# “Prioritisation in reef restoration investment – the role of modelling inputs” – Dr Steve Skull, Alluvium

## QMWN – February 2020

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# Project: Effective and Efficient Pathways for Investment in Improved Water Quality in the Great Barrier Reef

- Project led by the Great Barrier Reef Foundation
- Built on foundation work delivered by a similar team in 2016 for the Office of Great Barrier Reef
- Significant differences to the 2016 project
- Role of the private sector

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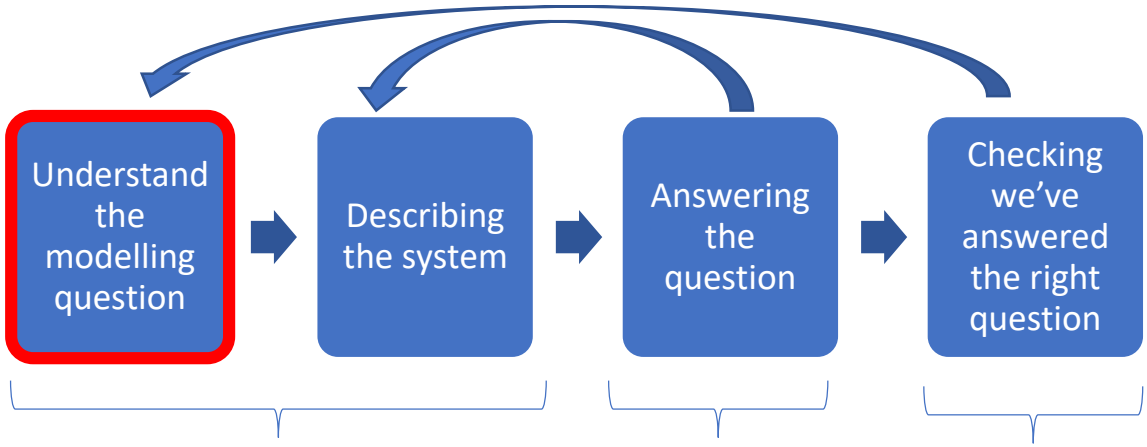
# A pipeline for water model delivery




Adapted from Hamilton et al (2015), Badham et al (2019), Jakeman et al (2006).

# Project: Effective and Efficient Pathways for Investment in Improved Water Quality in the Great Barrier Reef

Project aim:

To develop a quantitative assessment of the most cost-effective catchment management actions (built to collectively form a scenario or investment pathway) across the 46 reporting basins within the Great Barrier Reef catchments, and a data visualisation tool to support the comparison of the investment scenarios.

Governance:

Supported throughout its duration by the GBRF's Project Working Group and Peer Review Panel.

Understand the modelling question

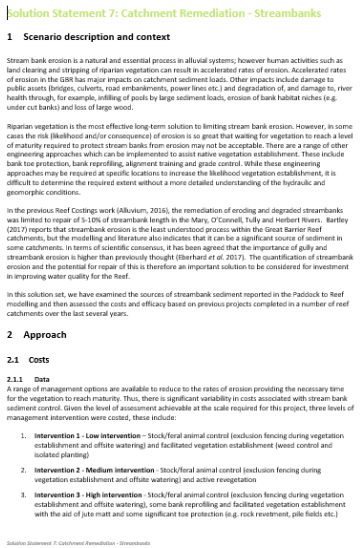
# WQ Pollutants and Intervention types

Three pollutants:

1. Nutrients (particularly Dissolved Inorganic Nitrogen- DIN)
2. Fine sediments (FS)
3. Pesticides

Ten intervention types

1. Practice change - Cane
2. Practice change – Grazing
3. Practice change – Pesticides
4. Practice change – Irrigation
5. Practice change – Horticulture (bananas)
6. Catchment remediation – Alluvial and hillslope gullies
7. Catchment remediation – Streambanks
8. Catchment remediation – Treatment systems
9. Point source WWTP management
10. Land use change



Solution Statement 7: Catchment Remediation - Streambanks

1 Scenario description and context

Stream bank erosion is a natural and essential process in alluvial systems; however human activities such as land clearing and stripping of riparian vegetation can result in accelerated rates of erosion. Accelerated rates of erosion in the GBR has major impacts on catchment sediment loads. Other impacts include damage to public assets (bridges, culverts, road embankments, power lines etc.) and degradation of, and damage to, river health through, for example, infilling of pools by large sediment loads, erosion of bank habitat niches (e.g. under cut banks) and loss of large wood.

Riparian vegetation is the most effective long-term solution to limiting stream bank erosion. However, in some cases the risk (likelihood and/or consequence) of erosion is so great that waiting for vegetation to reach a level of maturity required to protect stream banks from erosion may not be acceptable. There are a range of other engineering approaches which can be implemented to assist native vegetation establishment. These include bank toe protection, bank reprofiling, alignment training and grade control. While these engineering approaches may be required at specific locations to increase the likelihood vegetation establishment, it is difficult to determine the required extent without a more detailed understanding of the hydraulic and geomorphic conditions.

In the previous Reef Costings work (Alluvium, 2016), the remediation of eroding and degraded streambanks was limited to repair of 5-10% of streambank length in the Mary, O'Connell, Tully and Herbert Rivers. Bartley (2017) reports that streambank erosion is the least understood process within the Great Barrier Reef catchments, but the modelling and literature also indicates that it can be a significant source of sediment in some catchments. In terms of scientific consensus, it has been agreed that the importance of gully and streambank erosion is higher than previously thought (Eberhard *et al.* 2017). The quantification of streambank erosion and the potential for repair of this is therefore an important solution to be considered for investment in improving water quality for the Reef.

In this solution set, we have examined the sources of streambank sediment reported in the Paddock to Reef modelling and then assessed the costs and efficacy based on previous projects completed in a number of reef catchments over the last several years.

2 Approach

2.1 Costs

2.1.1 Data

A range of management options are available to reduce to the rates of erosion providing the necessary time for the vegetation to reach maturity. Thus, there is significant variability in costs associated with stream bank sediment control. Given the level of assessment achievable at the scale required for this project, three levels of management intervention were costed, these include:

1. **Intervention 1 - Low intervention** – Stock/feral animal control (exclusion fencing during vegetation establishment and offsite watering) and facilitated vegetation establishment (weed control and isolated planting)
2. **Intervention 2 - Medium intervention** - Stock/feral animal control (exclusion fencing during vegetation establishment and offsite watering) and active revegetation
3. **Intervention 3 - High intervention** - Stock/feral animal control (exclusion fencing during vegetation establishment and offsite watering), some bank reprofiling and facilitated vegetation establishment with the aid of jute matt and some significant toe protection (e.g. rock revetment, pile fields etc.)

*Solution Statement 7: Catchment Remediation - Streambanks*

46 basins

Understand the modelling question

# Overall investment development process

**Investment Pathways Consultancy**

**Investment Tool**
- Identify most cost effective actions based on $ invested in different catchments and for different objectives (nutrients, sediment, pesticides)

**Scenario development**
- Identify a series of investment scenarios, based on the agreed values and objectives

**Scenario analysis**
- Detailed analysis of feasibility, risk, uncertainty

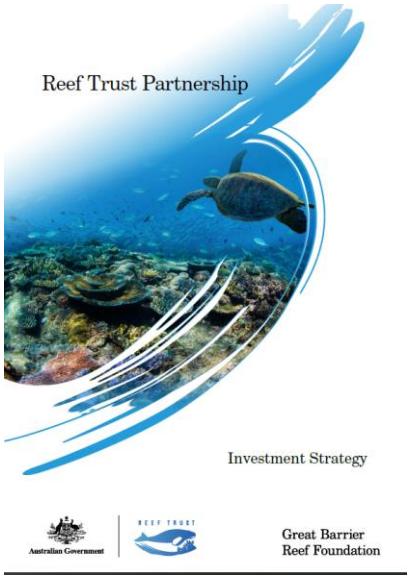
**Prioritisation Support Consultancy**

**Determine values and objectives**
- Identify values and objectives to inform prioritisation of investment options and design options for creating scenarios

**Scenario shortlist**
- Select a limited number of scenarios that best meet the objectives and values

**Scenario selection**
- Select preferred investment scenario

**5-Year Investment Strategy and Annual Workplan**




Understand the modelling question

# Some of the values considered

| Value Drivers | | | | |
|---|---|---|---|---|
| **Category** | **#** | **Value Driver** | **Value Driver Question** | **Value Driver Objective** |
| ***Economic*** Value Drivers | 1 | Reef dependent industries | How well does the investment scenario benefit Reef dependent industries? | The investment scenario is beneficial to Reef dependent industries, meaning that:<br>- It is beneficial to the tourism industry.<br>- It is beneficial to the commercial fishing industry. |
| | 2 | ***Social & Cultural*** Value Drivers | 4 Traditional Owners | How acceptable is the investment scenario to Traditional Owners? | The investment scenario is acceptable to Traditional Owners, meaning that:<br>- It integrates and respects Traditional Owner knowledge and perspectives.<br>- It integrates Traditional Owners in their design, delivery and evaluation.<br>- It delivers a plan that is easily communicable and understood by Traditional Owners.<br>- It is accepted by Traditional Owners. |
| | | | 5 S | ***Program*** Value Drivers | 11 Measurability | How well can the outcomes of the investment scenario be measured? | The investment scenario can be well measured, meaning that:<br>- The water quality improvement can be well measured across catchments.<br>- The changes in practice can be well measured across catchments.<br>- The link between changes in practice and water quality improvements can be well measured across catchments.<br>- The impacts on ecological and social indicators can be well measured across catchments. |
| | | | | | 12 Complimentary / Collaborative Partnerships | What are the complimentary and innovative characteristics of the intervention scenario? | The investment scenario is complimentary and innovative, meaning that:<br>- It drives innovation and partnerships in other water quality programs in Australia.<br>- It drives innovation and partnerships in other GBR programs.<br>- It drives innovation and partnerships in global water quality and reef protection initiatives.<br>- It maintains future interest in the GBR.<br>- It can be used to leverage further investment at present and in the future. |

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Understand the modelling question

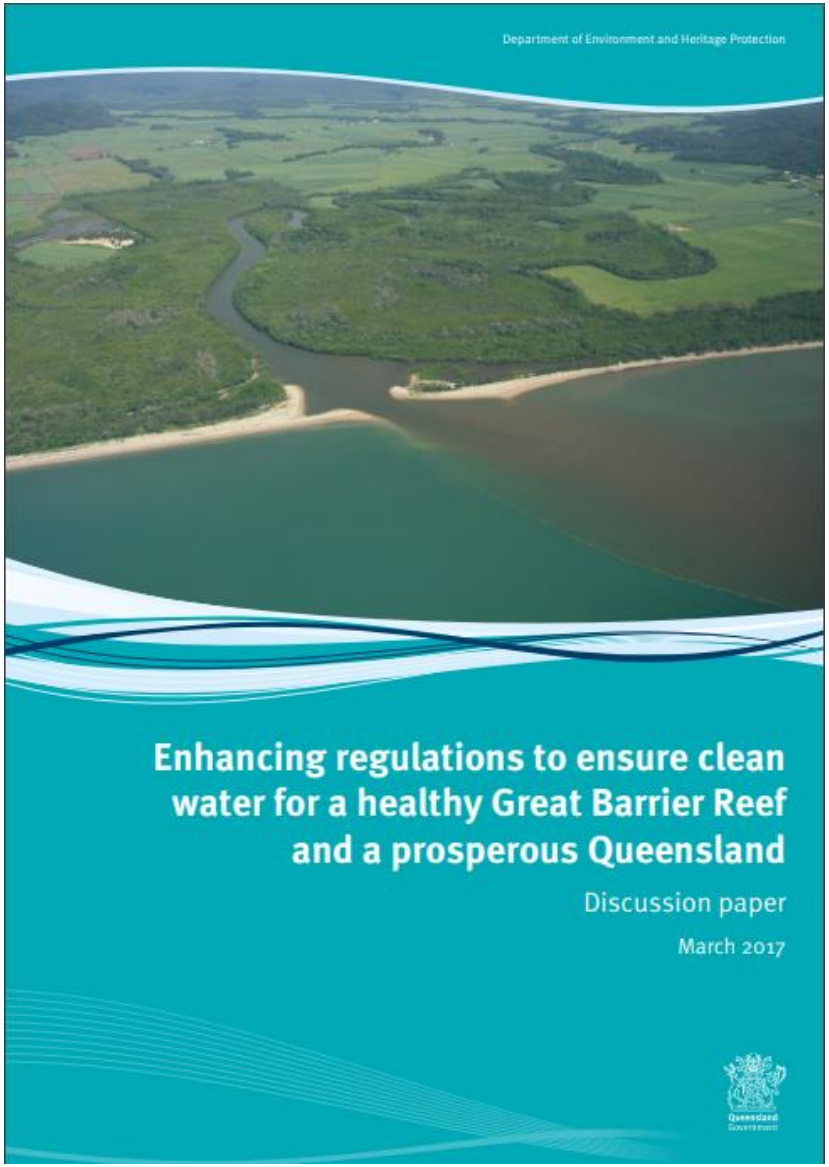
# 12 scenarios for initial modelling

Selected for assessment by both projects - an amalgam of three was selected as the final scenario to take forward for detailed assessment

| | | |
|---|---|---|
| **2.** | VHP and High Priority (HP), balanced portfolio (with pesticides) | - VHP and HP basins only<br>- Roughly even split between basins (greater $ to VHP basins)<br>- Roughly even split between FS and DIN<br>- $15m pesticides |
| **3.** | VHP and HP, balanced portfolio (no pesticides) | - As above, without pesticides |
| **4.** | All NRM regions | - Split by NRM region, with regard to priorities<br>- Wet Tropics and Burdekin $35m each<br>- Mackay Whitsunday, Fitzroy, Burnett Mary $20m each<br>- Cape York $5m<br>- Funding in each based on priority locations and cost effectiveness |
| **5.** | DIN Only | - VHP, HP and MP basins only<br>- DIN only<br>- Includes practice change to A. However, assumes a landholder moves no more than 2 steps in practice change (i.e. D-B, or C-A, but no D-A) |
| **11.** | Most cost effective options in HP and VHP basins | - VHP and HP basins only<br>- Even split between FS and DIN<br>- $15m pesticides<br>- Interventions based on most cost effective intervention |
| **12.** | Most cost effective option any location | - Any location<br>- Even split between FS and DIN<br>- $15m pesticides<br>- Interventions based on most cost effective |

Understand the modelling question

# Other important externalities




Understand the modelling question

# The front end - Tool discussion with key stakeholders

**What are the 'must haves'?**

- User selects:
  - What spatial scale? (NRM region and basin (46))
  - Which actions? Which constituent? Which basins?
  - % area of a given basin for a given action
- Reporting: Area treated, total cost, total load reduction, cost effectiveness
- Other?

**What are the 'nice to haves'?**

- Reporting: MACCs, maps, charts
- Other?

**What are we not including?**

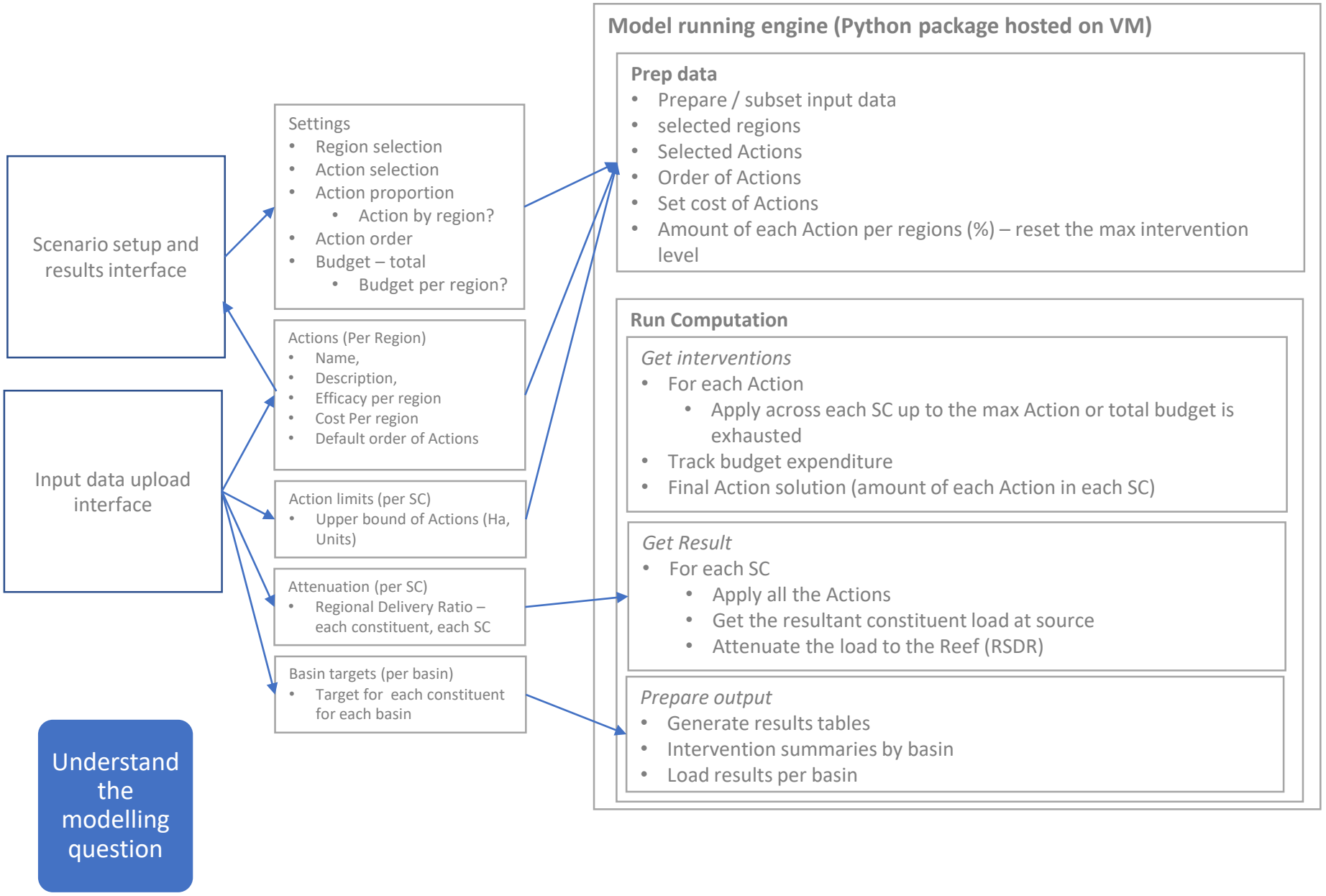
- Optimisation
- Multiple objectives (nutrients, sediment, pesticides) simultaneously
- Comparison of scenarios

**What's the process for refining and finalising the tool?**

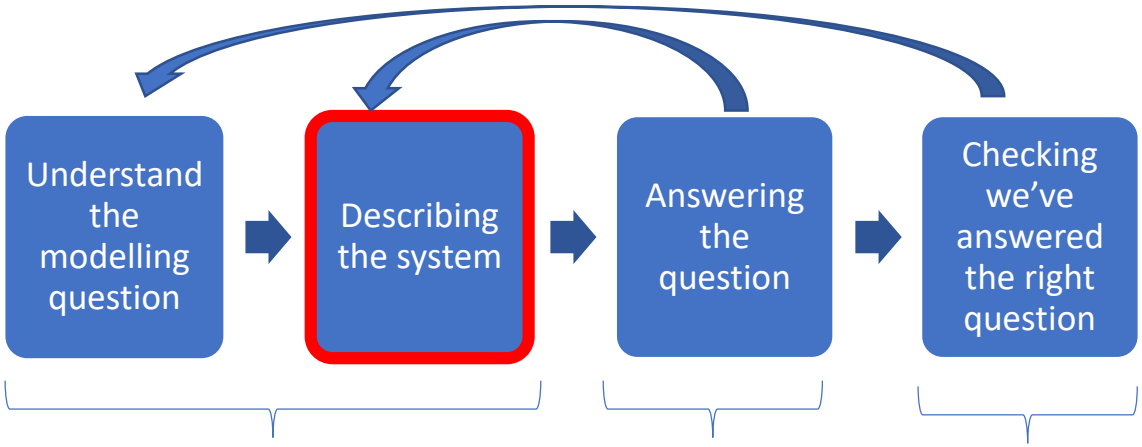
- How many iterations of the tool (when and how)

Understand the modelling question

# How could the tool work?



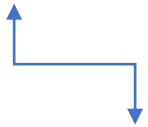
# A pipeline for water model delivery




Adapted from Hamilton et al (2015), Badham et al (2019), Jakeman et al (2006).

# Developing the conceptual understanding – model, visuals, flowchart

- Get out there and talk to people
- Describe the variables
- Visualise the processes and functions
- Outline indicators, scales, timeframes and timesteps
- Understand inter-relationships
- Consider if you have all the right people to build a conceptual understanding



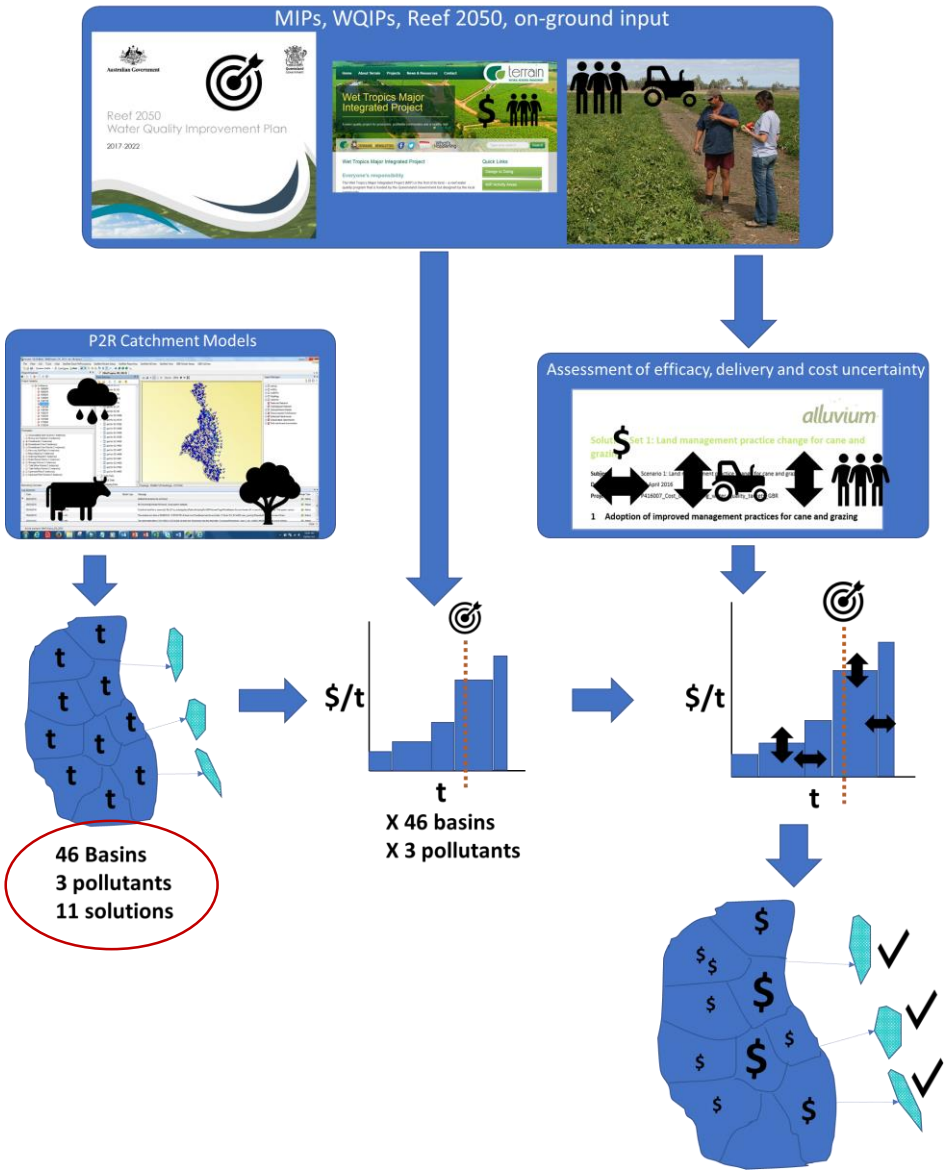
*We would like to acknowledge and thank the following people for their input into this report:*

*Kevin McCosker, Scott Wilkinson, David Waters, Robin Ellis and Melanie Shaw.*

*We would also like to acknowledge the input and feedback from members of the project's **Working Group** (Christian Roth, Jane Waterhouse, Kevin Gale, Scott Robinson, Robert Speed, Cedric Robillot) and **Peer Review Panel** (John Rolfe, Ian Prosser, Graham Bonnett, Bob Speirs, Christine Williams and Stuart Whitten).*

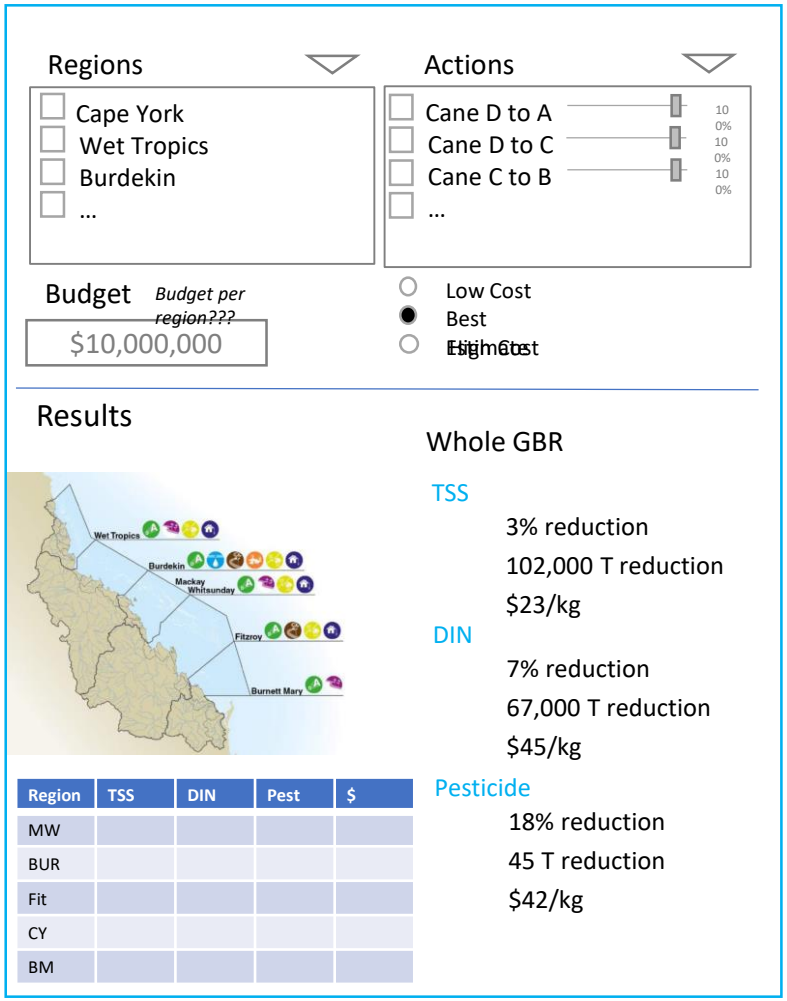
Describing the system

# Building the method




Describing the system

# Building the front end




Infinite range of scenarios

Can change

- Regions (6)
  - Possible catchments (45)
- Actions(~30)
  - Amount of each intervention (x10)
  - Amount of intervention for each region?
- Budget – continuous range
- Range of costs applied per intervention (3 x 6 x 30)
  - Select by region?

Setup values might change (e.g. Action costs, efficacy)

- Would need to change underlying data to drive the model

Need to program the model – python based package

- Need to create a python based model to conduct the computation (and Virtual Machine to serve it via API)

Describing the system

# Tool development

Describing the system

## Building the database (the 'back end'):

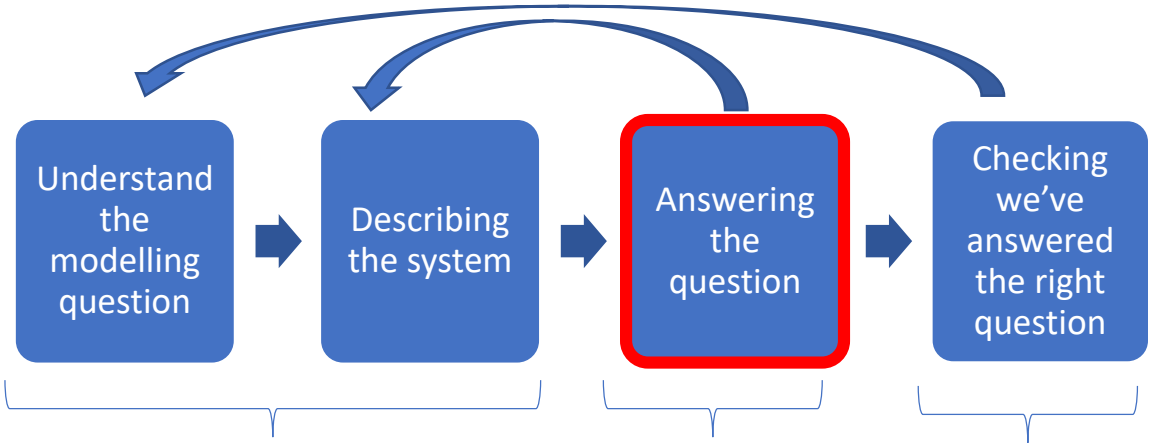
Cost-effectiveness

| NRM region | Basin | Solution set | Action | Area available (ha) | Current DIN load (kg) | % load reduction DIN | Total DIN load reduction (kg) | kg/ha | $/ha | Total cost ($) | $/kg DIN | Equivalent for Fine sediment and Pesticides |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Burdekin | Burdekin River | Practice change - cane | Cane D-C | 6619 | 81527 | 49% | 39948 | 6.04 | $48 | $318k | $8 | |
| Burdekin | Belyando | Practice change – cane | Cane D-C | 224 | 3056 | 49% | 1497 | 6.69 | $48 | $11k | $7.2 | |
| Burdekin | Burdekin River | Land use change | Cane (D) to grazing | 6619 | 81527 | 80% | 65200 | 9.9 | $20 | $132k | $2 | |
| Burdekin | Belyando | Land use change | Cane (D) to conservation | 224 | 3056 | 70% | 2139 | 9.55 | $30 | $7k | $3.1 | |
| Wet Tropics | Tully | Practice change – cane | Cane D-C | 4763 | 11822 | 13% | 1537 | 0.323 | $35 | $167k | $109 | |
| Wet Tropics | Mossman | Practice change – cane | Cane D-C | 1990 | 1978 | 13% | 257 | 0.22 | $35 | $69k | $271 | |

***For 46 basins X 36+ actions = 1656+ rows***

* Sample data only

# A pipeline for water model delivery




Adapted from Hamilton et al (2015), Badham et al (2019), Jakeman et al (2006).

# Answering the question

- Run the models
- Calibration, verification, validation
- Check results are fit for purpose
- Consider uncertainty and sensitivity
- Processing and visualisation – representing the results – both the model and the visualisation tool

"I don't trust models and I reckon ya numbers are rubbish"

Answering the question

# What the model told us for the preferred scenario

**Table 2. Final Scenario – Fine Sediment (FS)**

| Region | Basin | Priority | Pollutant | $ | Intervention | Cost effectiveness (5yr) ($/kg) | FS Reduction (kt) | FS Target (kt) | % to FS target |
|---|---|---|---|---|---|---|---|---|---|
| Burdekin | Bowen Bogie | VHP | FS | $6,130,000 | Grazing D to C | $0.03 | 196.8 | 426 | |
| Burdekin | Bowen Bogie | VHP | FS | $1,960,000 | Gully Type 1 Treatment | $0.04 | 44.9 | 426 | |
| Burdekin | Bowen Bogie | VHP | FS | $19,300,000 | Gully Type 3 Treatment | $0.21 | 89.9 | 426 | |
| ***Burdekin*** | ***Bowen Bogie*** | | | ***$27,300,000*** | | | ***331.6*** | ***426*** | ***78%*** |
| Burdekin | East Burdekin | VHP | FS | $1,040,000 | Grazing D to C | $0.07 | 15.5 | 75 | |
| Burdekin | East Burdekin | VHP | FS | $489,000 | Gully Type 1 Treatment | $0.09 | 5.4 | 75 | |
| ***Burdekin*** | ***East Burdekin*** | | | | | | ***20.9*** | ***75*** | ***28%*** |
| Fitzroy | Fitzroy River | HP | | | | | 17.4 | 201 | |

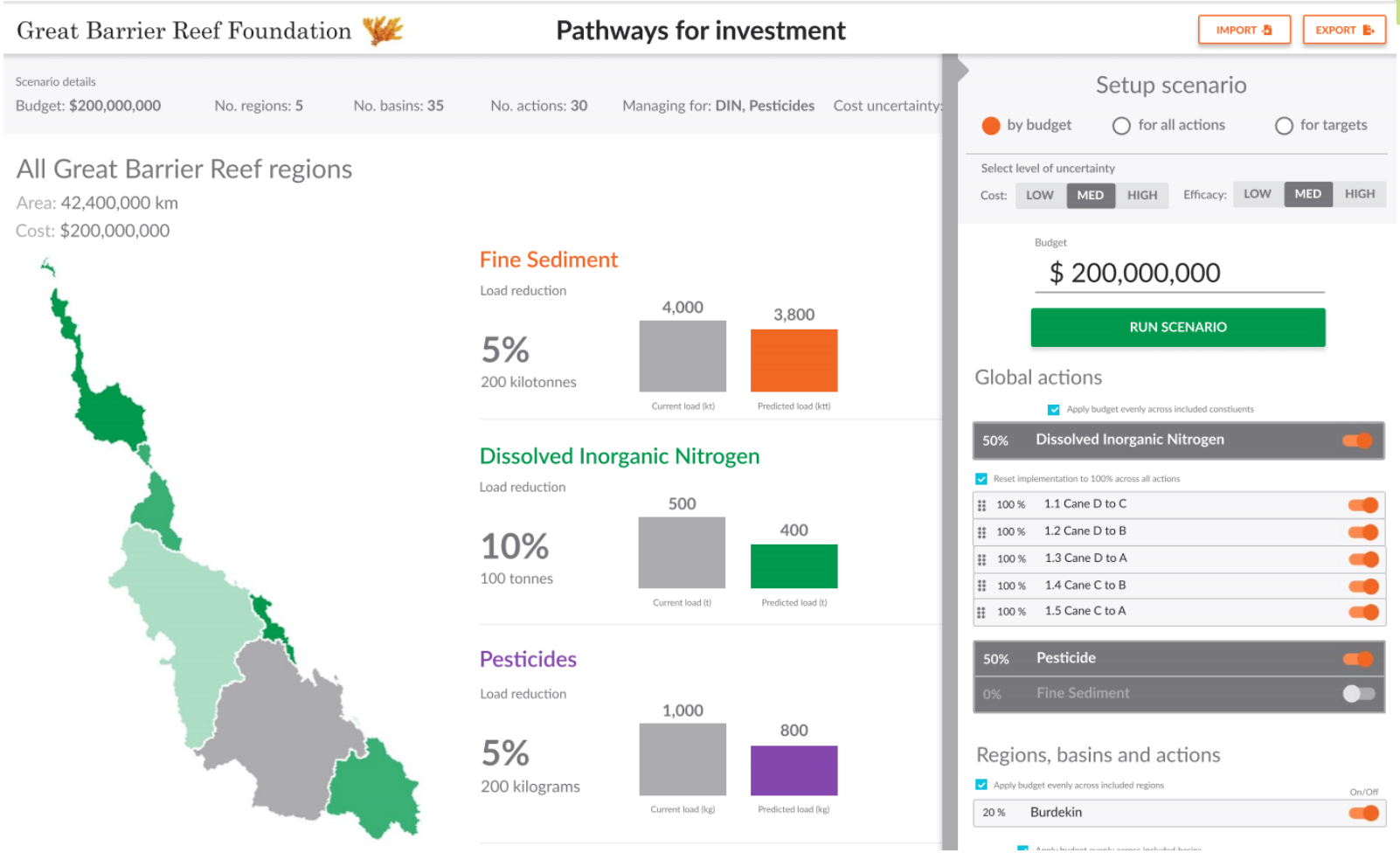
**Table 4. Final Scenario – NRM Region Summary**

| | DIN | Pesticides | Fine Sediment | Total |
|---|---|---|---|---|
| **Wet Tropics** | $34,000,000 | | $3,450,000 | $37,500,000 |
| **Burdekin** | $16,400,000 | $4,000,000 | $31,400,000 | $51,800,000 |
| **Mackay Whitsunday** | $11,700,000 | $11,000,000 | | $22,700,000 |
| **Fitzroy** | | | $19,600,000 | $19,600,000 |
| **Burnett Mary** | | | $9,400,000 | $9,400,000 |
| | **$62,100,000** | **$15,000,000** | **$63,900,000** | **$141,000,000** |

Did these outputs make sense based on our collaboratively agreed approach and assumptions?

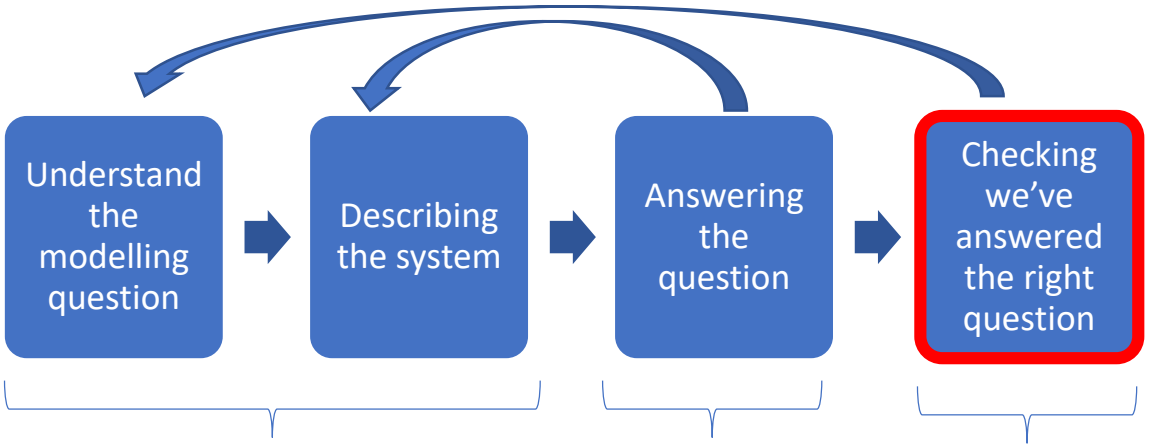
Answering the question

# The visualisation tool




Answering the question

# A pipeline for water model delivery




Adapted from Hamilton et al (2015), Badham et al (2019), Jakeman et al (2006).

# Looking at non-costs risks

- Evaluation of implementation factors or non-cost risks which can influence the costs and efficacy of actions – impacts CEA and scenario development.
- Key real-world issues such as variance to efficacy and timeframes of delivery, which would provide an indication of where uncertainty was likely to influence investment decisions.
- Minimal quantitative information to develop assessment framework, so it became largely qualitative.
- Moving forward needs greater focus and then application within investment decision frameworks.

| Action | Non cost risk component | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Adoption* | | | | *Efficacy* | | | | Assumed level of overall adoption |
| | Participation | Implementation | Affordability | Dis-adoption | Scientific & technical uncertainty | Design & location | Application | Operational | Checking we've answered the right question |
| WQ Intervention Type A | | | | | | | | | |

# Lessons learned…….

- Understanding the environment in which the modelling question is being asked
- The value of input from others
- The value of other information sources/processes
- Documenting the assumption/limitations
- Documenting the learnings
- Getting out there and understanding the system, the people and the context

# *Questions/comments?*

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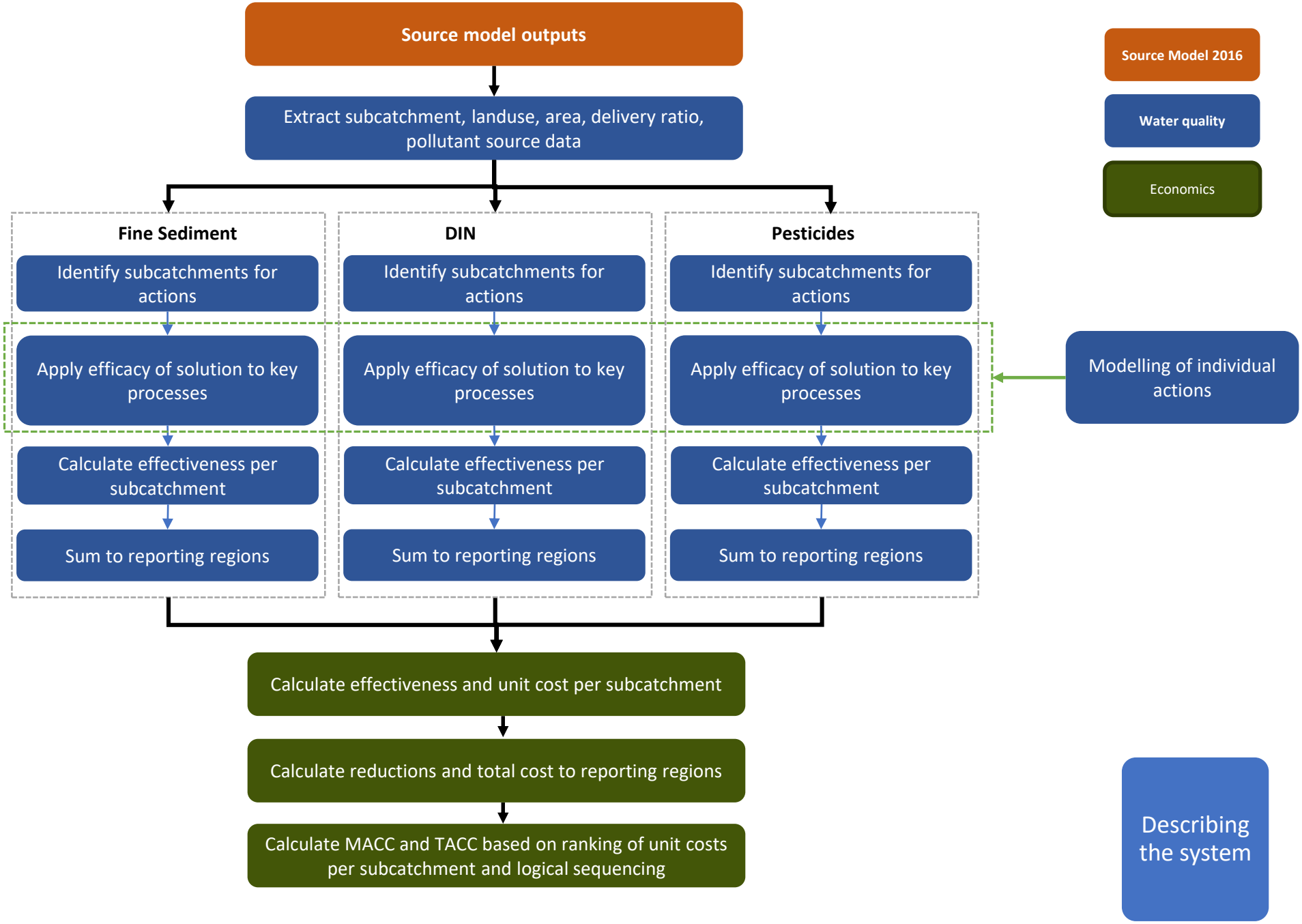
Source model outputs
Extract subcatchment, landuse, area, delivery ratio, pollutant source data
Fine Sediment
DIN
Pesticides
Identify subcatchments for actions
Identify subcatchments for actions
Identify subcatchments for actions
Apply efficacy of solution to key processes
Apply efficacy of solution to key processes
Apply efficacy of solution to key processes
Calculate effectiveness per subcatchment
Calculate effectiveness per subcatchment
Calculate effectiveness per subcatchment
Sum to reporting regions
Sum to reporting regions
Sum to reporting regions
Calculate effectiveness and unit cost per subcatchment
Calculate reductions and total cost to reporting regions
Calculate MACC and TACC based on ranking of unit costs per subcatchment and logical sequencing
Modelling of individual actions
Source Model 2016
Water quality
Economics
Describing the system