NIWA
Taihoro Nukurangi

Waikato Dynamic Models

Prioritisation results and work plan

Prepared for Waikato River Authority

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Background

The Waikato River Authority (WRA) has previously co-funded a project to identify and scope a set of dynamic models that will improve integrated management of water quality, quantity and ecology at the scale of the entire Waikato/Waipaa freshwater system. A model suite of this nature is required to support delivery of Te Whaimana o te Awa o Waikato (Vision and Strategy), with emphasis on supporting the response of Report Card Taura attributes to restoration actions.

In the previous project (completed in 2020), a comprehensive analysis of modelling needs was undertaken and a set of 13 candidate model components and overarching/support workstreams was developed and documented in a report. Based on the feedback from that project, it was decided to conduct a prioritisation exercise, with an aim to get priority items underway.

As a precursor to prioritisation, a “Prioritisation Background” report was prepared to identify modelling investment options, covering key factors such as needs, benefits, relationship to Report Card Taura, and indicative costs for the model components. Overarching requirements such as provisions for governance, overall benefits and limitations of the modelling initiative were also considered. That report informed two facilitated workshops (one Iwi-centred), which aimed to identify priority projects and funding pathways.

This report summarises the results from the prioritisation workshop, and identifies an initial project outline, broad project plan and indicative prices.

High-priority model components

The workshops identified the following priority areas for modelling:

- Water quality modelling of the river, with supporting contaminant generation and flow routing, including the role of groundwater.
- Water resources modelling (water availability and allocation).

Habitat suitability mapping in the lower river was of intermediate priority. Modelling of fish habitat creation was given lower priority overall.

Flood flows, operational forecasting of flow and water quality, cyanobacteria, and detailed modelling of Lake Taupo were given low priority. 1-D lake models were not noted as having high or low priority.

Other components may still be of high interest but were assigned lower priority for reasons such as lower cost-effectiveness or being of interest to a smaller range of parties.

Overarching considerations

Workshop participants stressed that the modelling should keep the health and wellbeing of the awa at the forefront, but it was acknowledged that models have limitations and cannot provide all the information desired for holistic river management.

Training and capability-building was seen as important by all parties. Iwi see capacity building as a very important part of a long-term strategy to close current gaps in understanding and capability relevant to their environmental management activities.

All parties confirmed a strong preference for free and open source models, provided that the models are fit for purpose.

Participants at both workshops stressed the importance of making model outputs available in user-friendly, practical forms (such a dashboards and maps accessible through a web portal, including pre-run scenarios). A specific work item has been introduced in the proposed project plan to address this need.

Governance should be established at the same time as significant project funding is secured. Iwi want to have input at governance level. Iwi also want to have a role in steering the direction of modelling, undertaking modelling, and use of models. Initial governance representation should be built around the set of project sponsors.

Hosting of datasets was seen as an important supporting component for modelling, which could be done by WRC. Further consideration needs to be given to the form of data hosting and whether licences can be arranged through WRC.

It would be desirable to have a dedicated project manager/administrator role in a project of this complexity.

Project plan

A five-year timeline with indicative costings for high-priority items has been prepared.

The cost for the high-priority model components and supporting workstreams such as fieldwork and capacity-building was **$3.8 million** (with an approximate split into a first phase of $2.4 million and a second phase of $1.4 million).

This represents a considerable reduction compared with the costs in the initial model scoping report, because lower-priority items have been dropped from the project scope. Further reductions in price could be made, but only by removing high-priority items.

Next steps

Immediate next steps were identified – these included presenting the project to the WRA Board (recently completed) and preparing a short (about one-page) project ‘prospectus’.

To progress development of any of these models and ultimately meet the objectives of Te Whaimana o te Awa o Waikato, it will be essential to obtain adequate funding for the programme. Currently, several parties have indicated an interest in continuing the project, and the desire for a NIWA-led coalition of funders. However, responses by workshop attendees suggest that the amount of funding currently available would not cover the cost of high-priority items. No further scoping or analysis steps were identified at the workshop. Therefore, to make progress with model development it will be necessary to discuss the funding at potential funder level again. The presentation to the WRA board may stimulate further funding discussions, and WRA funding application rounds may also prompt additional discussion

Once the funding is assured it will be appropriate to embark on next steps, which include establishment of governance and leadership teams, proceeding through to preparation of work briefs and project procurement.

1 Introduction

A recent Waikato River Authority (WRA) co-funded project "Waikato/Waipaa River Modelling Framework" proposed a set of dynamic models for water quality, quantity and ecology at the scale of the entire Waikato/Waipaa freshwater system. Access to a suite of models of this nature is essential to support Te Whaimana o te Awa o Waikato (Vision and Strategy), with emphasis on supporting the prediction of Report Card taura attributes. Dynamic models make predictions over time, as opposed to static models that provide a long-term average view – dynamic models therefore can provide more detail and more refined representation of processes and the response of water quality and flows to management actions. A key principle for the proposed modelling approach is to develop a co-owned set of models collaboratively with open access. In an earlier project, 13 model components (which include associated data collection) were identified (Table 1-1), along with some overarching/supporting work components. A tentative, ambitious work plan with indicative costing was reported (Elliott 2020a).

There is now a need to focus the model development programme into a series of high-priority projects with a specific workplan and agreed funding pathway, which is the focus of the current stage of work.

Table 1-1: List of model components and overarching supporting components considered at the workshop, based on the original model scoping report "Waikato/Waipaa River Modelling Framework".

Component	Title
Component 1	Contaminant generation
Component 2	Groundwater quality and quantity
Component 3	Runoff generation and routing to rivers for normal flows and floods
Component 4	Flow routing in mainstem and reservoirs
Component 5	Mainstem water quality
Component 6	Reservoir water quality
Component 7	1-D Lake models
Component 8	Taupo 3D model
Component 9	Water availability and allocation (water resources model)
Component 10	Habitat suitability mapping in lower river
Component 11	Operational forecasting for flood flows and water quality
Component 12	Cyanobacteria
Component 13	Fish habitat creation by floodgate modification
Overarching:	Data platform and hosting
	Students and building capacity
	Model hosting
	Governance, overall hosting, management

To assist with prioritisation, a report "Waikato dynamic models: Background document for prioritisation" was prepared outlining modelling investment options (Elliott 2020b). That report identified:

- A set of modelling options and associated data collection/collation activities based on the "Waikato/Waipaa River Modelling Framework" report.
- The types of question that could be answered if a particular modelling option is implemented, and Report Card Taura addressed.
- Benefits and costs of the options, including data collection.
- Risks associated with implementing each option.
- Overarching considerations such as data housing, training, governance, and model dependencies.

The prioritisation background report informed two facilitated workshops led by Helen Ritchie. The first workshop was Iwi-centred, while the second was a 'Multi-Party' workshop to which all project partners were invited. The workshops aimed to:

- identify priority modelling components
- discuss overarching considerations, including funding pathways.

This report completes the documentation of the prioritisation by:

1. Summarising the workshop findings.
2. Specifying an initial project outline and broad project plan.

This project was co-funded by the Waikato River Authority, the Waikato Regional Council, Te Waiora Joint Institute for Freshwater Management (NIWA and the University of Waikato), Mercury NZ, Watercare Services Limited, and DairyNZ. Those organisations are thanked for their support. Various staff from those organisations, and representatives of river Iwi, contributed to workshops and discussions, for which they are acknowledged and thanked.

2 Process and key findings of the workshops

2.1 Iwi workshop

The first, Iwi-centred, workshop took place on 9 December 2020, with representatives from some river Iwi (Te Arawa River Iwi Trust – Eugene Berryman, Raukawa – Marian Ruri, Tūwharetoa – Brett Taylor). Input was also provided by Waikato-Tainui through Tim Manukau[1], and Maniapoto are maintaining a watching brief with liaison through Tim Manukau. The workshop provided background on the project, and a general discussion of Iwi priorities and needs. Workshop minutes were prepared and circulated, and a summary was provided at the second workshop.

2.1.1 Prioritisation of components from the Iwi workshop

Iwi are interested in both water quality and water quantity. There are strong cultural, fisheries, and economic interests. Some tentative priorities were indicated (Table 2-1)., but it was noted that priorities will vary across iwi, all were supportive of each other's priorities – all contribute to river and lake health. Tūwharetoa did not specify components, but they are clearly interested in Lake Taupō and are currently taking an observation role until they have gathered more specific information.

Table 2-1: Tentative priorities identified at the Iwi workshop, in approximate order of highest priority component listed first. Darker colours indicated higher priority, but the colours are not directly comparable with Table 2-2.

Component description	Component Number	Number of parties
Mainstem water quality	Component 5	3
Reservoir water quality	Component 6	3
Water availability and allocation (water resources)	Component 9	3
Contaminant generation	Component 1	2
Groundwater quality and quantity	Component 2	2
Habitat suitability mapping in lower river	Component 10	2
Fish habitat creation by floodgate modification	Component 13	2
Operational forecasting for flood flows and water quality	Component 11	1

2.1.2 Other considerations from the Iwi workshop

The Iwi workshop identified several other important items:

- Capacity building is important. Training kaimahi is important as part of a long-term strategy to close gaps in technical understanding. This includes building capacity both at the 'power user' level (people who have detailed technical knowledge of models and can modify them), and at the more general user level (people who can ask questions of the model and interpret model results).
- It is important the models can provide user-friendly practical useful outputs, or that there are communications people to translate detailed results into useful outputs (for example, maps indicating where it is safe to swim).

[1] Tim Manukau acted in the role of Iwi facilitator for the project, not as a representative of Waikato-Tainui.

- The models can potentially provide critical information to complement the cultural health/ mauri data that iwi are collecting and monitoring, and could make use of remote sensing that is being undertaken by TARIT.
- It is important that the modelling doesn't lose sight of the taura and cultural elements that are more holistic and sensory. A key goal for the model should be to predict changes in cultural indicators under different interventions in the catchment and river. However, modelling will only provide a part of the overall picture.
- Iwi want to have input at multiple levels:
  - governance
  - shaping the model development and direction
  - technical development and use of the model
  - broader model application and use
- An overarching principle is to keep the health and wellbeing of the awa at the forefront.

2.2 Multi-party workshop

The second workshop, held on 16 February 2021, involved representatives from the project partners (with apologies from Watercare, and communication of Iwi interests by Tim Manukau). The workshop included:

- presentation of the project background and a summary of points from the Iwi workshop
- identification of prioritisation criteria
- elicitation of priority components, and subsequent grouping and
- discussion of overarching needs and funding opportunities.

Minutes from the workshop were prepared and circulated.

2.2.1 Prioritisation of components

The top three evaluation/prioritisation criteria identified by the group and applied to candidate models were:

1. Answers a critical question.
2. High benefit for low cost.
3. Foundational (needed by other model components).

These guided subsequent evaluation of model components. The resulting ranking is shown in Table 2-2. Some of the reasoning for these priorities is given in Appendix A. For example, Lake Taupō is acknowledged as treasure — but had a lower priority due to factors such as cost-effectiveness and that management issues are more localised. Flood routing was ranked as a lower priority because existing models are available (even though they are proprietary). Some of the lower-priority models may be included at a later stage, once foundational components are completed, or as exploratory pilot projects.

Table 2-2: Prioritisation of model components from the Multi-party workshop . Higher-priority items are listed first, with darker colouring. The colour scale is not directly comparable with that used in Table 2-1.

Component description	Component number/s
Highest ranking	
Contaminant generation	Component 1
Groundwater quality and quantity	Component 2
Mainstem and reservoir water quality (group combined these)	Components 5 & 6
Water availability and allocation	Component 9
Intermediate ranking	
Habitat suitability in the lower river	Component 10
Runoff generation and flow routing, excl. floods	Components 3 & 4
1D lake models	Component 7
Lowest ranking	
Lake Taupō 3-D modelling	Component 8
Fish habitat creation	Component 13
Cyanobacteria	Component 12
Operational forecasting	Component 11
Flood routing	part of Component 4

Following the workshop, Watercare have identified that their interests align with the highest-ranked set from the workshop, along with interest in cyanobacteria modelling (but acknowledging the difficulty of modelling cyanobacteria).

2.2.2 Other considerations

Input was obtained by 'bus-stop' and a Video Conference chat group on topics that included: hosting and administration, governance, and training and capacity building. Funding was also discussed. Selected points are highlighted below.

Hosting and administration

- Key datasets should be identified, and they could be stored/hosted by WRC.
- It would be desirable to have an easy-to-use web portal for public access to key information and outputs (e.g., dashboards). This could include pre-run scenarios. Designing this access point and user interface would need a dedicated workstream.
- It would be desirable to have a project manager/administrator role in the project, although it is unclear whether this would sit within a primary provider such as NIWA or be an independent role.

Governance

- A group representing project sponsors could provide a core for governance.
- Need strong iwi representation, and to discuss with iwi what that would entail.
- WRA would want a Board member on the governance group.

- WRC would like Senior Managers rather than elected representatives on the governance group.
- Firm legal agreements and MOU's would be required.
- Project governance should be established at the time major funding is secured.
- Governance will need to assist with working through IP issues.

2.2.3 Training and capacity building

- There is strong support for the open-source approach, but with the proviso that open-source models need to be fit for purpose and will be maintained into the future.
- Training and capacity building should be built into project workplans. This includes roles for iwi, and end-user training.
- The group would like to see training from a University, but due to changes in staff at the University of Waikato, alternative university support may need to be found. As an alternative approach, staff could be trained on an internship/secondment basis within model-provider organisations.

Progressing and phasing

- The water resources component could be largely stand-alone initially, although at later stages a groundwater flow component would be included, simplified representation of groundwater informed by more detailed modelling.
- The high-priority items centred on water quality are linked and could be funded as compound project. A starting point could be SWAT for contaminant generation, then mainstem flow routing, and groundwater quality and quantity, and then mainstem/reservoir water quality.

Resourcing and funding pathway

- Waikato River Authority: The overall project needs to be presented to the new WRA board to establish their interest.
- Waikato Regional Council could contribute limited funding now through Science, Policy and Integrated Catchment Management pools. There is no large funding for this work in the current Long-Term Plan, and the next round is three years away. Some smaller funding may be available through existing research projects. Councillors are likely to resist further investment in modelling of the Waikato catchment, given the recent significant investment in the Healthy Rivers programme (Plan Change 1). Co-funding would be required.
- DairyNZ might contribute because the project is aligned with their priorities, but no decisions have been made or considered closely.
- Mercury NZ could contribute data and be a supporting partner, but that would need approval.
- Watercare (not present at the meeting) might be interested in contributing. A conversation with them is needed.

- The Central Government Jobs for Nature project might be able to assist with internship/training aspects of the project.
- The proposed work aligns with NIWA's KPI's. SSIF funding could address some specific research aspects, but would not fund routine monitoring or modelling. The project would likely be difficult to fund through the Endeavour Programmes, due to the localised nature of the work (Waikato/Waipaa River only) and limited fund in the Environment portfolio, even though the project has some points of difference in the New Zealand context including modelling of a large river basin, surface-groundwater modelling, and orientation to Report Card taura and restoration.
- Following the workshop, Watercare have identified that they are interested in supporting modelling work.

Next steps identified at the workshop

- Develop a project plan for high-priority components. The plan should identify which parties have the required expertise, and the plan should identify both modelling needs and other aspects such as hosting and governance.
- Prepare a 1-page summary of the project plan.
- Present material to the WRA board.
- Aim to seek funding for a 'coalition' led by NIWA.

2.3 Synthesis of modelling priorities, overarching considerations, and next steps identified in the workshops

This section synthesises the findings of the two workshops and summarises key findings.

2.3.1 Modelling priorities

The workshops gave some clear directions for modelling priorities, which by and large aligned between the Iwi and Multi-party workshop.

Water quality of the river was the top priority for modelling. This involves inter-related steps of contaminant generation, groundwater transport, transport in the main-stem and reservoirs, and flow generation and routing as it affects water quality. These models should be considered as a group, but there may be some staging of their implementation. A key requirement is that the model can represent the net effect of catchment rehabilitation activities.

A second, high priority item was **water resources** (water availability and allocation). It is anticipated that this component will also eventually draw on groundwater modelling.

Habitat suitability mapping in the lower river was of intermediate priority. Modelling of fish habitat creation was given lower priority.

Flood flows were of lower priority because it was considered that they are addressed reasonably well with existing models. Operational forecasting of flow and water quality was of low priority due to its specialised nature and because it is targeted primarily for hazard management purposes. Predicting cyanobacteria was a low priority because cyanobacteria are difficult to model and that work could happen after other models are developed. A priority was not allocated to 1-D lake models. Lake Taupo modelling was of low priority, because of its complexity and localised applications.

While it all modelling components should keep the health and wellbeing of the awa at the forefront, it was acknowledged that all models have limitations and they cannot provide all the answers.

2.3.2 Overarching considerations

Training and capability-building was seen as important by all parties and should be built into the projects explicitly. This includes both training of modelling specialists (including student projects), and of broader-level model users (people who interpret and translate model information). Iwi see capacity building as a very important part of a long-term strategy to close current gaps in understanding and capability relevant to their environmental management activities.

A strong preference for **free and open source models** was confirmed**,** provided that the models are fit for purpose.

Both workshops stressed the importance of making model **output available in user-friendly practical forms** (such a dashboards and maps accessible through a web portal, including pre-run scenarios), rather than being hidden in obscure datasets. Achieving this objective will require dedicated effort and resources to complement the detailed dynamic modelling itself.

Governance should be established at the same time as any significant project funding is secured. Iwi want to have input at governance level. Iwi also want to have a role in steering the direction of modelling. Initial governance representation should be built around the set of project sponsors.

Hosting of datasets was seen as another important workstream, and this could be done by WRC.

It would be desirable to have a **project manager/administrator** role in the project.

Funding of the project will be difficult, because a potential core funder, WRC, do not have this work in their long-term plan and there are questions about whether the work would be high on the Councillors' priority list. It would be difficult to obtain funding from Central Government – for example, the project is not likely to be successful in an MBIE Endeavour proposal, and there are no funding avenues for large ambitious regional modelling projects. Several of the parties may be able to provide some funding, but that needs to be confirmed with follow-up internal discussions.

A **project plan**, including costing, timing and possible science providers should be prepared for high-priority components, preparation of this workplan should be led by NIWA and as part of a 'coalition'. A 1-page summary should also be prepared, and the WRA board should be introduced to the project at a Board meeting.

3 Proposed work plan

Key items and the staging of their development, based on feedback and direction provided at the prioritisation workshop and earlier model scoping, are described in the following sections. The original scoping project identified a wider range of modelling components and tasks with indicative costing, but here we focus on the higher-priority items as identified through the workshop process.

3.1 Database

It is proposed that a central database for collating and serving out a) base data for modelling and b) key model results is created, as depicted in Figure 3-1.

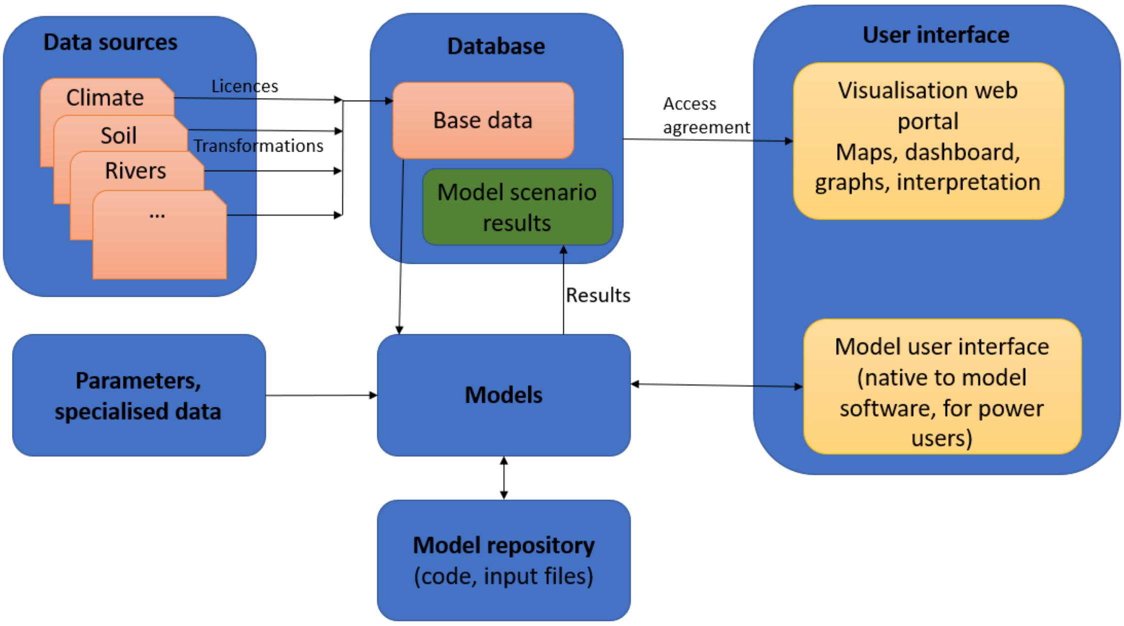

Figure 3-1: Data repository concept.

Data items

Data items in the database will include:

- flow records, updated regularly
- water quality data
- land use (including past land use)
- soil types and attributes
- climate records and interpolated surfaces
- hydrogeological maps or schematisations
- river and reservoir, and lake cross-sections/bathymetry
- stream network and subcatchments
- mitigation measure type and location (e.g., stock exclusion, riparian restoration).

Live feeds of data need not be included in the scope, because short-term forecasting is not in the list of high-priority modelling needs.

Each of these data items should be provided in standard formats such as SOS time series, NetCDF, shapefiles, and csv or sqlite tables, with appropriate metadata/discovery and web delivery service. These items should be agreed with the model developers, through a structured process, possibly driven by the programme manager and overseen by the Governance Group.

It is proposed that WRC be the agency responsible for collating and serving the data, because they have relevant expertise, responsibilities to deliver environmental monitoring data, they put such data to multiple uses, and they have licences for some datasets. However, WRC prefer a distributed approach to dataset provision rather than creating centralised/warehoused data, and they prefer using a single source of truth for each dataset rather than multiple uncontrolled variants. One solution to this problem may be to use a scripting approach, whereby the pathway from distributed reference data sources to the derivative modelling database are clear.

Data licences will need to be obtained and maintained, and a licence server used, so that providers of data are compensated if necessary and have assurance that data will not be used inappropriately or passed on without permission. At present WRC does not provide pass-through of data obtained from third parties, so that new arrangements will need to be made to overcome this obstacle.

Model results

For rapid and simplified access to model output by multiple parties, it is proposed that model results for pre-run scenarios be stored alongside the base data. As with the base data, the model results should be accompanied by meta-data and stored in common data format, to be served through web services.

Model repository

Separate from the data and model results, it is proposed that model inputs and code be stored in a Git repository, and curated by WRC (for example, respond to requests to pull updates into the database).

3.2 Model visualisation portal

Provision of an easily-used portal for accessing and visualising model results was identified as an important aspect of the project. The portal would interact with the database and provide explanations for the models and interpretation of results. It is proposed that a web-based portal be designed and established for this purpose, through a separate sub-project. As with other components of the project, it is desirable that the portal be developed using an open-source approach or using components that are commonly available. There are many open-access libraries and tools for mapping, charting, and summarising data (e.g., RShiny, leaflet, java graphical libraries), and it is preferable that they be used rather than commercial dashboard/business-intelligence tools. It is proposed that the main server for the dashboard be operated by WRC, to ensure that it is close to the data and there is strong institutional support.

3.3 Contaminant generation and mainstem water quality

3.3.1 SWAT Contaminant and runoff generation

The catchment model SWAT (Soil Water Assessment Tool) is proposed for use in this project. It is an open-source daily model which includes a rainfall-runoff component and soil-plant processes. It can predict nutrients (including forms), microbial contaminants, and sediment. SWAT is used by many modellers internationally, and some SWAT applications have been undertaken for small catchments in the Waikato region (Toenepi dairy, Whatawhata hill mixed, the Matahuru leading to Lake Waikare[2]), as well as in the Rotorua catchment and Lake Omapere catchment, Northland. Nevertheless, SWAT has some limitations. For example, the standard sediment model in SWAT does not include landslides, so this aspect of the model would need to be improved over time, building on existing efforts and algorithms in the literature (e.g., Lu and Chiang 2019). For N modelling in the upper catchment, historical changes in land use over time will need to be included, to capture the implications of groundwater lags on nitrogen levels. Some representation of regional groundwater would also be desirable to capture very slow components of groundwater discharge to streams.

It is proposed that SWAT be applied initially in three catchments (beyond the small catchments already studied) in a range of key settings (e.g.,pumice), and where calibration to a period of continuous monitoring is possible. This modelling could benefit from monitoring of dissolved nutrients undertaken by TARIT in the upper catchment, but additional monitoring such as turbidity and calibration to sampled concentrations would be needed to complement the TARIT dataset.

Following this pilot work, SWAT can be rolled out across all the subcatchments and the models combined to cover the entire catchment, using routine SOE monitoring for testing.

It is proposed that NIWA be the key provider, with input from Manaaki Whenua for mass erosion modelling.

3.3.2 Groundwater in the upper catchment

SWAT has been coupled with the groundwater model MODFLOW (the recommended groundwater model) in international applications but has not been attempted in New Zealand. Alongside the pilot application of SWAT in the upper catchment, links with MODFLOW should be investigated, building from previous groundwater modelling in the upper catchment.

[2] Preliminary work undertaken by Chris McBride

Model simplifications should also be investigated, to identify the potential to replace a full MODFLOW model with a faster-running approximation more suited to the full catchment. The groundwater modelling can build on previous studies undertaken by Aqualinc, GNS Science, ESR, and Lincoln Agritech, including work in the Hauraki catchment. Following a pilot application, a decision about the best approach for representing groundwater in the full catchment can be made. The groundwater modelling would also be useful for the Water Resource workstream.

3.3.3 River modelling

The proposed river models are D-Flow 1D for flow and D-Water Quality (D-WAQ) for water quality, both from Deltares in the Netherlands (described and discussed in the model scoping report). While SWAT can model the transport of contaminants down a river network, the algorithms are fairly simple, and the more specialised Deltares models are recommended. SWAT (and at later stages, SWAT-groundwater) will provide inputs to the river network.

It is proposed that this work be led by NIWA, but also that a collaborative agreement be established with Deltares to facilitate access to beta versions of the model, and that a service agreement also be established.

A period of monitoring along the river network will be required to obtain data suitable for calibration and testing of the model. Data collected by TARIT in the upper catchment could be useful but will need to be complemented with monitoring of other attributes such as sediment and algae. It is proposed that at least three sites be established on the mainstem of the Waikato River (upper, mid, lower), and one on the Waipaa, coinciding with SOE sites, and that these sites be monitored intensively (using an extended set of water quality variables and higher frequency) for at least one year.

It is proposed that initially the hydro reservoirs be represented using a 1-D flow model, which assumes vertical and lateral mixing. In reality there is some degree of seasonal stratification, and the implications of the 1-D approximation are uncertain. A 1-D flow model represents a reasonable starting point, and more complex reservoir modelling can be introduced at a later stage if necessary.

3.3.4 Reservoir modelling

Detailed modelling of the hydro reservoirs may be desirable to represent the role of stratification and some management interventions targeted at the reservoirs (e.g., outlet configuration and timing and mixing) and plant growth, and a better representation of algal growth dynamics in the full Waikato system. The previous model scoping identified Delft3D FM and D-Water Quality as the preferred option. There is limited capability/experience for using this model in the freshwater environment in New Zealand, although the model is used by NIWA in the estuarine and coastal environment and has been used for lakes internationally. NIWA is proposed as the primary provider, assisted by Deltares.

There would be a considerable fieldwork component to provide data to calibrate and test reservoir models (for example, sensor strings deployed at different distances down three lakes of interest, and water quality and biological sampling campaigns).

3.4 Water resources

WEAP was identified previously as the preferred water resources model (see the previous reports for details). WEAP is proprietary, but a suitable open-source alternative was not found in the model scoping study. While other models could meet some of the needs for water resources assessments, it is considered preferable to use a model such as WEAP that is targeted at water resources assessment.

It is anticipated that a relatively simple model could be established to start (a small number of subcatchments, simple demand rules), which could be refined over time, with additional demand and restriction rules, and better representation of groundwater and runoff in the future.

It is proposed that the initial work horizon addresses data collation, demand rule development, and preparation of a simple model to start, with refinements designed, funded and implemented in later stages. It is proposed that NIWA lead this work, with collaboration from major water users including local authorities, and inclusion of Iwi modellers in the team if available.

3.5 Training and capability building

Training and capability building is a key aspect of the modelling initiative. Initially it was proposed that the University of Waikato (UoW) take a lead in academic training, with training in the use of specific models and individual model components provided separately in student research projects. UoW now have reduced capability to provide this training, which now made need to occur either on an internship basis, or through an alternative tertiary institute such as the University of Auckland. The specific of the training component need to be confirmed, but an allowance should be made in the project plan for training, including students.

3.6 Staging and indicative funding

3.6.1 Staging

A proposed high-level work plan is shown in Figure 3-2. The work plan shows two main phases of work. In the initial 4-year phase, the aim would be to develop initial contaminant generation and water resource models, including an initial database and web portal. In the second stage, we anticipate the need to further develop and refine these models, and to develop detailed reservoir models. The second phase, beginning in year 4, would overlap with the first phase, and introduce additional reservoir models and model refinements, the nature of which may depend on the outcome of the first work phase.

Lower-priority items, which are not shown in the work plan, may be of particular interest to some parties, and could be undertaken later or with additional funding, as indicated in the initial model scoping study.

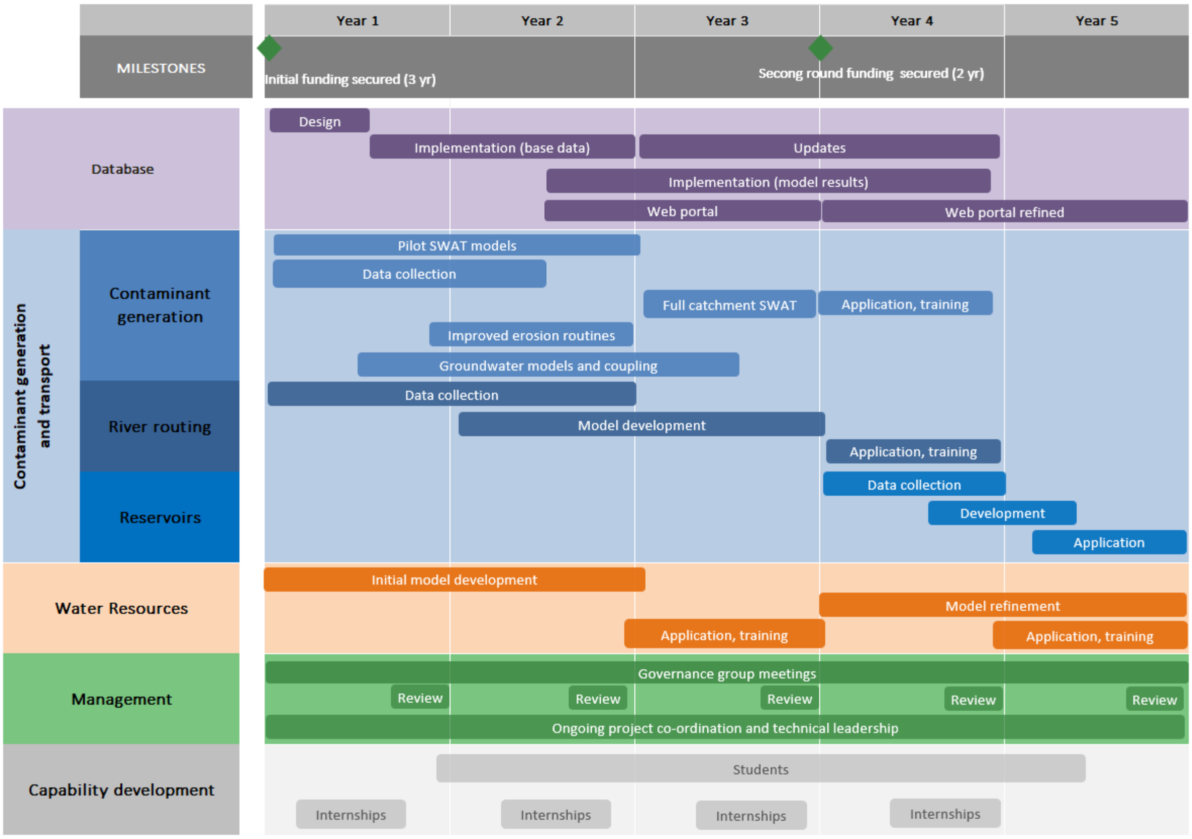

Figure 3-2: Proposed work plan.

3.6.2 Funding

Indicative funding is show in Table 3-1 . In summary, the costs are (to the nearest $0.1 million):

Stage 1: $2.4 million

Stage 2: $1.4 million

Stage 1 plus Stage 2: $3.8 million

Note that these are very preliminary price estimates that should not be used as the basis for contracting.

This cost is a considerable reduction from that envisaged in the initial scoping report (8.4 million), a result of removing lower-priority items.

Should funding for the full programme not be available, some model development could be done, but with significant reductions in scope to remove high-priority items: no improved sediment component, a simplified groundwater component, no reservoir component, water resources component only to the pilot stage, monitoring fewer sites, and no PhD students.

Table 3-1: Indicative costings for the full-price option. Stage 2 items are in parentheses.

Item	Sub-item	Non-fieldwork ($k)	Fieldwork ($k)
Database		120 (+75)	
SWAT	SWAT base model	250	300
	Improved erosion	150	
	Groundwater	250	
	Application, training	100	
River routing		350	300
Reservoirs		(+300)	(+400)
Water resources		250 (+100)	
Management		150 (+75)	
Capability development		450	
Licences		100	
Total		**2395 (+1400) = 3795**	

These costs assume that WRC would fund most of the database development internally and any data licence cost but allow for provision of the portal from parties outside the WRC (yet to be identified).

3.7 Organisational arrangements

Following from the workshop discussions, organisational arrangements along the lines of those shown in Figure 3-3 are proposed. There will be a need for project steering and direction, but to keep the relationships relatively simple, and because the Governance Group involves mainly sponsors and Iwi, it is proposed that the Governance Group also have a steering role. The project administrator lead could be from the primary provider, or an independent party.

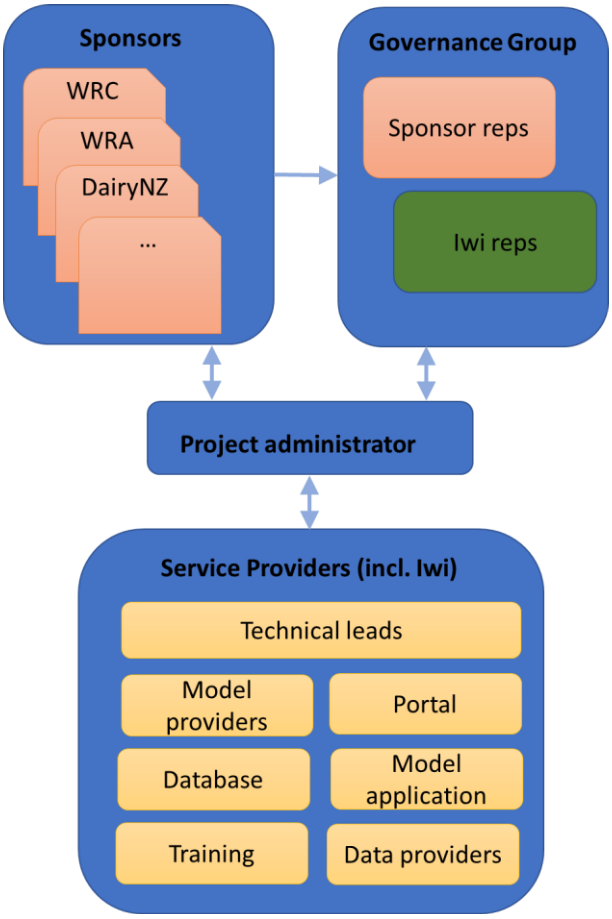

Figure 3-3: Schematic of proposed organisational arrangement.

3.8 Next steps

One work item identified in the workshops was to prepare at short (about one-page) 'prospectus' document describing the project, which will be disseminated to facilitate broader discussions.

A key next step is to obtain funding for the programme. Currently, several parties have indicated an interested in continuing the project, and the desire for a NIWA-led coalition of funders. However, early indications from the workshops were that amounts of funding currently available would not be sufficient to cover the high-priority items. No further scoping or analysis steps were identified at the workshop. Therefore for the project to progress, funding must be secured, necessitating further discussion at potential funder level.

Information about the programme was presented to WRA board members by Bryce Copper and Tim Manukau in April 2021, to familiarise them with the nature of the programme, and discuss progress in the project and prospects. This may stimulate further high-level discussions. Further WRA funding application rounds may also prompt additional discussion.

Once funding becomes available, project governance could be assembled, technical and administrative leads appointed, and work briefs developed and contracted.

4 Summary

This report has identified a set of priority modelling items for a set of Waikato Dynamic Models. This prioritisation was informed by a background document outlining the key options, followed by two workshops where options were prioritised and where overarching considerations such as funding and governance were discussed.

The workshops identified two priority areas for modelling:

1. Water quality modelling of the river, with supporting contaminant generation and flow routing, including the role of groundwater.

2. Water resources modelling (water availability and allocation).

Other components may still be of high interest but were assigned lower priority due to factors such as cost-effectiveness, and they are not included in the proposed work plan.

Data provision, capability-building, provision of results through graphical portals, and governance were also identified as key overarching aspects of the proposed modelling project.

A five-year timeline with indicative costings for high-priority items has been prepared. The cost for the high-priority model components and supporting workstreams such as fieldwork and capacity-building was **$3.8 million**, with an approximate split into a first stage of $2.4 million and a second stage of $1.4 million.

There is a significant gap between the funding needed to deliver this work to the standard required, and the funding that appears available based on preliminary indications.

Further discussions with potential funders will be essential to determine whether this gap can be closed. Once the funding is assured it will be appropriate to embark on next steps, which include establishment of governance and leadership teams, proceeding through to project procurement.

5 References

Elliott, S. (2020a) Dynamic models for the Waikato River system: Scoping study. Prepared from the Waikato River Authority. National Insititute of Water and Atmospheric Research. *NIWA Client Report* No: 2020171HN.

Elliott, S. (2020b) Waikato dynamic models: background document for prioritisation. *NIWA Client Report*. Waikato River Authority. 2020336HN.

Lu, C.-M., Chiang, L.-C. (2019) Assessment of sediment transport functions with the modified SWAT-Twn model for a Taiwanese small mountainous watershed. *Water*, 11(9): 1749.

Appendix A Reasons for prioritisation of components at the Multi-Party workshop

Prepared by Helen Ritchie.

Component	Rated	Reasons given by participants
1 Contaminant generation	High by all	• Critical question, high benefit • Critical foundational component for answering key questions • Fundamental to understanding water quality and mitigation targeting • Management and reduction of contaminants is a critical resource management issue • Critical question, we can do something about it – link to restoration, land use etc., Iwi rating – 2 out of the 3 who gave ratings rated this high
2 Groundwater quality and quantity	High by all	• Critical question, foundational • Linked to 1 and 9, feeds into 5 • Groundwater connected with surface water, linked to contaminant flows • Fundamental to understanding flow and water quality, especially in upper river • Largely an unknown resource, foundational, knowledge gap Iwi rating – 2 out of the 3 who gave ratings rated this high
3 Runoff generation and routing to rivers – normal flows & floods	High by 1 pair	• Important for targeting mitigation Iwi rating – Not rated high by iwi who gave ratings
4 Flow routing mainstem and reservoirs	High by 1 pair	• Foundational Iwi rating – Not rated high by iwi who gave ratings
5 Mainstem water quality	High by all but 1 pair	• Critical question • Key component for answering critical questions • Recreational and cultural use linked to water quality – linked to reservoir models • Tied to highly valued use i.e., drinking water, swimming, recreational use, cultural use etc Iwi rating – all 3 who gave ratings rated this high
6 Reservoir water quality	High by 1 pair + Low by 1	• High: Important community resource and impact on river water quality • Low: Not a whole system approach [separating reservoirs from main stem water quality] Iwi rating – all 3 who gave ratings rated this high
7 1-D Lake models	No rating	Not rated high or low by any present in the room Not rated high by iwi who gave ratings but Tūwharetoa said they are clearly interested in the lake
8 Taupō 3-D model	Low by 3 pairs	• High cost, low benefit • Lake Taupō data very important but not sure about a model • Taonga, but hard to see how model will have major effect

		Iwi rating – Not rated high by iwi who gave ratings but Tūwharetoa said they are clearly interested in the lake
9 Water availability and allocation	High by 2 pairs	• Critical component for answering key questions • Critical question, timely, Regional Plan/ NPS reviews, etc Iwi rating – All 3 who gave ratings rated this high
10 Habitat suitability in lower river	High by 1 pair	• Community interest in fishery management Iwi rating – 2 out of the 3 who gave ratings rated this high
11 Operational forecasting – flood flows and water quality	Low by 4 pairs	• Not foundational • Forecasting flood flows of less benefit operationally • Modelling more for hazard management related outcomes • Too specialised with external drivers that are challenging to model e.g., national electricity storage and demand Iwi rating – Not rated high by iwi who gave ratings
12 Cyanobacteria	Low by all	• Not foundational • Hard to model usefully • Too many unknowns in this space • Relevant issue but very difficult to model – reliant on other models - may be a pilot • Not foundational, too specific sub-set of others, hard to predict, not low hanging fruit Iwi rating – Not rated high by iwi who gave ratings
13 Fish habitat creation by floodgate mitigation	Low by 3 pairs	• Not foundational • Can be addressed by other work areas • Specific, not dynamic model question i.e., can answer via ecological info etc Iwi rating – 2 out of the 3 who gave ratings rated this high