

Groundwater Dependent Ecosystem Conceptual Modelling

Technical Specifications

April 2015 Version 1.0

Security classification: Public

Katharine Glanville and Tim Ryan
Queensland Herbarium
Science Delivery
Department of Science, Information Technology and Innovation

Kylie Galway
Wetlands
Ecosystem Outcomes
Department of Environment and Heritage Protection

© The State of Queensland (Department of Science, Information Technology and Innovation) 2015

The Queensland Government supports and encourages the dissemination and exchange of its information. The copyright in this publication is licensed under a Creative Commons Attribution 3.0 Australia (CC BY) licence



Under this licence you are free, without having to seek permission from DSITI, to use this publication in accordance with the licence terms.

You must keep intact the copyright notice and attribute the State of Queensland, Department of Science, Information Technology and Innovation as the source of the publication.

For more information on this licence visit <http://creativecommons.org/licenses/by/3.0/au/deed.en>

Disclaimer

This document has been prepared with all due diligence and care, based on the best available information at the time of publication. The department holds no responsibility for any errors or omissions within this document. Any decisions made by other parties based on this document are solely the responsibility of those parties. Information contained in this document is from a number of sources and, as such, does not necessarily represent government or departmental policy.

If you need to access this document in a language other than English, please call the Translating and Interpreting Service (TIS National) on 131 450 and ask them to telephone Library Services on +61 7 3170 5725

Citation

Department of Science, Information Technology and Innovation 2015, Groundwater Dependent Ecosystem Conceptual Modelling: Technical Specifications, Queensland Government, Brisbane.

April 2015

Document history

Version	Date	Status	Key changes made	Author/s	Reviewer/s
1.0	April 2015	Complete		K.G. K.Ga T.R	Queensland GDE Conceptual Model Committee

Table of contents

Document history	3
Table of contents	4
1 Introduction	6
2 Conceptual model management	6
2.1 Development	6
2.2 Queensland Groundwater Dependent Ecosystem Conceptual Model Technical Committee	6
2.3 Review process	7
Technical Review	7
Risk Assessment	7
2.4 Publication process	7
2.5 Update process	7
3 Symbology by theme	8
3.1 Fauna	8
Symbols	8
3.2 Flora	9
Symbols	9
3.3 Geology	12
Pattern	12
Colouration	14
Lines	19
Symbols	20
3.4 Hydrology	21
Colouration	21
Lines	22
Symbols	23
3.5 Meteorology/Climate	25
Symbols	25
3.6 Processes	26
Symbols	26
3.7 Other	26
Symbols	26
4 Other	28
4.1 Fonts	28

4.2 Legend	29
Spacing	29
Text	30
4.3 Watermark	30
5 Final product export specifications	31
5.1 Product specifications for delivery through <i>WetlandInfo</i>	31
6 Guiding questions for site specific conceptual modelling of groundwater dependent ecosystems	32
6.1 General Questions	32
6.2 Climate	32
6.3 Ecology	33
6.4 Geochemistry	33
6.5 Geography	33
6.6 Geology and Geomorphology	34
6.7 Hydrostratigraphy and Hydrodynamics	34
7 References	35
Appendix A - Excerpt of 'Document preparation, peer review and approval protocol' (DSITIA 2014)	36
Review Form	36
Attachment A – Response to reviewers' comments	37
Appendix B - Excerpt of DEHP's Risk and Impact Assessment	38
Risk and Impact Assessment Matrix for Review and Release of Products on <i>WetlandInfo</i>	38

1 Introduction

This document is intended as a guide to the process for developing, publishing and distributing groundwater dependent ecosystems (GDEs) conceptual models developed by the Queensland Government. The established development, review and approval process will increase model consistency, reduce the risk of effort duplication, and ensure that all models are easily accessible. Similarly, the symbology presented here is not representative of all available symbols that can be used in conceptual modelling but a sub-set of standard symbols to be used in Queensland Government GDE products. Where possible, consistency with this symbology should be maintained by newer conceptual models.

2 Conceptual model management

2.1 Development

It is recommended that a model creator should consult with representatives of the Queensland Groundwater Dependent Ecosystem Conceptual Model Technical Committee (Committee)¹ prior to developing conceptual models to ensure that suitable models are not already available or currently under developed and that there are no suitable models that could be modified. This will ensure that there is minimal duplication of effort in developing new conceptual models and those relevant models 'speak' to one another. During the development of a conceptual model, the creator may also wish to consult the current Department of Environment and Heritage Protection (DEHP) [conceptual modelling guidelines](#) (DEHP 2012).

2.2 Queensland Groundwater Dependent Ecosystem Conceptual Model Technical Committee

The Committee will be responsible for the review and management of GDE conceptual models developed by the Queensland Government. The Committee will be formed by a panel of experts representing a wide diversity of disciplines (e.g. hydrology, ecology, geology, etc.) and stakeholders (e.g. government departments, universities, etc.). DEHP will be responsible for ensuring draft products are circulated allowing for a sufficient review period and arranging meetings as required to review draft models. DEHP will be the designated custodian of conceptual models with responsibility for:

- maintaining the library of current and legacy GDE conceptual models
- maintaining the symbol library including related technical specifications
- maintaining a register of GDE conceptual model and symbol versions
- updating the library of GDE conceptual models and symbols as required
- ensuring the library of GDE conceptual models and tools is accessible (through a web platform and on request)
- advising on or reviewing the application of GDE conceptual models in projects and programs

¹ The Committee can be reached at wetlandinfo@ehp.qld.gov.au

2.3 Review process

Technical Review

To ensure that conceptual models are technically ready for publication and distribution, drafts should be peer reviewed for the scientific accuracy, communication effectiveness, relationship to existing models and model symbology consistency. This review will be conducted on an as-needed basis by the Committee in a workshop setting with the model creator. The review needs to be documented in line with the Department of Science, Information Technology, Innovation and the Arts (DSITIA) document preparation, peer review and approval protocol (DSITIA 2014) (see [Appendix A](#)) and filed appropriately. If recommended for publication by the Committee, the relevant project manager will be informed and the draft model will be placed into the relevant publication framework based on its scale and linkages to existing models. The Committee will also evaluate whether any new symbols originating from these models should be adopted as standard.

Risk Assessment

To ensure that conceptual models are ready for publication and distribution, technically reviewed drafts should also undergo a risk assessment prior to being recommended for publication. This can be undertaken in parallel with the above technical review process. It is recommended that DEHP's Risk and Impact Assessment Matrix (see [Appendix B](#)) is completed by the project manager and provided alongside the conceptual model(s) for review. Where high risks are identified, the Committee may wish to consider a formal external peer review process to reduce this risk.

2.4 Publication process

Conceptual models recommended for publication will require a watermark to be embedded in the model prior to publication according to the technical specifications. This watermark will include relevant creative commons details and a citation (see [4.3 Watermark](#)). The citation will be assigned to the work unit and department responsible for the development of the model. The watermark may include recognition of key source material where appropriate. The model will then be incorporated into the library and uploaded onto *WetlandInfo* which will form the point-of-truth for all GDE conceptual models.

2.5 Update process

All conceptual models should be reviewed every five years by the Committee to ensure continued scientific accuracy and the inclusion of new information.




3 Symbology by theme

The symbology presented here is not representative of all available symbols that can be used in GDE conceptual modelling but is a sub-set of standard symbols used in Queensland Government GDE products. Where possible, consistency with this symbology should be maintained. This includes ensuring that symbol integrity is maintained when scaling. Tips on symbology can be obtained from Appendix B of the DEHP [conceptual modelling guidelines](#) (DEHP 2012) titled 'Tips on making a pictorial conceptual model with Adobe Illustrator'. Examples of the use of symbols are available on WetlandInfo's '[Groundwater dependent ecosystems pictorial conceptual models](#)' web page. Many symbols presented in this document (noted in footnotes) are courtesy of the [Integration and Application Network](#), University of Maryland Center for Environmental Science. Please register as a user of the Integration and Application Network where many more symbols are available for use.

3.1 Fauna

Symbols

Where relevant to the intended key messages, the following fauna symbols should be adopted. Where species level knowledge of fauna is available and relevant to the conceptual model, this information can be provided in the accompanying legend as second tier legend text (see [4.2 Legend](#)).







Object	Description	Suggested legend text	Thumbnail
Generic fauna			
Fish ¹	This symbol represents the presence of fish without providing genus or species level information.	Fish	
Stygofauna	This symbol represents the presence of stygofauna without providing genus or species level information.	Stygofauna Aquatic fauna that live in groundwater	
Fauna by genus			
Dugong ¹	This symbol represents the presence of species <i>Dugong dugon</i> .	<i>Dugong dugon</i>	

¹ symbol courtesy of the Integration and Application Network












3.2 Flora

Symbols


Where relevant to the intended key messages, the following flora symbols should be adopted. Where species level knowledge of flora is available and relevant to the conceptual model, this information can be provided in the accompanying legend as second tier legend text (see section [4.2 Legend](#)).

Object	Description	Suggested legend text	Thumbnail
Generic flora symbols			
Mangrove ¹	This symbol represents the presence of mangroves without providing specific information on vegetation composition at the genus or species level.	Mangrove	
Patterned fens ¹	This symbol represents the presence of patterned fens.	Patterned fens	
Saltmarsh ¹	This symbol represents the presence of saltmarshes without providing specific information on vegetation composition at the genus or species level.	Saltmarsh	
Seagrass ¹	This symbol represents the presence of seagrasses without providing specific information on vegetation composition at the genus or species level.	Seagrass	
Sedge ¹	This symbol represents the presence of sedges without providing specific information on vegetation composition at the genus or species level.	Sedge	
Vegetation ¹	This symbol represents the current extent of vegetation without providing specific information on vegetation composition.	Current extent of vegetation	

¹ symbol courtesy of the Integration and Application Network

Object	Description	Suggested legend text	Thumbnail
Vegetation (historic) ¹	This symbol represents the historic extent of vegetation without providing specific information on vegetation composition.	Historical extent of vegetation	
Wetland ¹	This symbol represents the presence of wetlands without providing specific information on vegetation composition at the genus or species level.	Wetlands	
Flora symbols by genus			
<i>Acacia</i> spp. ¹	This symbol represents the presence of species within the <i>Acacia</i> genus.	<i>Acacia</i> spp.	
<i>Banksia</i> spp. ¹	This symbol represents the presence of species within the <i>Banksia</i> genus.	<i>Banksia</i> spp.	
<i>Casuarina</i> spp. ¹	This symbol represents the presence of species within the <i>Casuarina</i> genus.	<i>Casuarina</i> spp.	
<i>Cladium</i> spp. ¹	This symbol represents the presence of species within the <i>Cladium</i> genus.	<i>Cladium</i> spp.	
<i>Corymbia</i> spp. ¹	This symbol represents the presence of species within the <i>Corymbia</i> genus.	<i>Corymbia</i> spp.	
<i>Eleocharis</i> spp. ¹	This symbol represents the presence of species within the <i>Eleocharis</i> genus.	<i>Eleocharis</i> spp.	
<i>Eucalyptus</i> spp. ¹	This symbol represents the presence of species within the <i>Eucalyptus</i> genus.	<i>Eucalyptus</i> spp.	
<i>Melaleuca</i> spp. ¹ (Option 1)	This symbol represents the presence of species within the <i>Melaleuca</i> genus.	<i>Melaleuca</i> spp.	
<i>Melaleuca</i> spp. ¹ (Option 2)	This symbol represents the presence of species within the <i>Melaleuca</i> genus.	<i>Melaleuca</i> spp.	

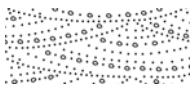









¹ symbol courtesy of the Integration and Application Network

Object	Description	Suggested legend text	Thumbnail
<i>Pennisetum</i> spp. ¹	This symbol represents the presence of species within the <i>Pennisetum</i> genus.	<i>Pennisetum</i> spp.	

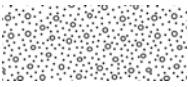
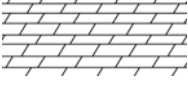
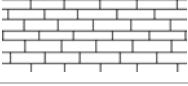
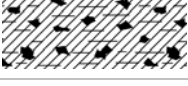




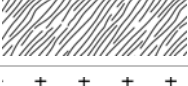
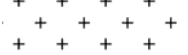
3.3 Geology

Pattern

Where specific lithology is known and relevant to the intended key messages, the following geological patterns should be adopted. The following geological patterns are adapted from the '[Digital Cartographic Standard for Geological Map Symbolisation Pattern Chart](#)' (Geologic Data Subcommittee 2006). Geological patterns, geological colouration and hydrological colouration may be combined in the legend (see [4.2 Legend](#)).

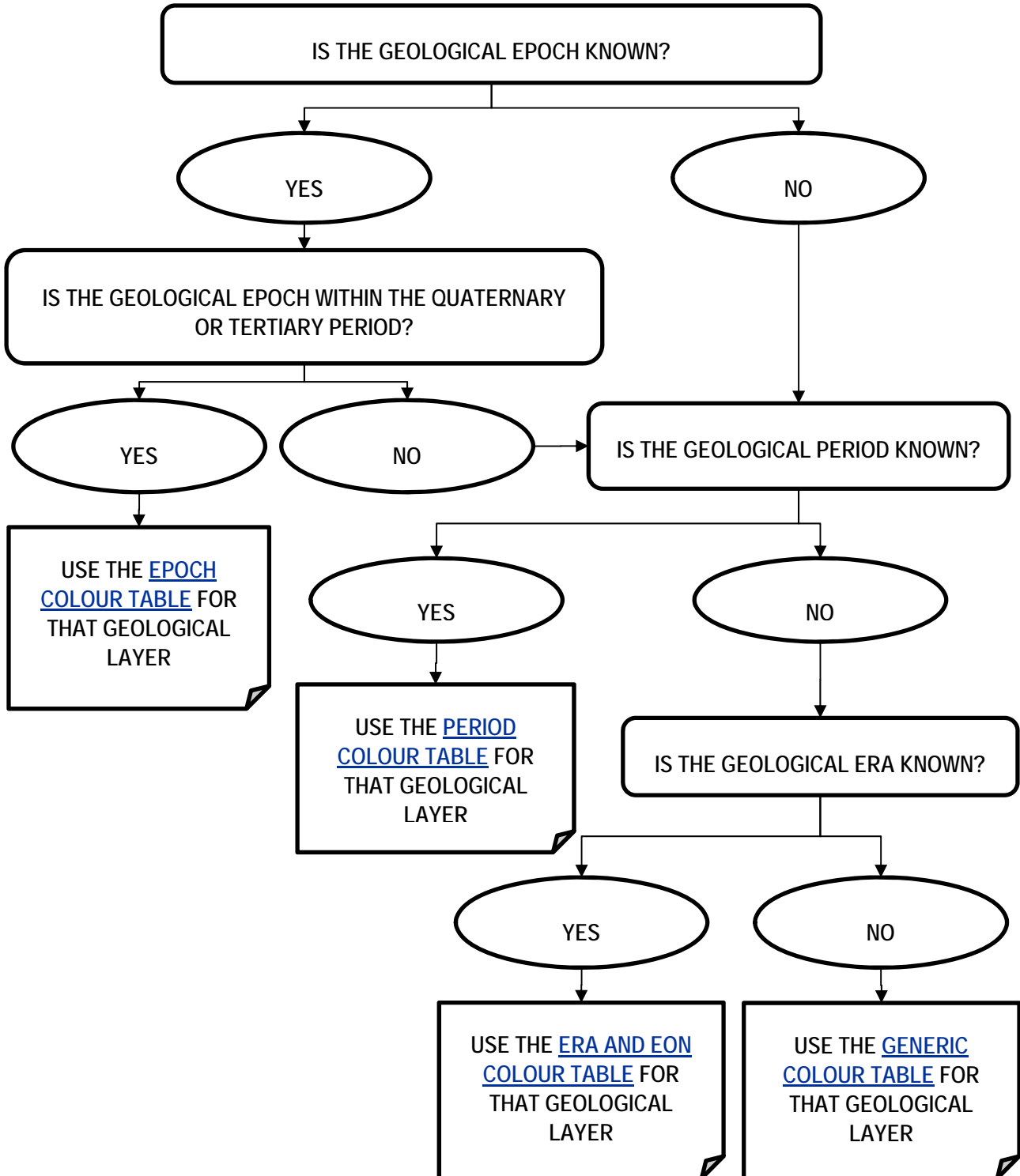
Geology type	Pattern reference code ¹	Suggested legend text	Symbol thumbnail
Unconsolidated lithology			
Alluvium	603 (Series 600)	Alluvia Unconsolidated sand, clay and gravel	
Colluvium	605 (Series 600)	Colluvia	
Gravel	103-K (Series 100)	Gravel	
Sand	102-K (Series 100)	Sand	
Soil	101-K (Series 100)	Soil	
Sedimentary lithology			
Calcareous sandstone	613 (Series 600)	Calcareous sandstone	
Calcareous shale	623 (Series 600)	Calcareous shale	
Calcareous siltstone	617 (Series 600)	Calcareous siltstone	
Clay	620 (Series 600)	Clay	
Coal	658 (Series 600)	Coal	

¹ This code identifies the pattern in the source document '[Digital Cartographic Standard for Geological Map Symbolisation Pattern Chart](#)' (Geologic Data Subcommittee 2006).








Geology type	Pattern reference code ¹	Suggested legend text	Symbol thumbnail
Conglomerate	602 (Series 600)	Conglomerate	
Dolomite	642 (Series 600)	Dolomite	
Limestone	627 (Series 600)	Limestone	
Peat	657 (Series 600)	Peat	
Sandstone	607 (Series 600)	Sandstone	
Metamorphic, igneous, and vein-matter lithology			
Basalt	731 (Series 700)	Basalt	
Generic igneous rock	722 (Series 700)	Igneous rock	
Generic igneous intrusive rock	719 (Series 700)	Igneous rock (intrusive)	
Generic metamorphic rock	705 (Series 700)	Metamorphic rock	
Granite	328-K (Series 300)	Granite	

Colouration





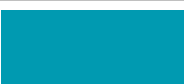






Where geological age is known and relevant to the intended key messages, the following geological colouration should be adopted. This colouration is adapted from the '[Australia Standard Colour Scheme and Stratigraphic Symbols for Geological Maps](#)' (Bureau of Mineral Resources n.d.). The geological colouration is based on the level of geological information known (e.g. epoch, period or era). A colouration key has been provided below to guide table selection. Geological patterns, geological colouration and hydrological colouration may be combined in the legend (see [4.2 Legend](#)).










Epoch colour table

	Geological epoch	Pantone Colour	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Colour thumbnail
Quaternary geological period	Holocene	358	38/0/45/0	161/255/143	Holocene 0 - 0.1 million years ago	
	Pleistocene	Yellow	0/0/100/0	255/255/0	Pleistocene 0.1 – 2.6 million years ago	
Neogene and Paleogene geological periods (formerly tertiary geological period)	Pliocene	109	0/10/100/0	255/240/0	Pliocene 2.6 – 5.3 million years ago	
	Miocene	124	0/27/100/0	230/204/0	Miocene 5.3 - 23 million years ago	
	Oligocene	110	2/24/100/7	191/191/18	Oligocene 23 – 33.9 million years ago	
	Eocene	397	10/1/98/15	204/235/0	Eocene 33.9 - 56 million years ago	
	Paleocene	104	7/13/100/28	161/161/48	Paleocene 56 - 66 million years ago	

Period colour table







	Geological period	Pantone Colour	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Colour thumbnail
Cenozoic geological era	Quaternary	Yellow	0/0/100/0	255/255/0	Quaternary 0 – 2.6 million years ago	
	Neogene and Paleogene (formerly Tertiary)	124	0/27/100/0	230/204/0	Neogene and Paleogene 2.6 - 66 million years ago	
Mesozoic geological era	Cretaceous	375	47/0/94/0	143/255/0	Cretaceous 66 - 145 million years ago	
	Jurassic	Green	95/0/58/0	18/255/97	Jurassic 145 - 201 million years ago	
	Triassic	320	100/0/30/2	0/255/191	Triassic 201 - 252 million years ago	
Paleozoic geological era	Permian	300	100/42/0/0	33/161/255	Permian 252 - 299 million years ago	
	Carboniferous	431	45/27/17/51	105/105/105	Carboniferous 299 - 359 million years ago	
	Devonian	272	60/50/0/0	112/112/224	Devonian 359 - 419 million years ago	
	Silurian	253	46/91/0/0	161/82/255	Silurian 419 - 444 million years ago	
	Ordovician	246	34/90/0/0	224/18/255	Ordovician 444 - 485 million years ago	
	Cambrian	221	8/100/24/35	191/18/112	Cambrian 485 - 541 million years ago	

Era and eon colour table



	Geological era	Pantone Colour	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Colour thumbnail	
Phanerozoic geological eon	Cenozoic	No colouration available. Please see either the Quaternary or Neogene/Paleogene (formerly Tertiary) period colouration (see 'Period colouration table').					
	Mesozoic	335	100/0/58/22	18/191/112	Mesozoic 66 - 252 million years ago		
	Palaeozoic	Process Blue	100/85/0/4	0/255/255	Palaeozoic 252 - 541 million years ago		
Proterozoic geological eon	Neoproterozoic (age late)	145	0/47/100/8	208/112/0	Neoproterozoic 541 - 1000 million years ago		
	Mesoproterozoic (age mid)	160	0/62/100/32	135/60/0	Mesoproterozoic 1000 - 1600 million years ago		
	Paleoproterozoic (age early)	194	0/100/64/33	143/41/41	Paleoproterozoic 1600 - 2500 million years ago		
	Unspecified	175	18/79/71/56	100/52/52	Proterozoic 541 - 2500 million years ago		
Archaean geological eon	Unspecified	140	13/42/100/56	138/102/0	Archaean 2500 - 4000 million years ago		

Generic colour table

Where geological age is not known or not relevant to the intended key messages, the following geological colouration should be adopted.

Geology	Pantone Colour	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Colour thumbnail
Alluvium	N/A	12/8/37/0	232/225/179	Alluvia Unconsolidated sand, clay and gravel	
Basement (geological basement)	N/A	32/54/76/33	141/98/57	Basement	
Basement (of model)	N/A	32/54/76/33	141/98/57	Basement of the model	
Estuarine deposits	N/A	25/25/40/0	203/187/160	Estuarine deposits	
Low permeability rock	N/A	28/46/67/21	165/124/82	Low permeability rock	
Moderate to high permeability rock	N/A	20/38/59/8	199/156/109	Moderate to high permeability rock Stores and transmits groundwater through void spaces in the rock	

Lines

Object	Line width and description	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Line colour thumbnail
Outline of geological layer (regardless of pattern or colouration) ¹	0.5 point	39/68/94/57	96/57/20	N/A ²	
Fault ³	3 point	4/2/33/0	250/242/192	Fault	





¹ This outline should be applied to the top most geological layer in Adobe Illustrator®, either geological colouration and/or pattern.

² This outline is combined with a geological colouration and/or pattern and therefore does not separately appear in the legend.

³ This option can be used where faults are appropriately represented by a line (e.g. regional models such as those models representing the Great Artesian Basin and Clarence-Moreton Basin).

Symbols

Where relevant to the intended key messages, the following geological symbols should be adopted.

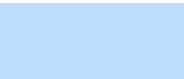

Object	Description	Suggested legend text	Thumbnail
Fault ¹ / Fracture	This symbol represents the presence of a fault or fracture.	Fault [or] Fracture Stores and transmits groundwater through the void spaces created by faults or fractures in the rock	
Paleochannel	This symbol represents the presence of paleochannels within alluvia.	Paleochannel Historic drainage systems filled with unconsolidated sand and clay	
Porosity (primary)	This symbol represents that the dominant porosity of the geological layer underneath (or otherwise indicated) this symbol is primary.	Primary porosity Predominantly stores and transmits groundwater through intergranular pore spaces	
Porosity (secondary)	This symbol represents that the dominant porosity of the geological layer underneath (or otherwise indicated) this symbol is secondary.	Secondary porosity Predominantly stores and transmits groundwater through void spaces created by fracturing	

¹ This option can be used in smaller models where faults are appropriately represented by a symbol (e.g. when demonstrating flow of groundwater through faulting).

3.4 Hydrology

Colouration





Where relevant to the intended key messages, the following hydrological colouration should be adopted. Geological patterns, geological colouration and hydrological colouration may be combined in the legend (see [4.2 Legend](#)).

Hydrology	Description	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Colour thumbnail
Saturation zone (groundwater)	Opacity is 40%	63/19/0/0	93/171/223	Saturated with groundwater ¹	
Saturation zone (marine water)	Opacity is 40%	63/53/0/0	114/120/184	Saturated with marine water ¹	

¹ This colouration is combined with a geological colouration and/or pattern and therefore does not separately appear in the legend. The suggested legend text refers to the second tier of text (see [4.2 Legend](#)).










Lines

Where relevant to the intended key messages, the following hydrological lines should be adopted.










Object	Line width and description	C/M/Y/K Colour	R/G/B (0-255)	Suggested legend text	Line colour thumbnail
Groundwater (watertable)	2 point dashed line (3 point dash and 3 point gap) with 40% opacity	73/43/5/0	77/129/189	Groundwater table	
Groundwater (potentiometric surface)	2 point dashed line (6 point dash, 3 point gap, 3 point dash, and 3 point gap) with 40% opacity	73/43/5/0	77/129/189	Potentiometric surface	
Marine water	2 point dashed line (3 point dash and 3 point gap) with 40% opacity	63/53/0/0	114/120/184	Marine water interface	
Sea Level	2 point dashed line (3 point dash and 3 point gap)	79/0/27/0	0/175/191	Sea level	

Symbols



Where relevant to the intended key messages, the following hydrological symbols should be adopted.

Object	Description	Suggested legend text	Thumbnail
Accumulation of substance ¹	This symbol represents the accumulation of a specified substance (e.g. salt, calcium carbonate) at the surface due to transportation by groundwater.	Accumulation of [specify]	
Direction of groundwater leakage ¹	This symbol represents the main direction of groundwater leakage between geological layers.	Groundwater leakage	
Direction of groundwater movement ¹	This symbol represents the main direction of groundwater movement.	Direction of groundwater movement	
Direction of marine water movement ¹	This symbol represents the main direction of marine water movement.	Direction of marine water movement	
Direction of surface water movement (overland flow) ¹	This symbol represents the main direction of surface water overland (e.g. not within a channel).	Direction of surface water movement outside of a channel	
Direction of surface water movement within a channel ¹	This symbol represents the main direction of surface water within a channel.	Direction of surface water movement in the channel	
Evaporation ¹	This symbol represents evaporation.	Evaporation	
Expression of substance at the land surface ¹	This symbol represents the expression of a specified substance (e.g. salt) at the surface due to transportation by groundwater.	Expression of [specify]	
Groundwater and marine water interface ¹	This symbol represents the approximate interface between groundwater and marine water.	Groundwater and marine water interface The position of the interface will vary temporally	

¹ courtesy of the Integration and Application Network

Object	Description	Suggested legend text	Thumbnail
Groundwater and surface water mixing ¹	This symbol represents the mixing of groundwater and surface water within a channel.	Mixing of groundwater and surface water	
Groundwater table	This symbol accompanies groundwater (watertable) line. This symbol should have 40% opacity and the lower point of the triangle should sit on top of the groundwater (watertable) line.	N/A	
Groundwater table (decrease) ¹	This symbol represents the lowering of a groundwater table.	Decreasing groundwater table	
Groundwater table (increase) ¹	This symbol represents the increasing of a groundwater table.	Increasing groundwater table	
Infiltration ¹	This symbol represents infiltration and percolation. The arrow head should be below the land surface.	Infiltration and percolation Rain infiltrates through the soil to recharge the aquifer below	
Limited groundwater leakage ¹	This symbol represents limited groundwater leakage between geological layers in specified direction. The centre of the red cross should sit across the geological contact.	Negligible groundwater leakage	
Limited groundwater movement ¹	This symbol represents limited groundwater movement in specified direction. The centre of the red cross should sit across the geological contact.	Negligible groundwater movement	
Limited infiltration ¹	This symbol represents limited infiltration and percolation. The arrow head should be below the land surface.	Limited infiltration and percolation Limited rain infiltrates through the soil to recharge the aquifer below	
No infiltration ¹	This symbol represents no infiltration and percolation. The arrow head should be below the land surface and the centre of the red cross should sit across the land surface.	No infiltration and percolation Rain cannot infiltrate the land surface	





¹ courtesy of the Integration and Application Network

Object	Description	Suggested legend text	Thumbnail
Spring	This symbol represents the location of a spring, a hydrogeological feature by which groundwater discharges naturally to the land or cave surface.	Spring A hydrogeological feature by which groundwater discharges naturally to the land surface or cave	
Tidal range ¹	This symbol represents the approximate tidal range.	Tidal range	

3.5 Meteorology/Climate

Symbols

Where relevant to the intended key messages, the following meteorological symbols should be adopted.



Object	Description	Suggested legend text	Thumbnail
Rain cloud ¹	This symbol represents rain. This should span the entirety of the model.	Rain	
Wetter periods of time ¹	This symbol represents wetter periods of time characterised by increased rainfall.	Wetter periods of time characterised by increased rainfall	
Drier periods of time ¹	This symbol represents drier periods of time characterised by decreased rainfall.	Drier periods of time characterised by decreased rainfall	
Wind ¹	This symbol represents wind.	Wind	

¹ courtesy of the Integration and Application Network

3.6 Processes

Symbols



Where relevant to the intended key messages, the following process symbols should be adopted.

Object	Description	Suggested legend text	Thumbnail
Biological processes			
Evapotranspiration ¹	This symbol represents the biological process of evapotranspiration.	Evapotranspiration Process whereby plants draw water up through their roots and move it out through their leaf pores	
Physical processes			
Deposition ¹	This symbol represents the process of deposition. The specific material being deposited (e.g. clay particles) is included in the legend.	Deposition of [specify]	

3.7 Other





Symbols

Where relevant to the intended key messages, the following symbols should be adopted.



Object	Description	Suggested legend text	Thumbnail
Focal Circle (Option A) ²	This symbol is used to draw attention specific elements of a conceptual model that have further information contained in the legend.	N/A	
Focal Circle (Option B) ²	This symbol is used to draw attention specific elements of a conceptual model that have further information contained in the legend.	N/A	

¹ courtesy of the Integration and Application Network

² The choice of focal circles is dependent on the underlying conceptual model colours. The intention is that the chosen focal circle should stand out.

Object	Description	Suggested legend text	Thumbnail
GDE circle for use in conceptual model	This symbol is used to highlight a specific class of groundwater dependent ecosystem within a conceptual model. The number in the circle is linked to the number overlying the corresponding 'GDE circle for use in legend' symbols (see below). Numbering by type of GDE should be consecutive (i.e. 1, 2, 3, etc.).	N/A ¹	
GDE circle for use in legend (terrestrial GDEs)	This symbol is used exclusively in the legend to highlight a terrestrial groundwater dependent ecosystem. The number in the circle is linked to the number in the 'GDE circle for use in conceptual model' symbol.	Terrestrial GDEs Regional ecosystems and riverine wetlands may depend on the sub-surface presence of groundwater within the capillary zone for some or all of their water requirements.	
GDE circle for use in legend (surface expression GDEs)	This symbol is used exclusively in the legend to highlight a surface expression groundwater dependent ecosystem. The number in the circle is linked to the number in the 'GDE circle for use in conceptual model' symbol.	Surface expression GDEs Lacustrine wetlands, palustrine wetlands and riverine water bodies may depend on the surface expression of groundwater for some or all of their water requirements.	
GDE circle for use in legend (subterranean GDEs)	This symbol is used exclusively in the legend to highlight a subterranean groundwater dependent ecosystem. The number in the circle is linked to the number in the 'GDE circle for use in conceptual model' symbol.	Subterranean GDEs Aquifer and cave subterranean wetlands may depend on the subterranean presence or expression of groundwater for some or all of their water requirements.	

¹ Suggested legend text is included in the 'GDE circle for use in legend' symbols.

Object	Description	Suggested legend text	Thumbnail
GDE circle for use in legend (surface expression GDEs - near-shore marine systems)	This symbol is used exclusively in the legend to highlight a near-shore marine surface expression groundwater dependent ecosystem. The number in the circle is linked to the number in the 'GDE circle for use in conceptual model' symbol.	Surface expression GDEs (near-shore marine systems) Near-shore marine wetlands may depend on the surface expression of groundwater for some or all of their water requirements. This sub-type of GDE is not currently mapped in the Queensland GDE Mapping.	
GDE circle for use in legend (surface expression GDEs – estuarine systems)	This symbol is used exclusively in the legend to highlight an estuarine surface expression groundwater dependent ecosystem. The number in the circle is linked to the number in the 'GDE circle for use in conceptual model' symbol.	Surface expression GDEs (estuarine systems) Estuarine wetlands may depend on the surface expression of groundwater for some or all of their water requirements. This sub-type of GDE is not currently mapped in the Queensland GDE Mapping.	

4 Other

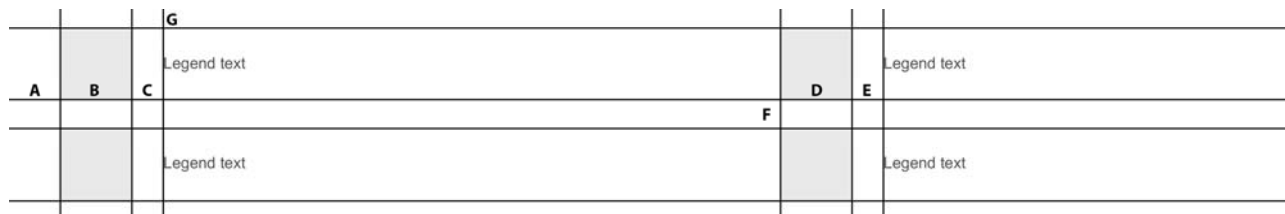
4.1 Fonts

Object	Font
Heading (e.g. catchment names, stratigraphic names of geological layers)	Arial, 11-12 pt
Supporting explanatory text (e.g. scale)	Arial, 10-11pt
Legend (First tier text)	Arial, 11 pt
Legend (second tier text)	Arial, 10 pt

4.2 Legend

Spacing

The following diagram and table illustrate the layout and sizing of conceptual model legends.



Object	Description	Spacing
A	The gap between the left side of the legend and the left edge of a legend symbol.	36 pixels
B	The alignment of the left edge of the legend symbol.	36 pixels
	The width and height of a legend symbol.	50 pixels by 50 pixels
C	The gap between the right edge of a legend symbol and the left edge of legend text.	20 pixels
D	The alignment of the left edge of the legend symbol.	540 pixels
	The width and height of a legend symbol.	50 pixels by 50 pixels
E	The gap between the right edge of a legend symbol and the left edge of legend text.	20 pixels
F	The gap between the first and second row of symbols in the legend.	20 pixels
G	The gap between the top of the legend and the top of the legend image.	5 pixels
N/A	The total width of the legend.	900 pixels

Text

Suggested text to accompany each symbol in the legend is presented in the symbology tables in section three. It is common for the text accompanying each symbol to be modified depending on the conceptual model under development. For example:

- Geological patterns, geological colouration and hydrological colouration are often combined in the legend, with the accompanying text modified.



Sand
Saturated with fresh groundwater



Sand
Saturated with saline marine water

- Additional relevant information on a symbol specific (e.g. species names, geological formations, etc.) to a conceptual model is often added as second tier legend text.



Low permeability rock
Indurated sand layers



Casuarina spp.

Including *Casuarina cristata* (also known as Belah) and *Casuarina cunninghamiana* (also known as River She-Oak).

4.3 Watermark

The following watermark structure should be included on the final conceptual model prior to publication. In Adobe Illustrator® set the transparency to “multiply” and the opacity to 50 percent for both the watermark symbol and text.



Work Unit Year, *Title (DD/MM/YYYY)*, Department Name, Queensland Government. Symbols courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/).

5 Final product export specifications

5.1 Product specifications for delivery through *WetlandInfo*

The final conceptual model and legends (e.g. geology legend, hydrology legend, focal circle legend, etc.) for delivery through *WetlandInfo* should be produced consistent with the following specifications. The conceptual model and each accompanying legend (e.g. geology, hydrology, flora, fauna, GDEs, focal elements) to be produced as separate files. This can be achieved using the artboard feature¹ and 'Save for Web' menu item² in Adobe Illustrator® with the following specifications:

- portable network graphics format (PNG-24)
- width of 1800 pixels for conceptual model
- width of 900 pixels for legend
- art or line optimized based on your model
- transparent background
- no border
- no title

¹ For example, artboards in Adobe Illustrator® can be used to separate individual conceptual model and legend components and set a width of 1800 or 900 pixels.

² The 'Save for Web' menu item in Adobe Illustrator® allows the specification of PNG-24 format and art or line optimized.

6 Guiding questions for site specific conceptual modelling of groundwater dependent ecosystems

The following questions should be used as a general guide to promote inclusion of multi-disciplinary knowledge and data during the development of site specific GDE conceptual models (including pictorial conceptual models, box-and arrow diagrams, descriptive text, tables, etc.) and to promote integration with the broader suite of conceptual models which already exist. The questions presented below are intended solely as a guide and do not represent an exhaustive list of considerations. The questions should be used in addition to other available guidance on conceptual model development such as DEHP conceptual modelling guidelines (DEHP 2012)¹.

Not all questions will be applicable to every site specific conceptual model and the relative importance of each question will depend on the intended purpose of the conceptual model as no single conceptual model can address all needs. Applicable questions should be considered at the most appropriate scale based on available information (e.g. questions may be considered at a regional scale where specific local information is not available, while other questions may be considered at both the regional and local scale).

6.1 General Questions

- What is the primary purpose of your site specific conceptual model? *For example, list two to three key objectives/messages underlying your conceptual model and consider what scale your objective is it relevant at including any areas around the site which might be influential.*
- What other conceptual models already exist which might assist with the new model and how do the existing conceptual models integrate with your proposed conceptual model? *For example, consider whether is it possible to get access to these existing conceptual models to use as a foundation for your conceptual model.*
- What data sources are available to support conceptualisation? *For example, consider both primary data sources (such as field surveys, monitoring data) and secondary data sources (such as previous desktop assessments, reports or other literature).*
- Identify experts with knowledge at a scale consistent with your conceptual model which may be able to provide information which is not available from your identified data sources?

6.2 Climate

- What are the climatic conditions at the site? *For example, consider climatic data measured from nearby weather stations such as aridity, temperature, rainfall, evapotranspiration. It may be important to consider not just average climate measurements but also extreme measurements (e.g. during droughts or floods) as these may be crucial to the importance of the site.*

¹ Conceptual modeling guideline is available at <http://wetlandinfo.ehp.qld.gov.au/wetlands/resources/pictorial-conceptual-models.html>

6.3 Ecology

- What are the key species assemblages at the site?
- What are the unique or highlight species at the site?
- Were there any influences on the GDE that may impact on natural species assemblages such as excavation, extraction, presence of invasive species, or local land use activities?
- How is the ecosystem reliant on groundwater contributions? *For example, are multiple sampling periods available? And if so, is there a relationship between water chemistry or flow rates and species abundance and richness?*
- What is the likely nature of this groundwater reliance?
- What is the likely sensitivity of the GDE to changes in groundwater availability?
- Illustrate the relationship between species assemblages and variation in groundwater availability?

6.4 Geochemistry

- Characterise water chemistry supporting GDEs at the site? *For example, consider available water chemistry data on pH, electrical conductivity, temperature, major ions, etc. and how this relates to underlying geology.*
- Are there any influences on water chemistry? *For example, consider the impact of evaporation or stock on water chemistry.*
- What are the trends in water chemistry over time that may identify contributions from potential water sources (including surface water, shallow aquifer units, and deeper aquifer units)?
- What does the trend in water chemistry over time suggest about seasonal variations in source water to the GDE?
- Does water chemistry information provide an indication of residence time and depth of flow path of groundwater sources?

6.5 Geography

- Where is the site located? *For example, locate the site in both a surface water catchment and a groundwater drainage basin.*
- What is the elevation at the site? *For example, consider sourcing digital elevation data.*
- What is the land use at and immediately adjacent to the site?
- What are the known threats to the site and the surrounding area?

6.6 Geology and Geomorphology

- What is the stratigraphic sequence underlying the site and the surrounding area? *For example, consider sourcing geological mapping and geological cross-sections across the site where available.*
- What is the association of outcropping sediments, structures, formation thinning or contacts with the location of GDEs at the site?
- What is the geomorphology at the site? *For example, consider landforms, soils, and regolith.*
- How may geomorphology at the site influence or control GDE presence and characteristics?
- Are there any known human modifications that may influence the presence of GDEs at the site?
- Are there any known features that may influence groundwater expression and/or flow at the site?

6.7 Hydrostratigraphy and Hydrodynamics

- What are the key aquifer units, including shallow aquifer units, which may be a source of groundwater for GDEs at the site?
- What are the surface water flow directions and pathways?
- What are the groundwater flow directions and hydraulic gradients between overlying aquifers?
- What is the potential for mixing between groundwater sources and between groundwater and surface water sources?
- What is the spatial and temporal connectivity of each water source with the site and GDEs?
- What is the variability of groundwater discharge at the site?
- Is the contribution of key aquifer units likely to vary through time?
- How are these groundwater interactions affected by surface water flows?
- What are the influences of groundwater source variability, if present, on GDEs at the site? *For example, consider changes in evapotranspiration and groundwater levels.*

7 References

Bureau of Mineral Resources n.d., *Australia Standard Colour Scheme and Stratigraphic Symbols for Geological Maps: Incorporating Decisions of Conferences of Government Geologists*, Department of National Resources. Available from: <<http://www.ga.gov.au/data-pubs/data-standards/standard-symbols>>. [26 February 2015].

Department of Environment and Heritage Protection 2012, *Pictures worth a thousand words: A guide to pictorial conceptual modelling*, Queensland Wetlands Program, Queensland Government. Available from: <<http://wetlandinfo.ehp.qld.gov.au/wetlands/resources/pictorial-conceptual-models.html>>. [26 February 2015].

Geologic Data Subcommittee 2006, *Digital Cartographic Standard for Geological Map Symbolization*, Federal Geographic Data Committee. Available from: <http://ngmdb.usgs.gov/fgdc_gds/geolsymstd.php>. [26 February 2015].

Integration and Application Network n.d., IAN Symbol Libraries, University of Maryland Center for Environmental Science. Available from: <<http://www.ian.umces.edu/symbols/>>. [26 February 2015].

Science Division 2014, *Document preparation, peer review and approval protocol - September 2014*, Department of Science, Information Technology, Innovation and the Arts, Queensland Government, Brisbane.

Appendix A - Excerpt of 'Document preparation, peer review and approval protocol' (DSITIA 2014)

Below is an excerpt of the Document preparation, peer review and approval protocol (DSITIA 2014) containing the 'Document Review Form' with modifications for peer review of conceptual models.

Review Form

Title of conceptual model	
Proposed places to be published	

Queensland Groundwater Dependent Ecosystem Conceptual Model Committee's recommendation

The model is recommended for publication:

- without revision – it meets appropriate standards
- subject to minor revision
- subject to major revision

OR

- the model is not recommended for publication

Queensland Groundwater Dependent Ecosystem Conceptual Model Committee's comments

Please answer the following questions

- | | | | | |
|---|--------------------------|-----|--------------------------|----|
| 1. Does the title adequately reflect the contents of the model? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 2. Is the supplementary text appropriate? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 3. Is the model worth publishing? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 4. Is the model presented clearly and concisely? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 5. Is the model rigorous and suitable? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 6. Is the model sound and supported by the data presented? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 7. Is the model free of errors of fact? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| 8. Is the model style appropriate for the intended audience? | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |

Queensland Groundwater Dependent Ecosystem Conceptual Model Committee's additional comments

Please add any additional comments below.

Attachment A – Response to reviewers’ comments

Response to Queensland Groundwater Dependent Ecosystem Conceptual Model Committee’s comments

The Project Manager should complete the below table for all criticisms of the science or science communication in the models.

Reviewers’ comment	Response of authors <i>include an explanation of why you believe the response is adequate or the criticism is invalid</i>

Appendix B - Excerpt of DEHP’s Risk and Impact Assessment

Below is an excerpt of DEHP’s Risk and Impact Assessment.

Risk and Impact Assessment Matrix for Review and Release of Products on Wetland/Info

Categories of Exposure	Risk²⁰			Review Actions to Reduce Risk
	Low ✓	Medium ✓	High ✓	
Statutory; Legislative; Legal²¹				<i>Add notes on the nature of the hazard and what checks (e.g. legal counsel) will be put into place to reduce identified risks</i>
Science²				<i>Add notes on the nature of the hazard and what checks (e.g. peer review) will be put into place to reduce identified risks</i>
Policy²				<i>Add notes on the nature of the hazard and what checks (e.g. consultation with relevant policy team) will be put into place to reduce identified risks</i>
Political²				<i>Add notes on the nature of the hazard and what checks (e.g. Ministerial endorsement) will be put into place to reduce identified risks</i>
Financial				<i>Add notes on the nature of the hazard and what checks will be put into place to reduce identified risks</i>
Operational				<i>Add notes on the nature of the hazard and what checks will be put into place to reduce identified risks</i>
Regional				<i>Add notes on the nature of the hazard and what checks (e.g. stakeholder consultation) will be put into place to reduce identified risks</i>
Local				<i>Add notes on the nature of the hazard and what checks (e.g. stakeholder consultation) will be put into place to reduce identified risks</i>
Environmental				<i>Add notes on the nature of the hazard and what checks (e.g. consultation with regional NRM bodies and other environmental NGOs) will be put into place to reduce identified risks</i>
Industry; Economic				<i>Add notes on the nature of the hazard and what checks (e.g. stakeholder consultation) will be put into place to reduce identified risks</i>
Social; Community				<i>Add notes on the nature of the hazard and what checks (e.g. community consultation) will be put into place to reduce identified risks</i>
Credibility				<i>Add notes on the nature of the hazard and what checks will be put into place to reduce identified risks</i>
Internal consistency				<i>Add notes on the nature of the hazard and what checks will be put into place to reduce identified risks</i>
External consistency				<i>Add notes on the nature of the hazard and what checks will be put into place to reduce identified risks</i>
Other				<i>Add notes on the nature of the hazard and what checks will be put into place to reduce identified risks</i>
Summary				<i>Establish a best fit approach by determining the level of review required and what checks need to be put into place to reduce identified risks</i>

²⁰ ‘Risk’ refers to the likelihood (i.e. probability of occurrence) x consequence (i.e. impact of occurrence).

²¹ If the identified statutory, legislative, legal, science, policy, and/or political risk is high, you may wish to consider a formal external peer review process.