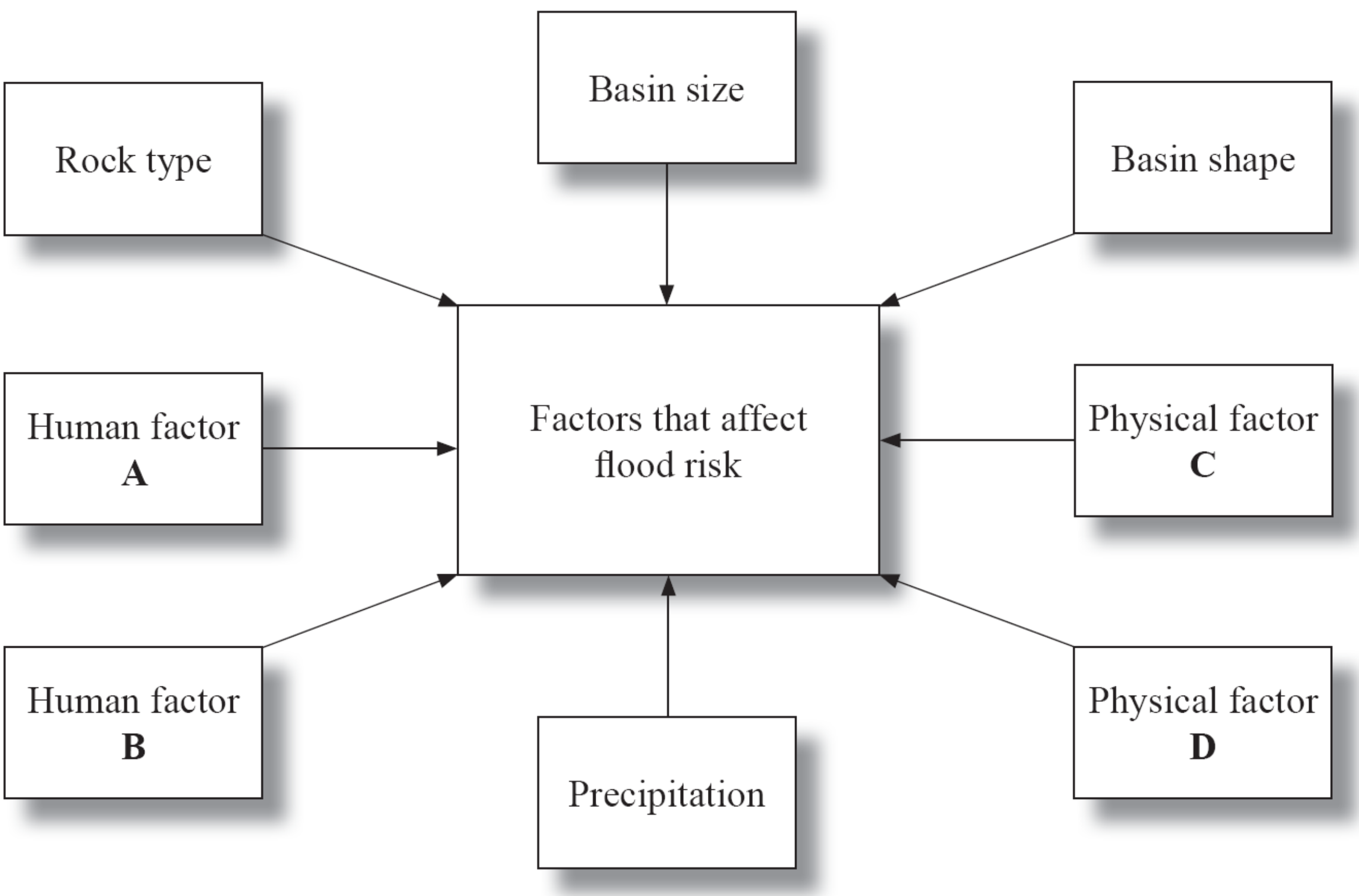
At band E, expect either a more detailed explanation of the consequences or a structured discussion of the two types of pollution.

At band F, expect both of these elements.

Marks should be allocated according to the markbands.

Examiners report

a.i. [N/A]
a.ii. [N/A]
a.iii. [N/A]
b. [N/A]
c. [N/A]



[Source: ©International Baccalaureate Organization 2013]

a. Identify possible human factors A and B and possible physical factors C and D. [4]

b. Explain how **two** physical factors other than precipitation can affect the magnitude of floods. [6]

c. "River management strategies always result in unwanted impacts." Using examples, discuss this statement. [10]

Markscheme

a. A and B could be urbanization, deforestation, overgrazing, relevant farming methods, bridges and blockages (no credit for flood defences). C and D could be soil type, steepness of slopes, drainage density, frozen ground, vegetation, saturated ground,

tidal influences.

Award ***[1 mark]*** for each correct factor.

b. Possible factors include: basin shape, drainage density, rock type, soils, relief, vegetation.

In each case award ***[2 marks]*** for explanation of how the factor operates/links made with hydrological processes and ***[1 mark]*** for link clearly established with flood ***[1 mark]*** magnitude. For example:
Basin shape: rounded basin shape has potential for high magnitude flash flooding ***[1 mark]*** due to arrival of high volume of water at the same time ***[1 mark]***. Whereas elongated basin shapes encourages lower peak discharge over an extended period of time ***[1 mark]****.*

c. A range of river management strategies is required, some of which can have unwanted impacts – channel straightening, artificial levées (also accept dams and reservoirs). These could be balanced with measures that do not have such large impacts, such as flood relief basins and channels, afforestation, wetland restoration, river restoration schemes, water quality measures. Example of a named basin should be included.

In addition to physical impacts, there are human (social, cultural, economic) impacts to consider, including land zoning issues, transport changes, gains and losses for different user groups (*eg* diversions, or forced migration from dam-building).

To access band D, examples must be used. However, the use of one named river basin and strategy which includes a range of impacts (*eg* Aswan High Dam) is unlikely to progress beyond the D/E border. At bands E and F, a range of impacts should be discussed and a conclusion arrived at.

Marks should be allocated according to the markbands.

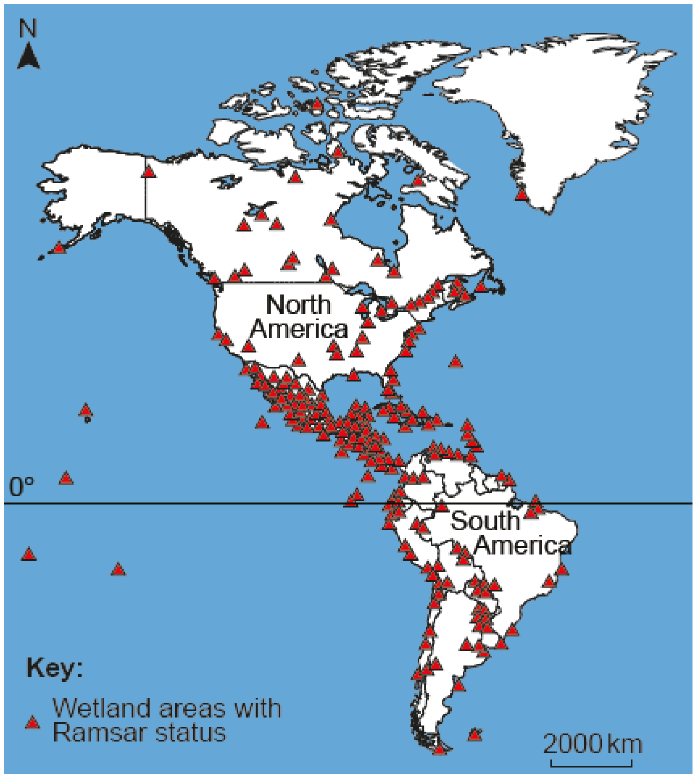
Examiners report

a. Posed few problems.

b. A small number of candidates found it difficult to link a factor with flood. Many misunderstood basin shape and drainage density, or confused a river channel for a basin. There were some good responses on the influences of rock type and vegetation on flooding.

c. A variety of river management case studies were used and most candidates were able to discuss a range of impacts, their merits and disadvantages. The weaker responses were limited by a single case study and sketchy detail.

The map shows the distribution of wetland areas in the Americas that have been given Ramsar status. The Ramsar Convention is the convention on wetlands of international importance.



[Source: adapted from www.gislounge.com]

a. (i) Define the term *wetland area*. [5]

(ii) Describe the pattern of wetland areas shown on the map.

b. (i) State **one** component of agricultural run-off that contributes to the eutrophication of lakes and wetlands. [5]

(ii) Suggest **two** impacts of eutrophication that can have adverse effects for people.

c. "The drainage basin is an open system with inputs, outputs, transfers and stores." Discuss how this knowledge helps people to prevent flooding. [10]

Markscheme

a. (i) An area regularly/seasonally/permanently/always saturated **[1]** by surface water and/or groundwater **[1]**.

[2 marks]

(ii) Possibilities include:

- mainly in the Tropics (Mexico/Central America/Caribbean) **[1]**
- fewer in higher latitudes **[1]**
- fewer in the Amazon/Brazil **[1]**
- concentrated along the coast **[1]**
- islands **[1]**.

[3 marks]

b. (i) nitrates/fertilizers/phosphates/manure **[1]**.

[1 mark]

(ii) *In each case, award **[1]** for a valid impact and **[1]** for further development.*

For example: Reduction of water quality for humans **[1]** resulting in health risks due to high nitrate concentrations **[1]**.

Other possibilities include:

- loss of wildlife/fish reduces tourism potential
- high cost of cleaning water
- other valid impacts.

[4 marks]

c. The drainage basin is the area of land drained by a river and its tributaries, separated from adjacent basins by a watershed. The drainage basin is an open system as it has an input in the form of precipitation and a series of outputs such as evapotranspiration and water returning to the sea.

There are stores and transfers facilitating the movement of water.

Flood prevention could be achieved by modifying different stores or parts of the system, *eg* forestry (interception) or reservoirs (less transfer). Knowledge of saturated soil stores can help with flood prediction though not prevention.

Some candidates may work systematically through each aspect of the drainage basin system, commenting on flood management in each case.

Good answers may discuss reasons why knowledge of the drainage basin system does not necessarily help prevent floods, for instance there are long-term unpredictable changes, *eg* climate change. Good answers might discuss the difference between flood prediction and flood prevention (knowledge of systems helps predict but not prevent).

At band D, expect some description of parts of the drainage basin system, with some relation to flooding.

At band E, expect <u>either</u> a more detailed explanation of the drainage basin system and possible flood prediction/prevention (may query whether a knowledge of drainage basins actually helps to <u>prevent</u> flooding) <u>or</u> explicitly discusses the relative importance of inputs, outputs, transfers and stores.

At band F, expect both.

Marks should be allocated according to the markbands.

[10 marks]

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Option A — Freshwater – issues and conflicts

The photograph shows the course of a river that flows into a lake.

[Source: ©International Baccalaureate Organization 2015]

a. Referring to photographic evidence, identify **and** briefly describe **two** natural features of the river valley floor clearly shown in the photograph. [4]

b. Suggest **three** ways in which humans might modify the floodplain shown in the photograph to reduce flood risk. [6]

c. “Wetland management strategies are never a complete success.” Discuss this statement, with reference to **one named** major wetland. [10]

Markscheme

a. Award ***[1 mark]*** for each valid, clearly visible feature that is identified. Award ***[1 mark]*** for each brief description using photographic evidence.

Possible features could include: meandering river, braided channel, floodplain, delta entering the lake, river cliff (lower left). For example:

- there is a meander bend ***[1 mark]*** where the river is shown to be curving around an area of high relief ***[1 mark]***
- there is braiding ***[1 mark]*** the photograph shows the river is split into three or four channels by deposition ***[1 mark]***.

Do not credit suggestions that are not clearly visible.

b. Award ***[1 mark]*** for the identification of each valid method and ***[1 mark]*** for further development through explanation or applied use of an example.

- construction of levees ***[1 mark]*** to increase channel storage ***[1 mark]***
- land-use zoning ***[1 mark]*** to ensure buildings are kept away from high risk flood locations ***[1 mark]***
- channel engineering/straightening ***[1 mark]*** to increase velocity and remove excess water quickly ***[1 mark]***
- flood relief channels ***[1 mark]*** to divert water away from high-risk/high-value property ***[1 mark]***
- storage basins and dams ***[1 mark]*** to reduce river discharge ***[1 mark]***.

Credit other valid suggestions and developments.

c. *Credit all content in line with the markbands. Credit unexpected approaches wherever relevant.*

Responses should clearly name, describe and locate one relevant major wetland. If more than one wetland is referred to, credit only the first.

Major wetlands include, for example, the Kissimee, the Mississippi Delta, the Norfolk Broads, but not small-scale ponds (award up to ***[6 marks]*** for an inappropriate scale of study if the discussion is good).

Strategies (there should be at least two included) should be clearly outlined with respect to why they were needed and what their aims were. Strategies can then be evaluated in terms of how successful they have been (or not). Good answers may approach the strategies from different perspectives (*eg* biodiversity, human water security, tourism, *etc*).

Answers that do not refer to a specific wetland should not proceed further than band C.

At band D, responses should describe one or more strategies for a major named wetland, and may assert success/failure.

For band E, there should be <u>either</u> greater detail of the strengths and weaknesses of a range of (at least two) strategies, <u>or</u> a more sophisticated discussion of the veracity of statement (but with less factual support).

At band F, expect both elements.

Examiners report

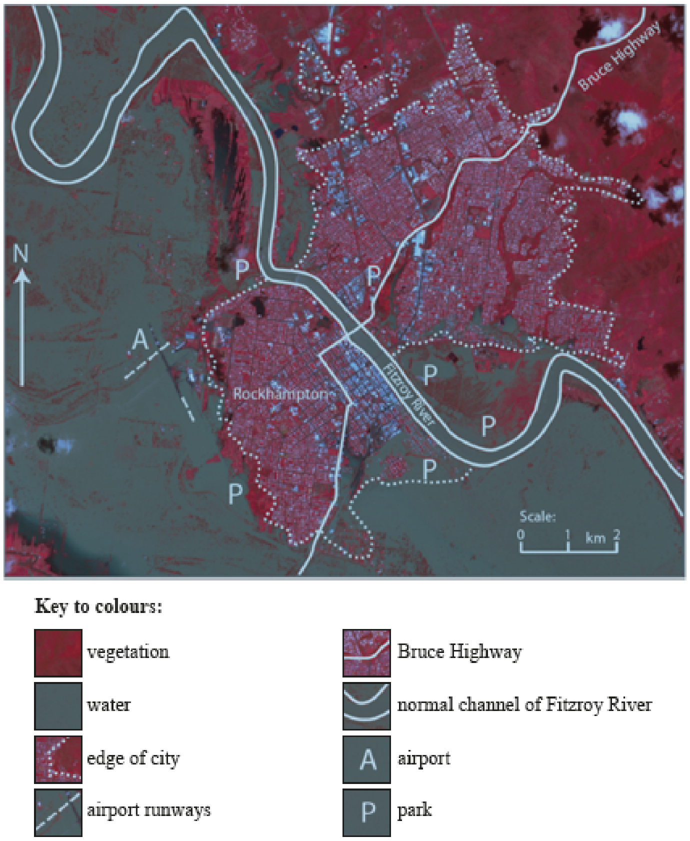
a. Although many were able to recognize discernible features, for example, braided river channel, meanders, delta, very few were able to relate the features to the photograph, or identified features that were not present, such as oxbow lakes.

b. Generally done well with valid modifications.

c. Wetlands are obviously being studied comprehensively, with the Kissimee and the Murray Basin being the most commonly read case studies. However, at least two strategies had to be discussed in order to reach the higher markbands. A number of responses could not elaborate on the strengths and weaknesses of the strategies adopted.

Optional Theme A — Freshwater – issues and conflicts

1. The satellite image shows the area around the Australian city of Rockhampton flooded by the Fitzroy River in 2011.



[Source of underlying image: www.earthobservatory.nasa.gov]

a. Briefly describe **four** possible impacts of the flood on different types of traffic movement in the area shown on the satellite image. [4]

b. Explain **two** ways in which agriculture and/or irrigation on flood plains can affect water quality. [6]

c. Examine the factors that affect the response of a stream hydrograph to a rainfall event. [10]

Markscheme

a. Award ***[1 mark]*** for each of four statements clearly relating to the photo, such as:

- airport under water (air traffic)
- Bruce Highway flooded (road vehicles)
- river transport disrupted (river traffic)
- isolation of Rockhampton from places to the west
- possible closure of bridges
- difficulty in crossing the flood plain (by any means of transport)
- some city streets likely to be impassable
- credit other valid suggestions *eg* “car parks flooded”.

Responses must make some reference to two types of traffic (road, air) for maximum ***[4 marks]*** but do not expect every point to be explicitly linked to a particular type of transport.

b. Explanations are likely to refer to two of the following – salinization, eutrophication, the impacts of agro-chemicals, effluent run-off. In each case,

award ***[1 mark]*** for the identification and up to ***[2 marks]*** for the explanation/developed exemplification.

The most likely focus for candidates will be:

Eutrophication ***[1 mark]*** occurs when fertilizers/nitrates are washed into a lake/river ***[1 mark]***. Algae grow, and then die, leading to oxygen depletion ***[1 mark]***.

c. Response of hydrograph should be addressed in terms of lag time, peak discharge, rising and recessional limb, overland flow/throughflow contributions, *etc*. Likely factors will include: basin shape, antecedent rainfall, rainfall intensity and duration, seasonality of rainfall, basin land use, type of farming soil and rock type, affecting porosity and permeability, basin relief, degree of urbanization, forest cover and seasonal changes.

   Possible responses include "flashy" response hydrographs (short time lag and very high peak flows), or a response that does not differ markedly from baseflow under some conditions (chalk lithology).

   At band D at least two factors should be described and linked to a valid response/change that may be observed in stream hydrographs.

   At band E, <u>either</u> a range of factors should be explained and linked with hydrograph features, <u>or</u> there is an examination of how certain factors interrelate *eg*, human/physical combination leads to very flashy response.

   At band F, expect both.

   Marks should be allocated according to the markbands.

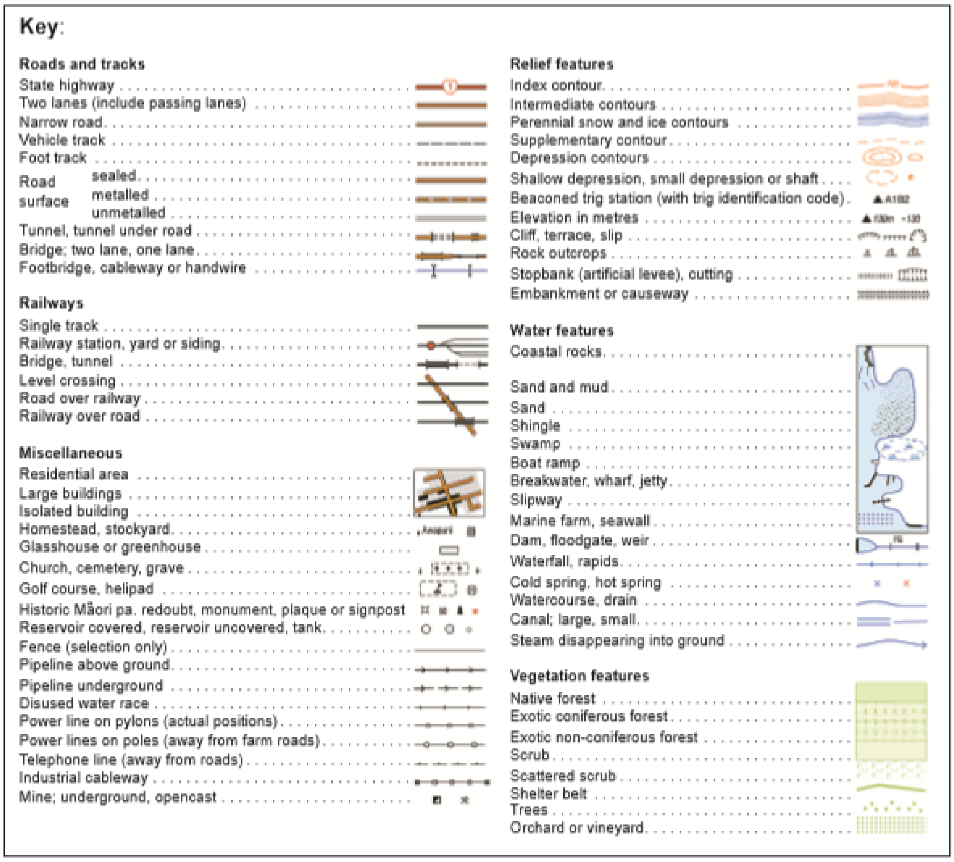
Examiners report

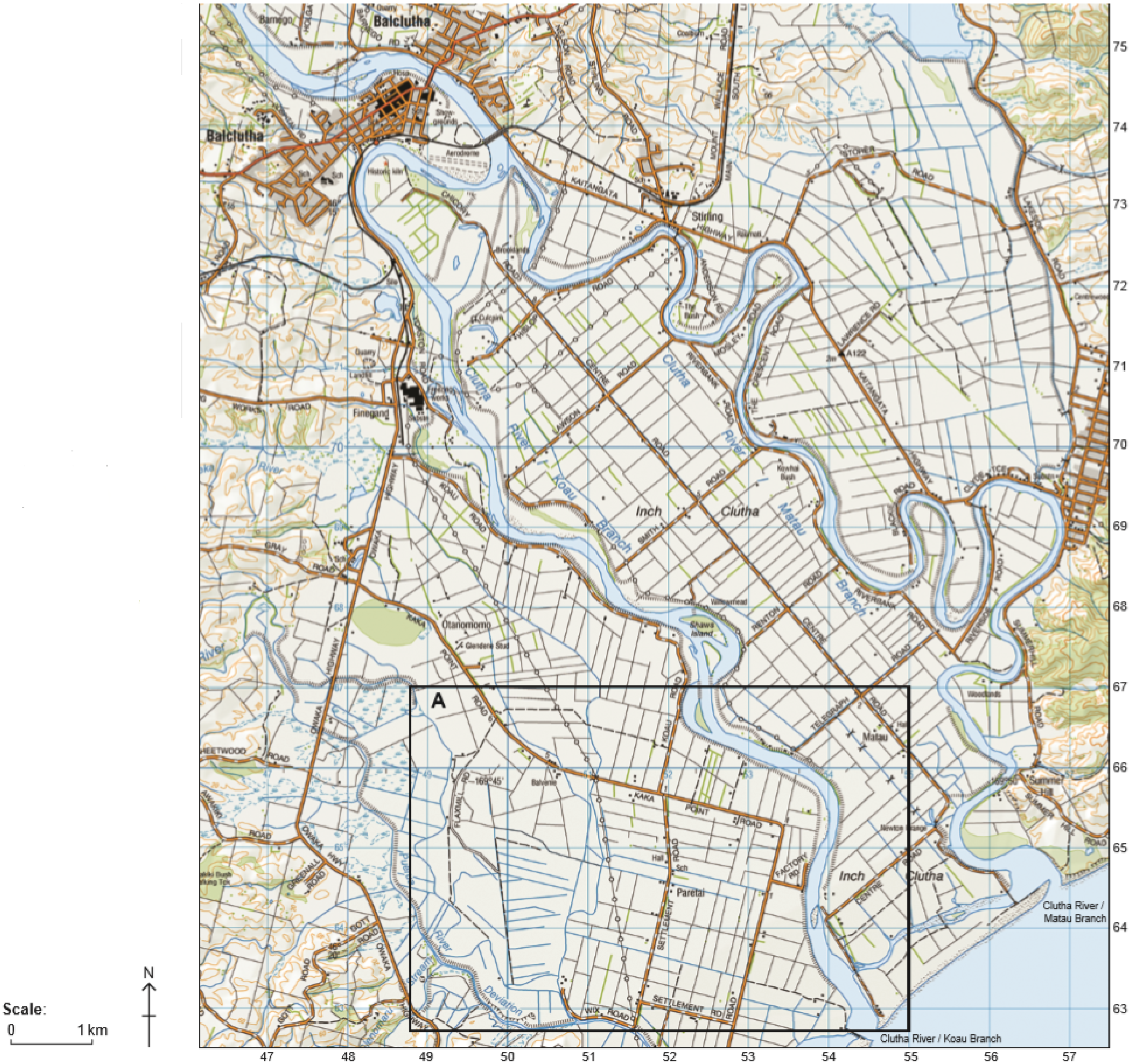
a. There were few problems in the interpretation of the satellite image. Some candidates did not keep to the question, and described impacts of flooding that were not related to traffic movement.

b. This was either done very well, identifying eutrophication and salinization as the main impacts of agriculture and/or irrigation, or missed the point all together.

c. There were some very good answers, showing clear understanding of the hydrograph and associated responses. Good knowledge was shown of factors affecting the stream hydrograph. The best responses included an annotated diagram of a stream hydrograph. However, many candidates either wrote about a flood event or tried to discuss the hydrological cycle, demonstrating a lack of understanding of the term "stream hydrograph".

The map shows the Clutha River and the town Balclutha on the South Island of New Zealand. The scale of the map is 1:50 000 and the contour interval is 100 metres.





[Source: Sourced from NZTopo Database. Crown Copyright Reserved.]

a. Identify **and** locate **two** natural river landforms found on the Clutha River's floodplain. [4]

b. (i) Briefly explain how **one** human modification of the floodplain shown in area A (outlined in black) may reduce river flooding. [6]

(ii) Suggest **two** ways in which the settlement of Balclutha may have led to increased river flooding.

c. Examine how the environmental impacts of agriculture and irrigation on water quality vary from place to place. [10]

Markscheme

a. *Award **[1]** for naming each feature eg meander, braiding, marshland, slip-off slope, river cliff, oxbow lake, distributary, eyot/ait/island, levee.*

*Award **[1]** for either a four-figure grid square reference or a valid locational/situational statement for each*.

For example:
There is a meander **[1]** southeast of Stirling **[1]**.
There is oxbow lake **[1]** at 4971 **[1]**.

b. (i)

*Award **[1]** for identifying a modification and **[1]** for explanation*.

For example:
Stopbank/artificial levee/embankment **[1]** allows higher discharge/flow/increased capacity **[1]**.
Drainage ditches/canals **[1]** carry water off the floodplain **[1]**.
River deviation scheme **[1]** diverts water away from the main channel **[1]**.

(ii)

*Award **[1]** for each valid suggestion and **[1]** for why it may have led to increased flooding*.

- Possibilities include:
- building on the floodplain
- infrastructure eg, roads on floodplain
- growth of town-impermeable surfaces
- bridge(s) over river
- railway embankment
- drains, culverts and sewers
- deforestation
- clearing of land for agriculture.

For example:
Road bridge over the river **[1]** constricts river flow and allows ponding/overflow of water **[1]**.
Urban growth of Balclutha increases concrete/asphalt **[1]** which is impermeable so water runs into river **[1]**.

c. Responses should show an understanding of a variety of impacts (from agriculture and irrigation) on water quality *eg*, eutrophication, salinization, agro-chemical run-off, groundwater pollution.

It would be expected that the causes and environmental consequences of at least two impacts should be explained.

Variation/scale/place-to-place should be considered.

Good candidates may consider, for example, that eutrophication is widespread wherever there is arable or pastoral farming with unregulated run-off into water courses and it is found worldwide. May affect rivers, lakes, wetlands and coastal margins.

At band D, answers are likely to be mainly descriptive and/or look only at one impact.

At band E, expect <u>either</u> a more detailed explanation of a range of impacts <u>or</u> an examination of how different places are affected in varying ways.

At band F expect both.

Marks should be allocated according to the markbands.

Examiners report

a. Most were able to identify two river landforms; meanders and ox-bow lake were the most common. There was a surprising inability to give a correct grid reference, or other location factor (although this was improved compared with previous sessions).

b. (i) No problems; most chose artificial levee/stopbank.

(ii) Few problems; most referred to impermeable surfaces and increased run-off.

c. Candidates showed understanding of a variety of impacts, such as eutrophication and salinization and their consequences, using located examples.