



# 2022 Scientific Consensus Statement | Process

Approach to Question Setting

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## **Citation**

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# 1. Introduction

The 2022 Scientific Consensus Statement (SCS) brings together the latest scientific evidence to understand how land-based activities can influence water quality in the Great Barrier Reef (GBR), and how these influences can be managed to improve water quality outcomes for the GBR. The SCS is updated periodically and is used by policymakers as a foundational evidence-based document for making decisions about managing GBR water quality. It is one of several projects that provides supporting information for the design, delivery and implementation of the Australian and Queensland government's Reef 2050 Water Quality Improvement Plan (WQIP). The WQIP defines objectives and targets related to water quality improvement, identifies spatial management priorities and describes actions for improving the quality of the water that enters the GBR from the adjacent catchment area. [C<sub>2</sub>O Consulting](#) coasts | climate | oceans was engaged by the Australian government (Department of Climate Change, Energy, the Environment and Water, DCCEEW) and Queensland government (Department of Environment, Science and Innovation, DESI) to coordinate and deliver the 2022 SCS, supported by a multidisciplinary group of over 70 scientists with expertise in GBR water quality and evidence synthesis.

The **primary outputs** of the 2022 SCS are shown in Figure 1 and are:

- The 2022 SCS Conclusions
- The 2022 SCS Summary
- The 2022 SCS Synthesis of the Evidence and high-level Evidence Statements.

These outputs follow an informal hierarchy in the level of detail presented, moving from the full details of the **synthesis of the evidence**, to a **summary** of that material followed by the highest-level **conclusions**.

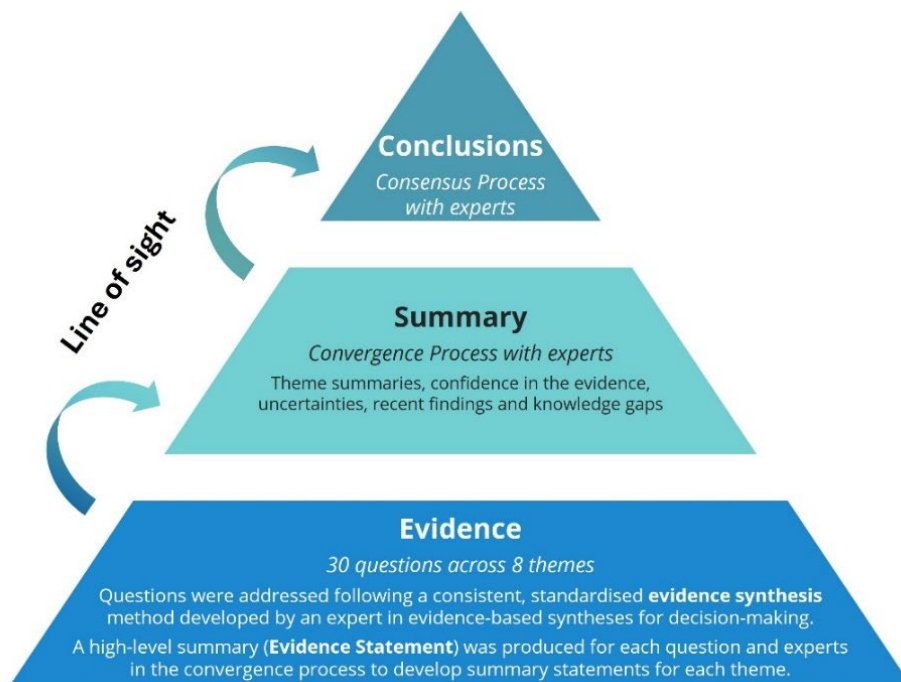


Figure 1. Main outputs and hierarchy of the 2022 Scientific Consensus Statement.

## 1.1. The need for a formal question setting process

Following a scoping exercise in 2021, a number of key features required for the 2022 SCS were identified by policy experts and managers, scientific experts and potential additional users of the SCS. These features were endorsed by the Reef Water Quality Independent Science Panel (ISP). In terms of question setting, two relevant recommendations were to:

- Establish the policy, planning and management context at the start of the project to generate a clear definition of the purpose and scope of the evidence synthesis.
- Develop a conceptual framework to assist in the framing of the evidence base and formulation of key questions in relation to the policy context (i.e., the questions to be answered through the evidence synthesis).

In contrast to previous iterations of the SCS which were based around specific topics presented as chapters, it was agreed that the 2022 SCS would be built around a series of well-defined priority questions designed and agreed in consultation with a diverse group of stakeholders and end users including policy teams, researchers, industry, conservation organisations and Traditional Owners. This was considered a vital first step to being more transparent about how the SCS was developed, and making the evidence more accessible and relevant to a broader audience base. The questions were designed to synthesise current knowledge to assist in the design and implementation of programs to improve the quality of water entering the GBR.

This paper describes **the detailed approach to the question setting process for the 2022 SCS.**

## 1.2. Summary of question setting process

The question setting process used an iterative approach involving policy and management representatives, stakeholder and scientific teams to identify a set of priority needs that could be met by answering a set of well-defined questions. Potential topics for questions to be addressed in the 2022 SCS were initially identified from a range of sources including previous SCSs, topics raised during the 2019 Senate Inquiry<sup>1</sup>, emerging science since the 2017 SCS, and a paper from a peak agricultural body. This exercise resulted in the identification of over 100 potential questions across eight broad themes. These questions were refined through an iterative and consultative process over several months to identify priority questions. The process involved consultation with scientific experts, a small group of policy and management representatives, stakeholder and Traditional Owner groups to discuss their ideas and needs for questions to be addressed in the 2022 SCS. It involved formal meetings and circulation of the draft list of questions to over 70 stakeholders and end users including policy and management representatives, scientific groups, Traditional Owners, agricultural and tourism industries, and conservation organisations. In total, 30 written responses were received. Further meetings were held with policy and management representatives to review and prioritise the questions. The SCS Coordination Team (C<sub>2</sub>O Consulting) also assessed whether questions could be combined or consolidated to avoid potential overlap in content, and whether some questions were more appropriate for other projects or initiatives. At the end of the consultation process, a total of 32 questions, several containing sub-questions, were defined across eight themes. Later in the process, three background questions about the drivers, pressures and threats to the current condition of the GBR (1.2, 1.3 and 2.1) were merged resulting in a final list of 30 questions. The final list of questions was endorsed by ISP and signed off by the DCCEE and DESI Contract Managers. The wording of some questions was slightly modified once Lead Authors were appointed to clarify the intent of the question. Any changes to questions were endorsed by the ISP. The major steps of the question setting process are presented in Figure 2.

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<sup>1</sup> [Rural and Regional Affairs and Transport References Committee: Identification of leading practices in ensuring evidence-based regulation of farm practices that impact water quality outcomes in the Great Barrier Reef, October 2020](#)



Figure 2. The main steps in the 2022 Scientific Consensus Statement question setting process.

### 1.3. 2022 SCS guiding principles

A set of guiding principles were developed that underpin the delivery and implementation of all aspects of the 2022 SCS process. These principles were supported and endorsed by a variety of audiences, stakeholders and end users including Australia's Chief Scientist, the Reef Water Quality Independent Science Panel (ISP), Reef 2050 Plan Independent Expert Panel (IEP) and the Reef 2050 Advisory Committee (RAC). Steps to align the question setting process with the guiding principles are described below.

- 1. Demonstrated independence from end users in the synthesis of the evidence and review of the outputs.**
  - Non-governmental organisation (C<sub>2</sub>O Consulting referred to as the SCS Coordination Team) responsible for running the question setting process.
  - Consultation process involving >70 stakeholders, Traditional Owner groups and end users from range of organisations and industries.
- 2. Establish and use fit for purpose methods and processes, and engage fit for purpose experts.**
  - Drew on expertise and experience of many different audiences with an interest in GBR water quality management to identify priority questions.
  - Worked with an evidence synthesis expert and applied best practice principles for evidence synthesis to refine wording of questions to meet end user needs.
- 3. Increased transparency and robustness in design and delivery.**
  - An extensive consultation phase was undertaken where the full draft list of questions was shared with >70 individuals and organisations. Written responses were invited and fully documented. Follow up meetings were coordinated for further discussion or clarification as required.
  - A complete description of the development of the 2022 SCS question setting process is documented here and is publicly available.
- 4. Minimise the potential for bias in reviewing outputs and synthesis.**
  - Diverse range of user groups consulted during the question setting phase.
  - Where questions could not be addressed as part of the 2022 SCS, the rationale was documented and where possible, questions or topics were shared with other relevant projects and initiatives.
- 5. Assess and present levels of confidence in the evidence.**
  - Discussions took place during the question setting process to understand and evaluate the level of confidence needed by end users for each question.
  - Questions were assigned to two variations of the method to synthesise the evidence to meet two different levels of rigour in the reviews: the SCS Evidence Summary and the SCS Evidence Review (which included an additional quality assurance step).
- 6. Ensure inclusive, genuine and timely engagement with end users, stakeholders, and audiences.**
  - >70 stakeholders and end users were engaged as part of the question setting consultation process.
  - Briefings were provided at key stakeholder meetings to provide updates and seek input.
  - Project Updates (including on the question setting process) were published on the 2022 SCS social engagement platform and via mailing lists.
- 7. Improve accessibility to the science underpinning the SCS.**
  - The approach to question setting focused on identifying the subject and type of evidence that was most useful to policy, management and other end users with the intention of making the outputs publicly available.
  - Broad consultation to initiate discussions about the science underpinning the SCS.
  - Outputs and process documents are publicly accessible on the 2022 SCS website.

## 2. Approach to question setting

### 2.1 Overarching conceptual framework

The overarching conceptual framework in Figure 3 was developed in consultation with the ISP and a small group of scientific experts, primarily the lead authors from the 2017 SCS. The framework was used to help policy and management frame the questions and refined through the delivery of the 2022 SCS process.

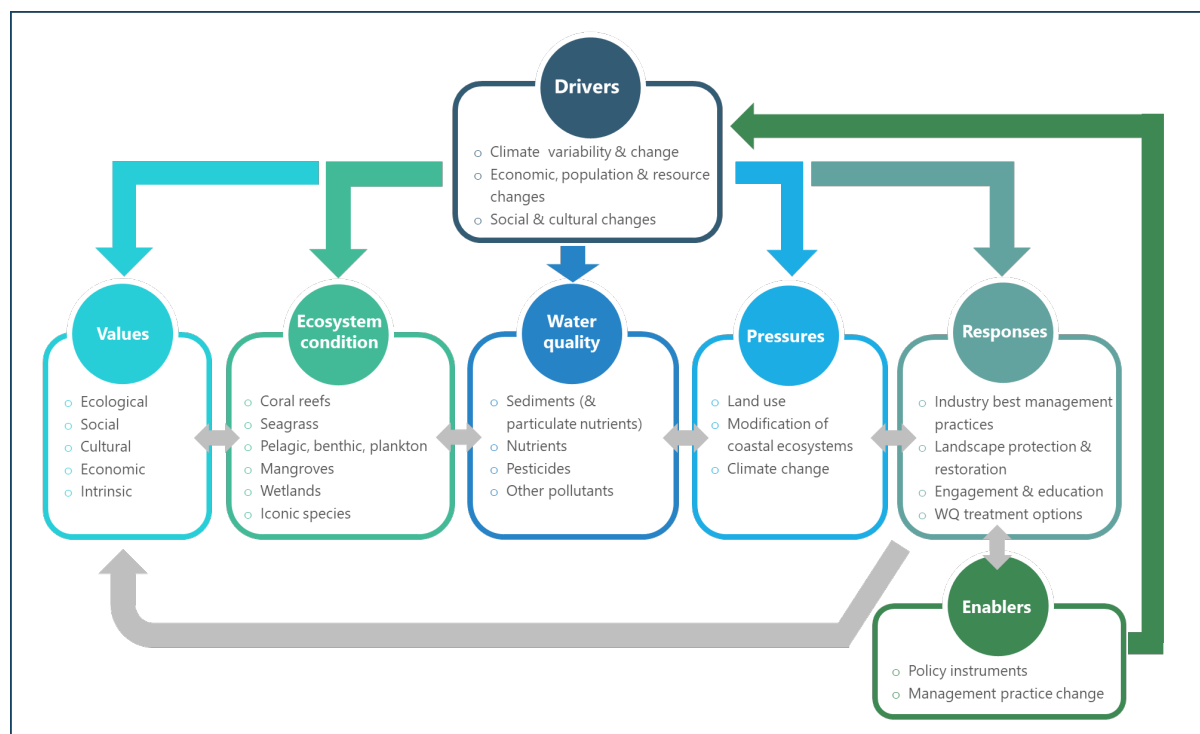


Figure 3. Overarching conceptual framework for the scope of the 2022 SCS used to initiate the question setting conversations.

Conceptual models (and other tools) were used to facilitate discussions with technical teams and policy and management experts to determine:

- Key topics that were considered the most important in terms of up-to-date understanding for decision making.
- The type of evidence that would be most useful, for example, evidence of how something works (causal), what factors influence the effectiveness of something (effect modifiers), trend or status information, economic, social or biophysical science-based evidence.
- The topics perceived by experts to have high confidence in the existing evidence.

### 2.2 Main steps of the 2022 SCS question setting process

The question setting process ran from October to December 2021, with some minor refinements to questions following the appointment of Lead Authors and an initial exercise to clarify the intent of the questions. The steps of the question setting process and outcomes are described below. Table 1 details the timing, participation and outcomes from each step, including the number of questions contributed through each step.



Table 1. Description of the main steps in the 2022 Scientific Consensus Statement question setting process, timing, purpose, involvement and outcomes. Note: The SCS Coordination Team and the Evidence Synthesis Expert were involved in all steps.

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
<p><b>1. Preliminary list of questions</b> for consideration at the policy/management meetings. By 21 October 2021</p>	<p>Drawing from:</p> <ul style="list-style-type: none"> <li>– Review of the overarching conceptual framework by the Reef Independent Science Panel (ISP) September 2021 (final version in Section 2.1).</li> <li>– Detail from the 2017 SCS (structured and framed as questions).</li> <li>– Assessment of application of the findings of the 2017 SCS in the Reef 2050 Water Quality Improvement Plan (WQIP).</li> <li>– Issues raised in the Senate Inquiry (<a href="#">Rural and Regional Affairs and Transport References Committee: Identification of leading practices in ensuring evidence-based regulation of farm practices that impact water quality outcomes in the Great Barrier Reef, October 2020</a>).</li> <li>– The paper prepared by Canegrowers ‘Growers’ questions about the science of farming, water quality and the health of the GBR lagoon, May 2020’.</li> <li>– Emerging science / National Environmental Science Program (NESP) outputs.</li> </ul> <p>The <b>SCS Coordination Team</b> collated questions to be used as background information in the process.</p>	Contract Managers	Supporting spreadsheet of questions with consolidated preliminary list of questions, included 105 questions sorted into 8 groupings: 1) ecological impacts, management of 2) sediments, 3) nutrients, 4) pesticides and 5) other pollutants, 6) science informing policy design, 7) questions from 2017 risk assessment and 8) wetland specific questions.
<p><b>2. Meeting with scientific experts</b> to: <b>i) refine the overarching conceptual framework</b> presented to ISP on 24 September 2021 and b) provide initial feedback on <b>preliminary list of questions</b> 26 October 2021, 28 October 2021 (Marine only)</p>	<p>A group of <b>scientists</b> (predominantly lead authors from the 2017 SCS) assisted in testing and refining the draft conceptual framework.</p> <p>The scientists were asked to:</p> <ul style="list-style-type: none"> <li>– Review the overarching conceptual framework and provide any feedback on gaps or views regarding emphasis.</li> <li>– Identify which areas of the model presented the highest confidence in the conclusions of the current research, and the areas of the model with the lowest confidence and why.</li> <li>– Following the meeting, the scientific experts were also asked to provide feedback on the preliminary list of questions, including:</li> <li>– Feedback on main topic groupings and structure</li> <li>– Suggested refinement of the wording of the questions</li> </ul>	Scientific experts involved in 2017 SCS	<ul style="list-style-type: none"> <li>– Meeting notes and recordings.</li> <li>– Scientist individual responses (n=5).</li> <li>– Revised list of questions incorporating scientists’ feedback.</li> <li>– Number of new questions incorporated: 5</li> </ul> <p>Input from the scientific experts provided guidance on relevance, priority, status of the science (contested vs. settled), source of required evidence (GBR vs. external), level of evidence required and proposed evidence synthesis method to use for each question. This enabled the SCS Coordination Team to revise the list and remove some of the questions that were either similar or duplicated, or unlikely to be answered or not suitable for the SCS (e.g., policy questions).</p> <p>Scientist’s input on the conceptual framework and draft ‘themes’ also led to a revised proposed structure for the 2022 SCS.</p>

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
	<ul style="list-style-type: none"> <li>For each question, consider its relevance, priority, status of the science (contested vs. settled), source of required evidence (GBR vs. external), level of evidence required and proposed evidence synthesis method to use.</li> </ul>		The revised draft list of questions provided a solid basis for policy, management and stakeholder input.
<p><b>3. Meeting with a small policy /management group to define and prioritise questions for the 2022 SCS.</b></p> <p>26 October 2021</p>	<p>A small <b>policy/management group</b> (test group) was asked to:</p> <ul style="list-style-type: none"> <li>Discuss how they will use the evidence, and in what form – both now and over the next five years.</li> <li>Use the conceptual models to identify key areas of application of the knowledge in decision making for GBR water quality management.</li> <li>Which areas of the model are of most relevance to the policy needs for development of the WQIP?</li> <li>How will new understandings in this area influence policy decisions?</li> <li>What is the nature of the evidence (for example, understanding how something works or knowing the state/condition of an asset) most useful for policy in developing the WQIP?</li> <li>What are the greatest uncertainties for policy (in relation to the model) and what research could most effectively reduce these?</li> <li>Does the choice of policy mechanisms influence the confidence required in the evidence (or the reverse)? For example, is a higher level of confidence required in the evidence for setting regulation rather than financial incentives or education-based programs?</li> </ul> <p>As a follow up exercise, the ‘test’ group also provided feedback on the <b>preliminary list of questions</b>. During this stage, groups assessed a preliminary list of questions and identified the relevance, priority, areas of new knowledge, contestability, confidence and classification of questions. These groups also provided feedback on the 2022 SCS structure to frame the questions.</p>	<p>DESI DCCEEW GBRF</p>	<ul style="list-style-type: none"> <li>Meeting notes and transcript.</li> <li>Policy individual responses (n=2)</li> <li>Additional feedback GBRMPA.</li> <li>Revised list of questions incorporating policy feedback.</li> <li>Number of new questions incorporated: 8</li> </ul> <p>The policy and management input refined the intent of several questions, identified preliminary priorities and highlighted gaps.</p>
<p><b>4. Initial consultation with stakeholders.</b></p> <p>11 Nov - RAC 15 Nov - Canegrowers</p>	<p>Initial consultation with stakeholders to discuss their concerns/priorities and ideas about the SCS process.</p>	<p>Separate meetings between the SCS Coordination Team and representatives from the</p>	<ul style="list-style-type: none"> <li>Meeting notes.</li> <li>Revised list of questions incorporating stakeholder feedback.</li> <li>The stakeholder input identified preferred areas of emphasis and highlighted gaps.</li> </ul>

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
<p>17 Nov - AgForce 18 Nov - MEPA 18 Nov - QFF 25 Nov - GBRF</p>		<p>following stakeholder groups from the RAC:</p> <ul style="list-style-type: none"> <li>- Canegrowers</li> <li>- AgForce</li> <li>- Queensland Farmers Federation (QFF)</li> <li>- Marine Ecosystem Policy Advisors Pty Ltd (MEPA)</li> <li>- GBRF Traditional Owner Partnerships Team</li> </ul> <p>Additional feedback was provided by representatives from:</p> <ul style="list-style-type: none"> <li>- Queensland Water Directorate</li> <li>- Australian Marine Conservation Society (AMCS)</li> <li>- Queensland Resources Council</li> <li>- Greening Australia</li> </ul>	<p>Note that most questions proposed through the consultation process were included/covered within the final list of questions.</p>
<p><b>5. Refined questions and structure</b> before consulting with a broader set of policy / management.</p> <p>28 October to 2 November 2021</p>	<p>Review approach and scope plus preliminary questions based on test meetings.</p> <p>Finalise material and approach for the broader policy / management and stakeholder meetings.</p>		<ul style="list-style-type: none"> <li>- Revised list of questions incorporating feedback (spreadsheet).</li> <li>- Draft list of questions for consultation v161121: Total 123 questions.</li> </ul>
<p><b>6. Meetings with policy/management groups to define and prioritise the</b></p>	<p>Targeted meetings with <b>policy and management groups</b> seeking further input on:</p> <ul style="list-style-type: none"> <li>- Areas of priority knowledge needed in developing the Reef 2050 WQIP.</li> <li>- Level of confidence required by policy on each topic.</li> </ul>	<p>28 representatives from the following organisations (number of attendees shown in brackets):</p>	<ul style="list-style-type: none"> <li>- Meeting notes and recordings.</li> <li>- A total of 28 people attended the online meetings coordinated for each organisation.</li> <li>- Number of new questions incorporated: 30</li> </ul>

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
<p><b>questions for the 2022 SCS.</b></p> <p>5 Nov - DCCEEW 5 Nov - DAF 11 Nov - DESI 8 Nov -GBRMPA 8 Nov - Wetlands focus</p>	<p>– Any missing questions or suggested re-wording.</p>	<p>– DCCEEW (8) – Great Barrier Reef Marine Park Authority (GBRMPA) (4) – DESI (9) – Department of Agriculture and Fisheries (DAF) (3) – DESI (wetlands focus, 4) – a sub-group including some of these representatives plus the Great Barrier Reef Foundation (GBRF Reef Trust Partnership) (2)</p>	<p>– Priority areas of interest were identified for each group.</p>
<p><b>7. Broader consultation with policy/management, science groups and stakeholders.</b></p> <p>16–19 November 2021</p>	<p>The draft list of questions and associated guidance was circulated to over 70 policy and management, science and stakeholder representatives (through the Reef 2050 Reef Advisory Committee, RAC) (including all of those consulted in Step 4 above) on 16 November with feedback on priority questions (all questions plus ‘top 10’, confidence required, additional comments and identification of gaps.</p> <p>This list was also provided to IEP for comment and discussed at their meeting on 19 November 2021.</p> <p>The draft list was also provided to ISP for information at their meeting on 26 November 2021 (noting that the revised list was still being compiled).</p>	<p>The following written responses were received:</p> <p><b>Policy:</b></p> <p>– DCCEEW – DESI – DAF – GBRMPA</p> <p><b>Science:</b></p> <p>– AIMS – CSIRO – UQ – Others: Alluvium, Eberhard Consulting, Star Economics – JCU – IEP</p>	<p>A total of 30 written responses were received:</p> <p>– Policy - 9 responses – Science - 11 responses – Stakeholders - 8 responses</p> <p>All feedback was very constructive, and all groups were supportive of the proposed approach and improvements to the transparency and consultation approach used for the 2022 SCS.</p>

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
		<ul style="list-style-type: none"> <li>- ISP (all members, meeting 26 November 21)</li> <li><b>Stakeholders:</b></li> <li>- Canegrowers</li> <li>- AgForce</li> <li>- QFF</li> <li>- Qld Water Directorate</li> <li>- Greening Australia</li> <li>- AMCS</li> <li>- MEPA</li> </ul>	
<p><b>8. Review and consolidate policy/management, science and stakeholder feedback, and consider evidence synthesis methods.</b></p> <p><i>20–28 November 2021</i></p>	<p>All consultation feedback was assessed, interpreted and consolidated into a compiled draft list of proposed questions, including:</p> <ul style="list-style-type: none"> <li>- Consolidation, sorting and grouping of questions.</li> <li>- Clarification of priorities (with higher weight given to policy priorities, due to the nature of the SCS).</li> <li>- Identification of suitable evidence synthesis processes and rationalisation of effort.</li> </ul>		<ul style="list-style-type: none"> <li>- Revised list of questions incorporating feedback (v281121).</li> </ul>
<p><b>9. Final review of questions with a smaller representative group of policy/management.</b></p> <p><i>1 December 2021</i></p>	<p>Final review on revised list of questions by a policy sub-group with representatives from DCCEEW, DESI, GBRF and DAF.</p> <p>The policy/management group was asked to:</p> <ul style="list-style-type: none"> <li>- Review the final set of questions and approaches (all questions were discussed individually).</li> <li>- Raise any questions for consideration by ISP.</li> <li>- Identify likely application of findings and desired outputs in terms of overarching synthesis questions.</li> </ul>	<p>DESI (5): DCCEEW (1) DAF (1) GBRF (2):</p>	<ul style="list-style-type: none"> <li>- Meeting notes.</li> <li>- Policy - 4 additional written responses received.</li> <li>- Revised the list of questions and provided to policy (v281121): Total 44 questions.</li> </ul> <p>The additional input from the policy/management representatives refined the final list and allowed some questions to either be consolidated as sub-questions to other questions, removed if not deemed to be appropriate for the SCS, or shifted to the Spatial Management Prioritisation or Targets Review projects (see Appendix 2). The concept of having several overarching synthesis questions was also discussed as an additional section in the structure.</p>
<p><b>10. ISP review of final proposed questions</b></p>	<p>The list of questions was revised with all previous feedback and provided to ISP for review and final consideration (including</p>	<p>ISP members</p>	<ul style="list-style-type: none"> <li>- ISP notes and minutes.</li> </ul>

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
<p><b>and evidence synthesis approaches.</b></p> <p>3 December 2021, 9 December 2021 (ISP Out of Session meeting)</p>	<p>proposed authors for each question, as a result of the independent author selection process) (see original final list of questions in Appendix 1).</p> <p>The ISP feedback was received, discussed at an Out of Session meeting and provided to the SCS Coordination Team.</p>		<ul style="list-style-type: none"> <li>– Revised list of questions provided to ISP (v031221): Total 33 questions.</li> <li>– ISP supported the list of questions, subject to the consideration and incorporation of additional feedback.</li> <li>– Response to ISP feedback from SCS Coordination Team is documented.</li> <li>– Revised document including ISP feedback (v131221).</li> </ul>
<p><b>11. Final sign off by contract managers (DCCEEW and DESI).</b></p> <p>13 December 2021 (circulation), 14 December 2021 (meeting)</p>	<p>ISP feedback was incorporated to a final list for approval by DCCEEW and DESI circulated on 13 December 2021.</p> <p>Authors were informed of the outcomes of the selection process and communicated their assigned questions on 20 Dec 2021.</p>	<p>DCCEEW</p> <p>DESI</p>	<ul style="list-style-type: none"> <li>– Documentation of final inputs from Contract Managers.</li> <li>– Final revised list of questions (v171221): Total 32 questions in 8 sections plus Introduction and Conclusions sections.</li> </ul>
<p><b>12. Ongoing consultation with Traditional Owner (TO) groups</b></p> <p>17 December 2021</p>	<p>A representative from the GBRF Reef Trust Partnership Traditional Owner Partnerships team coordinated input from their Technical Working Group to revise the questions (17 December 2021), for circulation to the TO representatives on the RAC and IEP.</p> <p>The SCS Coordination Team liaised with DESI and a joint meeting was held on 18 January 2022 to finalise these questions, and the arrangements for delivering them. Further consultation with the meeting participants occurred, with additional detailed feedback from GBRF. The final question was endorsed by ISP on 13 May 2022.</p>	<p>GBRF TO Partnerships team</p> <p>TO representatives from RAC and IEP</p>	<ul style="list-style-type: none"> <li>– Input to question setting process on proposed Traditional Owner (TO) groups, coordinated by GBRF TO Partnerships team.</li> <li>– Supported the intent of the proposed questions, and recognising the need to scope options for further involvement of TO knowledge in future iterations of the SCS.</li> </ul>
<p><b>13. Final list of Questions</b></p> <p>January to May 2022</p>	<p>Small changes in the wording of the questions were taken into consideration during the author consultation process.</p> <p>ISP reviewed and endorsed those final changes in the question list during the session of 13 May 2022 (refer to Table 2).</p>	<p>Lead Authors</p> <p>ISP</p>	<ul style="list-style-type: none"> <li>– Revised document including revisions (v090522, v24052022 incorporating revisions for ISP, v230622 list endorsed by ISP).</li> </ul>
<p><b>14. Author interpretation of Questions</b></p> <p>2022</p>	<p>As a first step in the synthesis of the evidence methods, Authors' expert interpretation of the Questions resulted in some additional minor changes in wording and the merging of Questions 1.2, 1.3 and 2.1. Relevant definitions were also defined.</p> <p>To facilitate this step, individual meetings were held between each Lead Author, the SCS Coordination Team and the evidence synthesis expert to ensure that the Lead Author had all the</p>	<p>Lead Authors</p> <p>Contract Managers</p> <p>ISP</p>	<ul style="list-style-type: none"> <li>– Revised document: SCS 2022 Q list_v1.3 Nov2022.</li> </ul>

Step & timing	Purpose / Key points	Participants	Documentation/outcomes and comments
	<p>necessary information to interpret their question. The following items were addressed:</p> <ul style="list-style-type: none"> <li>– Consultation feedback. Authors were provided with a de-identified set of consultation feedback for their question to provide guidance on scope and where appropriate, emphasis.</li> <li>– Clarification and notes on the scope and intent of the question. In some cases, proposed refinement of the wording of the questions was proposed as an outcome of individual discussions with authors.</li> <li>– Expectations for author leadership, involvement and coordination.</li> <li>– Clarification of the evidence synthesis methods.</li> </ul> <p>The following key considerations were also provided to the Lead Authors beforehand for discussion in the meeting:</p> <ul style="list-style-type: none"> <li>– What definitions are needed to help clarify your question?</li> <li>– Do you think external evidence searches are required?</li> <li>– Do you think that a 1990 cut off for evidence is going to create unnecessary restriction or bias in the search?</li> <li>– What proportion of studies based on modelling do you anticipate will make up the evidence?</li> <li>– How important do you think the extrapolation of a study location(s) is to answering your question? What restriction can you see on individual studies regarding wider spatial applicability?</li> <li>– How important do you think the extrapolation of a study sampling period/duration/time of year is to answering your question? What restriction can you see on individual studies regarding wider temporal applicability?</li> </ul> <p>Contract Managers provided additional feedback and clarification of the scope of questions and definitions as required.</p> <p>ISP reviewed and endorsed those final changes in the question list (November 2022).</p>		

### 3. Final list of questions and structure of the 2022 SCS

The final list of questions that were addressed in the 2022 SCS are listed in Table 2, and the final structure of the 2022 SCS providing the groupings for the questions is shown in Figure 4. Twenty-one (21) questions were addressed using the SCS Evidence Summary method and nine (9) were addressed using the SCS Evidence Review. A Systematic Map was also prepared as Stage 1 for the questions associated with the role of wetlands in improving water quality in the GBR catchments (4.7 and 4.8). The outcomes of the assessment guided the final definition of the questions and methods for the final outputs for Questions 4.7, 4.8 and 4.9. Note that these questions were co-funded by the Reef Trust Partnership (through GBRF) as an area of high priority for guiding future investment.

Table 2. Final list of questions addressed in the 2022 Scientific Consensus Statement.

New Ref#	Questions	Priority / Method
	<b>Background (Themes 1–2): Values, condition and drivers of health of the Great Barrier Reef</b>	
1.1	What are the socio-ecological, cultural, economic and intrinsic values of the Great Barrier Reef?	Evidence Summary
1.2 /1.3 /2.1	What is the extent and condition of Great Barrier Reef ecosystems and what are the primary threats to their health?	Evidence Summary
1.4	How are the GBR's key ecosystem processes connected from the catchment to the reef and what are the primary factors that influence these connections?	Evidence Summary
2.2	What are the current and predicted impacts of climate change on GBR ecosystems (including spatial and temporal distribution of impacts)?	Evidence Summary
2.2.1	<b>Sub-question to 2.2:</b> How is climate change currently influencing water quality in coastal and marine areas of the GBR, and how is this predicted to change over time?	
2.3	What evidence is there for changes in land-based runoff from pre-development estimates in the GBR?	Evidence Summary
2.4	How do water quality and climate change interact to influence the health and resilience of GBR ecosystems?	<b>VERY HIGH</b> Evidence Summary
2.4.1	<b>Sub-question to 2.4:</b> How are the combined impacts of multiple stressors (including water quality) affecting the health and resilience of GBR coastal and inshore ecosystems?	
2.4.2	<b>Sub-question to 2.4:</b> Would improved water quality help ecosystems cope with multiple stressors including climate change impacts, and if so, in what way?	
	<b>Theme 3: Sediments and particulate nutrients – catchment to reef</b>	
	<i>Ecological processes</i>	
3.1	What are the spatial and temporal distributions of terrigenous sediments and associated indicators within the GBR?	Evidence Summary
3.1.1	<b>Sub-question to 3.1:</b> What is the variability of turbidity and photic depth in coastal and marine areas of the GBR?	
3.2	What are the measured impacts of increased sediment and particulate nutrient loads on GBR ecosystems, what are the mechanism(s) for those impacts and where is there evidence of this occurring in the GBR?	<b>VERY HIGH</b> Evidence Review
	<i>Delivery and source</i>	
3.3	How much anthropogenic sediment and particulate nutrients are exported from GBR catchments (including the spatial and temporal variation in export), what are the most	Evidence Summary



New Ref#	Questions	Priority / Method
	important characteristics of anthropogenic sediments and particulate nutrients, and what are the primary sources?	
3.4	What are the primary biophysical drivers of anthropogenic sediment and particulate nutrient loss to the GBR and how have these drivers changed over time?	Evidence Summary
3.4.1	<b>Sub-question to 3.4:</b> What evidence is there to link low groundcover, vegetation and tree clearing with poor water quality and runoff?	
3.4.2	<b>Sub-question to 3.4:</b> What is the relationship between land condition and sediment and particulate nutrient runoff for management of GBR catchments?	
	<i>Management options</i>	
3.5	What are the most effective management practices (all land uses) for reducing sediment and particulate nutrient loss from the GBR catchments, do these vary spatially or in different climatic conditions?  What are the costs and cost-effectiveness of these practices, and does this vary spatially or in different climatic conditions?  What are the production outcomes of these practices?	<b>VERY HIGH</b>  Evidence Review
3.6	What is the effectiveness of restoration works (e.g. gully and streambank) in reducing sediment and particulate nutrient loss from the GBR catchments, does this vary spatially or in different climatic conditions?  What are the costs and cost-effectiveness of these works, and does this vary spatially or in different climatic conditions?  What are the production outcomes of these practices?	<b>VERY HIGH</b>  Evidence Summary
3.6.1	<b>Sub-question to 3.6:</b> What is the benefit of vegetation restoration in 1) riparian zones and 2) hillslope and floodplain zones, in reducing sediment and particulate nutrient loss to the GBR?	
	<b>Theme 4: Dissolved nutrients – catchment to reef</b>	
	<i>Ecological processes</i>	
4.1	What is the spatial and temporal distribution of nutrients and associated indicators within the GBR?	<b>VERY HIGH</b>  Evidence Summary
4.1.1	<b>Sub-question to 4.1:</b> What is the variability of nutrients in coastal and marine areas of the GBR?	
4.2	What are the measured impacts of nutrients on GBR ecosystems, what are the mechanism(s) for those impacts and where is there evidence of this occurring in the GBR?	<b>VERY HIGH</b>  Evidence Review
4.3	What are the key drivers of the population outbreaks of crown-of-thorns starfish (COTS) in the GBR, and what is the evidence for the contribution of nutrients from land-runoff to these outbreaks?	<b>VERY HIGH</b>  Evidence Review
	<i>Delivery and source</i>	
4.4	How much anthropogenic dissolved nutrient (nitrogen and phosphorus species) is exported from GBR catchments (including the spatial and temporal variation in export), what are the most important characteristics of anthropogenic dissolved nutrients, and what are the primary sources?	Evidence Summary
4.5	What are the primary biophysical drivers of anthropogenic dissolved nutrient loss to the GBR and how have these drivers changed over time?	Evidence Summary
4.5.1	<b>Sub-question 4.5:</b> What proportion of nutrient is lost by surface and sub-surface pathways?	
4.5.2	<b>Sub-question 4.5:</b> How do nutrients transform during the transport and delivery to the GBR lagoon (e.g. bioavailability of particulate nutrients)?	

New Ref#	Questions	Priority / Method
	<i>Management options</i>	
4.6	What are the most effective management practices for reducing dissolved nutrient losses (all land uses) from the GBR catchments, and do these vary spatially or in different climatic conditions?  What are the costs of the practices, and cost-effectiveness of these practices, and does this vary spatially or in different climatic conditions?  What are the production outcomes of these practices?	<b>VERY HIGH</b>  Evidence Review
4.6.1	<b>Sub-question to 4.6:</b> What is the potential of Enhanced-Efficiency-Fertilisers (EEFs) in reducing nitrogen runoff and what are the primary challenges in implementation?	
4.6.2	<b>Sub-question to 4.6:</b> What are the implications of mill mud application in influencing nitrogen losses and what are the primary challenges for implementation?	
4.6.3	<b>Sub-question to 4.6:</b> What are the primary factors that influence nutrient losses from irrigated areas and how can these be managed?	
4.7	What is the efficacy of natural/near natural wetlands, restored, treatment (constructed) wetlands and other treatment systems in GBR catchments in improving water quality (nutrients, fine sediments and pesticides)?	Systematic Map completed  Evidence Review
4.7.1	<b>Sub-question to 4.7:</b> What are the key factors that affect the efficacy of natural/near natural wetlands, restored, treatment (constructed) wetlands and other treatment systems in GBR catchments in improving water quality and how can these be addressed at scale to maximise water quality improvement?)	
4.8	What are the measured costs, and cost drivers associated with the use of natural/near natural wetlands, restored, treatment (constructed) wetlands and other treatment systems in GBR catchments in improving water quality?	Scoped as part of Systematic Map for 4.8  Evidence Summary
4.9	What role do Natural/ Near Natural wetlands play in the provision of ecosystem services and how is the service of water quality treatment compatible or at odds with other services (e.g. habitat, carbon sequestration)?	Evidence Summary
	<b>Theme 5: Pesticides – catchment to reef</b>	
	<i>Ecological processes</i>	
5.1	What is the spatial and temporal distribution of pesticides across GBR ecosystems, what are the (potential or observed) ecological impacts in these ecosystems and what evidence is there for pesticide risk?	<b>VERY HIGH</b>  Evidence Review
	<i>Delivery and source</i>	
5.2	What are the primary sources of the pesticides that have been found in GBR ecosystems and what are the key factors that influence pesticide delivery from source to ecosystems?	Evidence Summary
	<i>Management options</i>	
5.3	What are the most effective management practices for reducing pesticide risk (all land uses) from the GBR catchments, and do these vary spatially or in different climatic conditions?  What are the costs of the practices, and cost-effectiveness of these practices, and does this vary spatially or in different climatic conditions?  What are the production outcomes of these practices?	Evidence Review
	<b>Theme 6: Other pollutants – catchment to reef</b>	
6.1	What is the spatial and temporal distribution and risk of other pollutants in GBR ecosystems, and what are the primary sources?	<b>VERY HIGH</b>  Evidence Summary

New Ref#	Questions	Priority / Method
	<b>Theme 7: Human dimensions of water quality improvement</b>	
7.1	What is the mix of programs and instruments (collectively and individually) used in the GBR catchments to drive improved land management actions for GBR water quality benefits and how effective are they?	Evidence Summary
7.2	What are the behavioural (attitudinal), economic, social and cultural factors that hinder or enable the uptake of management practices that aim to improve water quality outcomes for the GBR?	Evidence Review
7.2.1	<b>Sub-question to 7.2:</b> What factors influence disadoption of management practices in agricultural industries and are there examples from elsewhere on how to address it?	
7.3	What are the critical success factors for greater Indigenous involvement in water quality decision making in the GBR region?	Evidence Summary
	<b>Theme 8: Future directions and emerging science</b>	
8.1	What are the co-benefits e.g., biodiversity, carbon, productivity, climate change, and drought resilience, of land management to improve water quality outcomes for the GBR?	Evidence Summary
8.2	What are the key attributes of successful M&E programs to support coastal and marine water quality management, and what examples are there of innovative M&E frameworks, methods and approaches that are applicable to the GBR?	Evidence Summary



Figure 4. Structure of the 2022 Scientific Consensus Statement.

## Appendix 1. Original final list of 2022 SCS questions following consultation, December 2021

Table A1. Final list of questions for the 2022 Scientific Consensus Statement as of 17 December 2021. Questions were assigned to one of two evidence synthesis methods – an Evidence Summary or an Evidence Review. See the Approach to Methods Development (Pineda et al., 2024<sup>2</sup>) for more details on the Methods.

Ref#	Questions	Method	Priority
	<b>Theme 1: Ecological, cultural and social and economic asset values and condition of the Great Barrier Reef</b>		
1.1	What are the ecological, social, cultural, economic and non-economic values of the GBR?	Background chapter - values	
1.2	What is the change in the extent, condition and ecological function of Great Barrier Reef ecosystems?	Background chapter - status	
1.3	How are the GBR ecosystems connected from the catchment to the reef and what are the primary factors that influence these connections?	Evidence Summary	
	<b>Theme 2: Context and extent of anthropogenic impacts on water quality as a threat to the Great Barrier Reef</b>		
2.1	What are the primary threats to the long-term health of GBR ecosystems and what is the relative impact of these threats (current and predicted)?	Evidence Summary	<b>VERY HIGH</b>
2.2	What are the current and predicted impacts of climate change on GBR ecosystems (including spatial and temporal distribution of impacts)?	Evidence Summary	
2.3	What are the primary drivers of water quality in the Great Barrier Reef?	Evidence Summary	<b>VERY HIGH</b>
2.3.1	<b>Sub-question to 2.3:</b> What is the natural variability of turbidity and photic depth in coastal and marine areas of the GBR?		
2.3.2	<b>Sub-question to 2.3:</b> What is the natural variability of nutrients in coastal and marine areas of the GBR?		
2.3.3	<b>Sub-question to 2.3:</b> What evidence is there for increases in land-based runoff from pre-development estimates in the GBR?		<b>VERY HIGH</b>
2.4	How do water quality and climate change interact to influence the health and resilience of GBR ecosystems?	Evidence Summary	<b>VERY HIGH</b>
2.4.1	<b>Sub-question to 2.4:</b> How is climate change currently influencing water quality in coastal and marine areas of the GBR, and how is this predicted to change over time?		<b>VERY HIGH</b>
2.4.2	<b>Sub-question to 2.4:</b> How are the combined impacts of multiple stressors (including water quality) affecting the health and resilience of GBR coastal and inshore ecosystems?		
2.4.3	<b>Sub-Question to 2.4:</b> Would improved water quality help ecosystems cope with multiple stressors including climate change impacts, and if so, in what way?		<b>VERY HIGH</b>
	<b>Theme 3: Sediments and particulate nutrients – catchment to reef</b>		
	<i>Ecological processes</i>		
3.1	What are the spatial and temporal distributions of anthropogenic sediments and associated indicators within the GBR?	Evidence Summary	
3.2	What are the measured impacts of increased sediment and particulate nutrient loads on GBR ecosystems, what are the mechanism(s) for those impacts and where is there evidence of this occurring in the GBR?	Evidentiary Rapid Review	<b>VERY HIGH</b>

<sup>2</sup> Pineda M-C, Waterhouse J, Richards R (2024) 2022 Scientific Consensus Statement: Approach to the Development of Methods for the Synthesis of Evidence. Published by C<sub>2</sub>O Consulting, Townsville, Queensland. 48pp.

Ref#	Questions	Method	Priority
	<i>Delivery and source</i>		
3.3	How much anthropogenic sediment and particulate nutrients are delivered to the GBR ecosystems (including the spatial and temporal variation in delivery), what are the most important characteristics of anthropogenic sediments and particulate nutrients, and what are the primary sources?	Evidence Summary	
3.4	What are the primary biophysical drivers of anthropogenic sediment and particulate nutrient loss to the GBR and has this changed over time?	Evidence Summary	
3.4.1	<b>Sub-question to 3.4:</b> What evidence is there to link low groundcover with poor water quality and runoff?		
3.4.2	<b>Sub-question to 3.4:</b> What is the relationship between land condition and sediment and particulate nutrient runoff for management of GBR catchments?		
	<i>Management options</i>		
3.5	What are the most effective management practices (all land uses) for reducing sediment and particulate nutrient loss from the GBR catchments, do these vary spatially or in different climatic conditions?  What are the costs and cost-effectiveness of these practices, and does this vary spatially or in different climatic conditions?  What are the production outcomes of these practices?	Evidentiary Rapid Review	<b>VERY HIGH</b>
3.6	What is the effectiveness of restoration works (e.g. gully and streambank) in reducing sediment and particulate nutrient loss from the GBR catchments, does this vary spatially or in different climatic conditions?  What are the costs and cost-effectiveness of these works, and does this vary spatially or in different climatic conditions?  What are the production outcomes of these practices?	Evidence Summary	<b>VERY HIGH</b>
3.6.1	<b>Sub-question to 3.6:</b> What is the benefit of vegetation restoration in 1) riparian zones and 2) hillslope and floodplain zones, in reducing sediment and particulate nutrient loss to the GBR?		
	<i>Human dimensions of management</i>		
	Link to Theme 7		
	<b>Theme 4: Dissolved nutrients – catchment to reef</b>		
	<i>Ecological processes</i>		
4.1	What is the spatial and temporal distribution of nutrients and associated indicators within the GBR?	Evidence Summary	<b>VERY HIGH</b>
4.2	What are the measured impacts of nutrients on GBR ecosystems, what are the mechanism(s) for those impacts and where is there evidence of this occurring in the GBR?	Evidentiary Rapid Review	<b>VERY HIGH</b>
4.3	What are the key drivers of the population outbreaks of crown-of-thorns starfish (COTS) in the GBR, and what is the evidence for the contribution of nutrients from land-runoff to these outbreaks?	Synthesis Eco-Evidence	<b>VERY HIGH</b>
	<i>Delivery and source</i>		
4.4	How much anthropogenic nutrient (nitrogen and phosphorus species) is delivered to the GBR ecosystems (including the spatial and temporal variation in delivery), what are the most important characteristics of anthropogenic nutrients, and what are the primary sources and transport processes?	Evidence Summary	
4.5	What are the primary biophysical drivers of anthropogenic nutrient loss to the GBR and has this changed over time?	Evidence Summary	
4.5.1	<b>Sub-question 4.5:</b> What proportion of nutrient is lost by different transport pathways in different land uses?		
4.5.2	<b>Sub-question 4.5:</b> How do nutrients transform during the transport and delivery to the GBR lagoon (e.g. bioavailability of particulate nutrients)?		

Ref#	Questions	Method	Priority
	<i>Management options</i>		
4.6	<p>What are the most effective management practices for reducing nutrient losses (all land uses) from the GBR catchments, and do these vary spatially or in different climatic conditions?</p> <p>What are the costs of the practices, and cost-effectiveness of these practices, and does this vary spatially or in different climatic conditions?</p> <p>What are the production outcomes of these practices?</p>	Evidentiary Rapid Review	<b>VERY HIGH</b>
4.6.1	<b>Sub-question to 4.6:</b> What is the potential of Enhanced-Efficiency-Fertilisers (EEFs) in reducing nitrogen runoff and what are the primary challenges in implementation?		
4.6.2	<b>Sub-question to 4.6:</b> What are the implications of mill mud application in influencing nitrogen losses and what are the primary challenges for implementation?		
4.6.3	<b>Sub-question to 4.6:</b> What are the primary factors that influence nutrient losses from irrigated areas and how can these be managed?		
4.7	What is the efficacy of natural/near natural wetlands, restored, treatment (constructed) wetlands and other treatment systems in GBR catchments in improving water quality (nutrients, fine sediments and pesticides)?	Systematic Map to start then questions to be refined and methods selected	
4.7.1	<b>Sub-question to 4.7:</b> What are the key factors that affect the efficacy of natural/near natural wetlands, restored, treatment (constructed) wetlands and other treatment systems in GBR catchments in improving water quality and how can these be addressed at scale to maximise water quality improvement?)		
4.8	What are the measured costs, and cost drivers associated with the use of natural/near natural wetlands, restored, treatment (constructed) wetlands and other treatment systems in GBR catchments in improving water quality?	Scoped as part of Systematic Map for 4.8	
4.9	What role do Natural/ Near Natural wetlands play in the provision of ecosystem services and how is the service of water quality treatment compatible or at odds with other services (e.g. habitat, carbon sequestration)?	Evidence Summary	
	<i>Human dimensions of management</i>		
	Link to Theme 7		
	<b>Theme 5: Pesticides – catchment to reef</b>		
	<i>Ecological processes</i>		
5.1	What is the spatial and temporal distribution of pesticides across GBR ecosystems, what evidence is there for pesticide risk and what are the (potential or observed) ecological impacts in these ecosystems?	Evidentiary Rapid Review	<b>VERY HIGH</b>
	<i>Delivery and source</i>		
5.2	What are the key factors that influence pesticide delivery from the GBR catchments, and where are these factors most significant?	Evidence Summary	
	<b>Sub-question to 5.2:</b> What types, levels and combinations of pesticides are delivered to the GBR, and what are the primary sources of pesticides?		
	<i>Management options</i>		
5.3	<p>What are the most effective management practices for reducing pesticide risk (all land uses) from the GBR catchments, and do these vary spatially or in different climatic conditions?</p> <p>What are the costs of the practices, and cost-effectiveness of these practices, and does this vary spatially or in different climatic conditions?</p> <p>What are the production outcomes of these practices?</p>	Evidence Summary	
	<i>Human dimensions of management</i>		
	Link to Theme 7		

Ref#	Questions	Method	Priority
	<b>Theme 6: Other pollutants – catchment to reef</b>		
6.1	What is the spatial and temporal distribution and risk of other pollutants in GBR ecosystems, and what are the primary sources?	Evidence Summary	<b>VERY HIGH</b>
	<b>Theme 7: Human dimensions of water quality improvement</b>		
7.1	What are the behavioural (attitudinal), economic, social and cultural factors that serve as barriers or enablers of improved practices in the GBR and how do these vary?	Evidentiary Rapid Review	
	<b>Sub-question to 7.1:</b> What factors influence disadoption of management practices in agricultural industries and are there examples from elsewhere on how to address it?		
7.2	What is the mix of policies, programs and instruments (collectively and individually) currently being used to drive improved land management in the GBR catchments and how effective are they?	Evidence Summary	
7.3	How can Traditional Owner knowledge compliment science-based decision making for water quality management in the GBR?	TBD	
7.3.1	<b>Sub-question to 7.3:</b> What are the best practice approaches to achieving meaningful Traditional Owner engagement in water quality program design and implementation?	TBD	
	<b>Theme 8: Future directions and emerging science</b>		
8.1	What other benefits can arise from management actions/interventions for water quality improvement, e.g. climate change mitigation, soil carbon remediation, drought resilience, landscape restoration for the GBR?	Evidence Summary	
8.2	Are there innovations in monitoring and evaluation available from other locations that are relevant to informing planning and management for GBR water quality management? OR What are the key considerations in monitoring and evaluating pollutant loads and ecological response across the catchment to reef landscape at large scales and in variable climatic conditions, and what are the latest innovations in methods? <i>Preliminary wording to be refined.</i>	Evidence Summary	

## Appendix 2. Questions identified in the consultation process for consideration in the Spatial Management Prioritisation and Targets Review projects

Several questions were identified through consultation with policy, management and stakeholder representatives that were determined to be more suitable for the Spatial Management Prioritisation or Review of the GBR Water Quality Targets projects being led by C<sub>2</sub>O Consulting. Information that addresses the questions is being considered within these projects where appropriate.

### **Spatial Management Prioritisation**

- What is the spatial distribution of pollutant-sensitive GBR ecosystems (e.g. seagrass, benthic and planktonic communities, freshwater and estuarine, wetlands) at risk of exposure to anthropogenic land-based pollutants? What are the implications of this risk to the values of the GBR (including impact on environmental, social, cultural and economic values and connectivity issues)? *Include impact on values as qualitative assessment in the Spatial Management Prioritisation.*
- What is the spatial and temporal distribution of climate change-related pressures (such as increased temperature, ocean acidification) across the GBR?
- What is the estimated time lag for ecologically-relevant responses to be detected in Reef ecosystems from improvements in water quality?
- What is the most appropriate method for calculating cost-effectiveness for gully and streambank remediation projects in the GBR catchments?
- What is the spatial and temporal distribution of pesticides across GBR ecosystems, what evidence is there for pesticide risk and how do these risks occur? *Addressed in SCS but relevant to Spatial Management Prioritisation*
- What are the potential impacts caused by expected land transition along the GBR coast and how can this be incorporated into management strategies?
- What is the relative impact of new agricultural development and land-uses for future developments across Northern Australia and the relevance to the GBR?
- What are the water quality outcomes and relative cost-effectiveness of greater investment in water quality management in 'smaller' land uses such as urban areas, public land public spaces? *Addressed in SCS but relevant to Spatial Management Prioritisation*

### **Review of the GBR Water Quality Targets**

- What progress has been made towards the sediment reduction targets, and what progress could be expected in the future? Equivalent questions for nutrients and pesticides.