LWRRDC Project UME60

NPIRD Modelling Scoping Study

A Review Of Computer Based Models In Use In The Irrigation Industry

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University of Melbourne

Soil Solutions Pty Ltd

FINAL REPORT

Summary

The National Program of Irrigation Research and Development (NPIRD), Management Committee has been conscious for some time that there is a wide range of computer models available and in use in the irrigation industry. The extent of use and the value of the models have been uncertain. No systematic analysis of models in use in the industry has been made but at this stage of development of the irrigation industry there is a need for such an analysis.

The Management Committee of NPIRD plans to organise a national workshop (or appropriate alternative approach) to communicate information on the extent and use of models in the irrigation industry and at which a number of key models are presented to industry stakeholders. From this workshop, NPIRD wants to identify industry priorities in relation to future modelling investment. As a precursor to the workshop it has been essential to make an inventory of many of the models used in the irrigation industry and this scoping consultancy has been undertaken with the objective of providing some guidance to industry requirements.

As part of this consultancy, the consultants contacted several groups of stakeholders in the irrigation industry including:

- Wholesalers of water such as Water Supply Agencies
- Retailers or irrigation organisations
- Major water user groups.
- Universities and other research organisations
- Private consultants

The consultants designed and tested a survey, which was sent to 24 organisations and individuals of which 20 provided fully completed questionnaires. The survey identified 48 models and application software currently in use in the irrigation industry. The consultants also identified a reference group comprising representatives of 7 major industry organisation, which will continue to advise NPIRD on future modelling requirements.

The analysis of the survey questionnaires shows that:

- A total of 37 models identified in the survey are classified as soil-water hydrologic simulation models and 11 models as application software for automation of routine tasks
- The largest group of models (23) is used for planning the operation of irrigation systems and the economic evaluation of operation or planning strategies for irrigation systems and river basins. Few models, (5) are reported to be in use for on-farm applications.
- The largest group of models identified in the survey is models developed in house. A large proportion of these are soil-water hydrologic models developed for specific purposes by research institutions and universities.
- Irrigation authorities use most software applications to operate the water supply system and assist with accounting and infrastructure management tasks. The applications were often developed externally to meet the specific needs of the organisation.
- Most models identified by the survey are in either high cost (>$20,000) or low cost (<$1,000) categories. Commercial applications and those developed to meet a specific purpose account for most of the high cost

models. Installation, training and hardware may not have been costed in models and applications identified as low cost (<$1,000).

- The PC platform has become the standard hardware used to run models and application software used in the irrigation industry. There are a few examples where a mainframe platform is used. Many earlier applications developed to run on mainframes have now been adapted to run on PCs.
- There is general satisfaction with the reliability and capability of the models identified by the survey. Most responses also indicate that models have adequate provision for data recovery in the event of model failure. The replies also indicated that adequate support is available either in house or from commercial suppliers.
- Almost equal numbers of soil-water hydrologic process models are stated to have built-in checking or calibration facilities; or to need calibration after runs or that the model output is still being tested. About 80% of the models are quoted as producing output that can be used directly. The remainder of the respondents indicated that some degree of post-processing is required.
- For about half of the models surveyed, respondents stated that minor changes are needed to improve them, whilst a similar number of models are quoted as requiring improvement or the addition of new modules. The main areas of change and improvement relate to the quality of data and usefulness of output.
- The rate of adoption of individual models identified in this survey across the irrigation industry is very low. Only one model is quoted by three users, three models register two users and all the remaining models register a single user.
- The impression was gained that many models were organisation specific or developed in house to meet particular needs perceived as being different from other organisations. As a result there is little sharing and adaptation of models to meet the needs of another organisation. Rather organisations tend to start from basics. As a result, the industry as yet does not identify key or essential models that are of particular utility to the industry. This may represent an immature phase of modelling in the industry.
- All the models surveyed have been either fully developed in Australia, or developed in Australia using pre-existing modules developed overseas.
- Use of models seems to be quite fragmented and there are few models which can be identified as having particular merit over others or recognised by large sections of the irrigation industry as a model which could be regarded as the standard for the industry. It was therefore not possible to identify a number of key models that could be adopted by the industry. The processes adopted by NPIRD from this scoping study should assist to begin to identify what should become key models.

The key aim of the scoping study is to make recommendations on the modelling information that is considered most useful to industry stakeholders and the best mechanisms of delivery of this information.

The salient conclusion of the study is the low rate of adoption of individual models. It is therefore recommended that a strategy be developed by NPIRD to encourage

the adoption of industry standard or generic models as a cost-effective practice. The strategy includes the establishment of a regularly updated database and a workshop involving key users and developers of models. A single workshop with appropriate representation from all States is preferable to multiple workshops. Important aims of the workshop would be to:

- Determine whether there is a need and a demand for adapting selected models that are currently purpose-built into generic simulation tools that can be used by a wide range of organisations needing the same model simulation. This could apply primarily to models designed for simulation of catchment and river basin systems.
- Identify in more detail the future demand for processes, which will require model simulation to help define priority areas for funding of further model development.
- Define the types of modelling which require NPIRD funding on the basis of comparative advantage to commercial developers:
- Consider establishing a database of models similar to existing research databases. The database could also include modelling capability available in various research institutions and Universities.
- Consider whether NPIRD should develop a website where the database of models are listed and where the model users and developers can add new models and find where to locate suitable models for their tasks.
- Discuss intellectual property issues arising from further development of existing models with NPIRD funding. This also applies to any model or module developed overseas.
- Identify a process whereby NPIRD can consider new modelling requirements. The workshop should enable NPIRD to set appropriate protocols in consultation with industry stakeholders for funding new modelling initiatives.
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1 Purpose of the Review

For some time, the Management Committee of the National Program of Irrigation Research and Development (NPIRD) has been conscious for some time that a wide range of computer models is available and in use in the irrigation industry. The extent of use and the value of the models have been uncertain. As a result, it wishes to ensure that the irrigation industry stakeholders are:

- aware of the extent of modelling work that has been undertaken to date.
- aware of the main features of a number of the key models that are considered most useful to the industry.
- aware of the data and calibration requirements of those models.
- aware of the value of particular models to their business.
- better able to trial and access models in their own operation.
- in a position to provide feedback to the Management Committee on the future modelling R & D requirements – the extent and nature of knowledge gaps.

The Management Committee of NPIRD plans to organise a national workshop (or appropriate alternative approach) to communicate information on the extent and use of models in the irrigation industry and at which a number of key models are presented to industry stakeholders. From this workshop, NPIRD wants to identify industry priorities in relation to future modelling investment. As a precursor to the workshop it has been essential to make an inventory of many of the models used in the irrigation industry. This scoping consultancy has been undertaken with the objective of providing some guidance to industry requirements.

A significant amount of effort has gone into research and development of computer based models for the irrigation industry. The major focus has traditionally been in the area of hydrology (both surface and groundwater), however, in more recent times modelling of very specific issues such as structural adjustment and water transfer markets has been carried out. As a result, there are now many models covering a wide range of matters in the irrigation industry. The sources of models can be from commercial sources, in house development and from public domain. Some models are not used outside the developing organisation because it is not directly adaptable to another but similar situation or because of commercial confidentiality. Other models have been discarded because of the difficulty of operation, lack of suitable data or unreliability. Some of these may have become more useful today if they have been updated and data is now more accessible. As a result, there is need to assess the computer-based models available and identify those of most value to the industry and the areas where new models may be of benefit. Proper identification of modelling gaps is important to ensure efficient use of research and development funding.

NPIRD commissioned the Department of Civil and Environmental Engineering of the University of Melbourne and Soil Solutions Pty Ltd to carry out the scoping study.

2 Terms of Reference for the Consultancy

NPIRD adopted the following terms of reference for the consultancy, which was conducted under the guidance of their Management Committee:

- Establish a reference group of key industry stakeholders.
- Ascertain the information on modelling requirements needed by a broad cross section of the irrigation industry.
- Obtain a listing and brief description of models related to irrigation/water resource management.
- Review in consultation with the Reference Group, the information needs against the list of existing models to identify those models that are most relevant and for which further information would be useful.
- Provide recommendations to the NPIRD on the proposed format and extent of a workshop (series of workshops if appropriate)
- Document all outcomes of this scoping for NPIRD and industry consideration.

3 Stakeholders

Agreement was reached with NPIRD on whom were to be included in the categories of stakeholders. The agreed list included:

- Wholesalers of water such as agencies who supply bulk entitlements of water to irrigation retailers or irrigation authorities.
- Retailers or irrigation organisations who distribute water to individual customers who l generally are irrigation farmers. In some instances the wholesaler may also act as the retailer.
- Major water user groups. In this instance, the group could be a small private irrigation company or cooperatives or else a group of irrigators who represent irrigators in an irrigated area.
- Universities and other research organisations that are involved in development of models or in consultancies on irrigation industry planning, policy and use of irrigation water.
- Private consultants who are involved in design, planning, economic evaluation and policy advice.

4 Methodology Used by the Consultants

4.1 Definition of stakeholders

The first task that the consultants faced was to define the range of stakeholders who needed to be included in the scoping study. The major users of models, particularly the more complex models, are the policy and planning organisations, universities and research organisations. The models are used for advice and training as well as research and policy development.

Other users are wholesale and retail water suppliers including cooperative groups who may have a range of predictive models and application software for management of resources and assets and for operation of water and drainage systems.

Consultants supporting the irrigation industry may have a range of models from farm level support models such as irrigation scheduling, earthwork calculations, dam design and channel and drain design.

It was decided that irrigators would not be directly included in the survey. Instead, models used for on-farm irrigation design and management would be included through other stakeholders who either developed these models, such as Universities and research organisations, or used the models to provide services and advice to irrigators, such as consultants and irrigation authorities.

The agreed list of stakeholders has already been listed in Section 4.

4.2 Reference group

NPIRD asked that a reference group be formed to guide the scoping study and subsequently the follow-up activities. Having defined the stakeholders for the purpose of the scoping study, the consultants then identified a number of major industry organisations and proceeded to select names and invite them to become part of the Reference Group. The following people agreed to become members of the reference Group for the scoping study:

- Derek Poulton - Goulburn-Murray Water
- Brent Godkin - Sunraysia Rural Water
- David Ledgerwood - Murrumbidgee Irrigation
- Ned Hamilton - Jemalong Irrigation District
- Jerry Killen - Namoi Water Users Association
- Geoff Calder - SW Irrigation
- Brett Tucker - NPIRD

4.3 Survey of users

The consultants proposed an initial draft questionnaire when they submitted their tender for the consultancy. The questionnaire was designed to be simple and demand little time to answer, and at the same time elicit answers that are relevant to the purpose of the scoping study. With these factors in mind, the design of the questionnaire aimed to:

- Identify models in use, experience with the models and future needs, models needed and models no longer in use.

- Ask for users experience rather than be a technical survey.
- Obtain the cooperation of those asked to fill in the questionnaire by limiting the number of questions and providing multiple choice answers where boxes needed to be filled in.
- Make it easy to distribute by using a spreadsheet-based questionnaire, which could be distributed and returned by E-mail.

4.4 Development and testing of questionnaire

A list of questions was developed by discussion between the consultants and NPIRD. One consultant then prepared a first working draft of the questionnaire, which was then reviewed and modified. The modified questionnaire was then tested by the consultant, using a model with which he was familiar. The questionnaire was again modified in the light of this and then tested by interviewing a person in an irrigation organisation who was familiar with the models in use there. This person was not the person to whom the final version would be sent in the survey. After a further revision, a final version was derived after another of the team had tested the questionnaire using a model he used. The final questionnaire is presented in Appendix 1.

4.5 Selection of organisations

An initial list of organisations was developed based on the consultants' knowledge and networks throughout Australia as well as that of NPIRD. Questionnaires were forwarded to a majority of organisations on that list.

From the contacts with the interviewees, further people and organisations were identified. Reference was also made to reports containing lists of relevant organisations. From this further questionnaires were sent out.

4.6 Circulation

A contact person in each organisation was identified and initial contact was made by telephone to obtain their agreement to take part in the survey. (There was only one refusal). The survey was then forwarded by E-mail and requested to be returned in the same way. A total of 24 organisations and individuals were contacted from which 20 completed questionnaires were received. Appendix 2 contains the list of all the organisations contacted for the survey.

4.7 Analysis

The analysis of the replies was based on the frequency of responses to each question and additional narrative answers provided by the interviewees. The following analysis of results is structured around the key sections of the questionnaire, which contained related questions.

4.8 Key Models:

NPIRD asked for key models to be identified. Though no definite criteria was discussed in detail with NPIRD, these were taken to be a models acknowledged by a number of industry users as the best for carrying out a particular modelling task, i.e. widely adopted by the industry for a particular use.

5 Results

A total of 48 models were listed by the 20 respondents to the survey. It is important to note that several questions in the survey could be answered with more than one choice. In such questions, respondents often selected more than one answer that applied to their models. This accounts for the fact that the total of responses can differ from the total number of models identified by the survey.

5.1 Purpose of Models

Table 1 shows a summary of the models identified in the survey according to their purpose. Irrigation system planning and operation makes up the largest group of models in the survey. Irrigation authorities have needed this type of model in order to modernise the planning and operation of water supply systems more effectively. Groundwater behaviour, water entitlements and transfer and economic evaluation are other types of models frequently used by irrigation authorities. Fewer farm irrigation scheduling and drainage operations models are available

Table 1- Classification of Models According to their purpose

Model Purpose	**Users**
Asset management	4
Irrigation system planning and operation	14
Drainage system operation	1
Economic evaluation of irrigation options for planning and operation	9
Irrigation scheduling	5
Water entitlements and water transfer	6
Shallow groundwater modelling	9
Other	10

or in use by irrigation authorities and other users. This is consistent with the authors' experience that few models have been developed to the stage where they are useable by farmers or other consultants. A substantial number of models are used for economic analysis and planning of irrigation and river basin systems. These models are used primarily to evaluate the economic outcome of different water allocation policies and in some instances water allocation to the environment and impact of soil and river salinity. A total of 9 groundwater models are also used for evaluation of aquifer behaviour. Overall, models are more often

used for planning the operation of large water systems than for on-farm applications.

The largest group of models is used for planning the operation of irrigation systems and the economic evaluation of the operation or planning strategies for irrigation systems and for river basins. Few models are reported in use for on-farm applications.

5.2 Processes Simulated or Automated by Models

The processes and tasks simulated or assisted by the computer models which were identified in the survey can be grouped in two categories:

(a) simulation of soil and water hydrologic processes[1]; and

(b) software applications for automation of routine tasks.

The first category includes all those models that contain some form of water transport processes such as water allocation, canal operation, soil-water movement and irrigation scheduling. A total of 36 models were identified in this category.

The second category contains application software used for automation of routine tasks includes those for asset management and maintenance management system, billing, etc. A total of 12 applications were identified in this category. In some cases applications such as asset management have some capability to simulate various future scenarios of asset management and investment.

Appendix 3 shows the list of models surveyed and the processes simulated.

A total of 37 models identified in the survey are classified as soil-water hydrologic simulation models and 11 models are classed as application software for automation of routine tasks.

5.3 Sources of Models

Respondents were asked where they obtained the computer models that they used. Table 2 shows the breakdown of sources for the models under 5 categories. The prevalence of either commercial applications or those developed in-house indicates that models are largely purpose-built for a specific application. This correlates well with the fact that many of the models surveyed are used by irrigation authorities. It also supports the conclusion those purpose-built software applications, which have

[1] This is a broad categorisation of models that include simulation of water flow processes in soils, overland and pipelines, and solute transport processes in soils and streams. In some cases, it also includes economic analysis overlaid on these basic physical processes.

been developed in-house for specific purposes have not yet been widely adopted by other users. The largest numbers of models developed in-house belong to Universities and research institutions, although irrigation authorities have developed some applications. In a few instances, respondents selected more than one source for the model, often indicating that the model obtained from a particular source was further developed in house. Also, some in-house models rely on modules developed by other organisations, mainly in Australia.

Table 2 – Classification of Models According to their Source

Source	**Number**
Commercial	19
Public domain	7
Developed in house	23
Adaptation of another model	2
Specially developed by another source for your use	8
Other	1

The analysis of data indicates that:

- Software applications for processing routine tasks are used by irrigation authorities and the majority have been specially developed for the organisation's own use by an external source.
- Some of these applications were originally developed by the IT Departments of former large irrigation organisations. With the fragmentation of irrigation authorities into smaller and more regional organisations and improved communication technology, some of these applications have been adapted to meet their specific conditions.
- A number of soil-water hydrologic process models are from commercial sources.
- The large numbers of in-house models include many models developed by research institutions and universities to meet specific needs.

Models developed in house represent the largest group of models identified by the survey. A large proportion of these are soil-water hydrologic models developed by research institutions and universities for specific purposes.

The second largest group of models is from commercial sources. Both soil-water process models and software application are represented in similar proportions in this group.

Most software applications are used by irrigation authorities to operate the water supply system and assist with accounting tasks. These applications have often been developed by external sources to meet the specific needs of the organisation.

5.4 Cost of Models

The cost of most of the models used by the respondents is either low (<$1,000) or very high (>$20,000). There were a smaller number with intermediate cost (25%). The low cost group includes primarily models developed in house and for on-farm applications. There is a clear correlation between high cost (>$20,000) commercial models or those developed for a specific purpose by external developers and use by irrigation authorities for asset management and system operation. A few respondents chose not to disclose this data on grounds of commercial confidentiality.

Some of the costs quoted in the answers do not seem to include all the development cost of the model. In the low cost group, only the visible cost of purchase have probably been included and the less visible costs of staff time to select, install and maintain the program, and the cost of hardware upgrades (often required), training and data acquisition have been missed.

Table 3 shows the breakdown of model according to their cost.

Table 3 – Cost of Computer Models

Cost	Number
Up to $1000	10
$1000 to $5000	3
$5000 to $10000	2
$10000 to $20000	6
Over $20000	20

Most models identified by the survey have either a high cost (>$20,000) or low cost (<$1,000). Commercial applications and those developed for meet a specific purpose account for most of the high cost models. Installation, training and hardware costs may not have been included in those models and applications identified as low cost (<$1,000).

5.5 Hardware and Staff requirements

The survey data shows that most models can be run on a PC platform (88%), with only a small group of models (12%) requiring a mainframe to run. Models that were quoted as requiring a network to run have been interpreted as running on a local area network (LAN) of PC units. This is consistent with the continuous increase in processing and storage capacity of PC units. A few models can be run on both platforms.

60 % of the respondents indicated that specialist trained staff was required to run the models. Most of the soil-water process simulation models fall in this category. Specially trained administrative staff operate 35% of the models. The complexity of most models and the understanding of the basic processes being simulated warrant in most cases specially trained staff to run the models.

It is clear that with the rapid increase in computer power available on PC platforms, most of the models can now run within the data storage and processing capacity of these units. Many models were originally developed to run on mainframe computers because of inadequate processing capacity of PC platforms. With the rapid increase in PC computing power, many of these early models have migrated to PC platforms. It is likely that the few application still running on mainframes fall in the category of early models and application.

The PC platform has become the standard hardware used to run most models and application software used in the irrigation industry. There are few instances identified by this survey where a mainframe platform is used. Many earlier applications developed to run on mainframes have now been adapted to run on PCs.

5.6 Data Requirements and Cost

Because successful operation of models depend on the availability of suitable data, questions were asked about the availability and accessibility of data for the models, and source, format and cost of obtaining data for the models.

In 25% of responses, some degree of difficulty was reported in obtaining data in the quantity, quality or format required. This question was not answered in several questionnaires while two respondents answered both that data is always available and at the same time difficult to obtain. All the responses that indicated difficulties in obtaining data related to hydrologic models either for on-farm irrigation or catchment and river system models.

A similar proportion of models used data generated by themselves as for those sourced from other organisations.

The number of models that require data to be entered manually into the model is similar to those relying on data already in electronic format. Nearly half of these require some form of pre-processing into another format before use.

The annual cost of procuring data for the model ranges from $5,000 to over $10,000 per annum. Several respondents did not supply this information on the

25% of respondents indicated difficulties in obtaining data for the models. These difficulties are always associated with on-farm models and watershed and river system models. There is an identifiable cost for obtaining data for use in the models

basis of commercial confidentiality. Of those that answered the question, the majority (65%) indicated an annual cost of between $5,000 and $10,000.

5.7 Program Reliability and Capability

The survey shows a general degree of satisfaction among model users with the existing capability and reliability of the programs. In 83% of replies, users indicated that the existing capability of the models is satisfactory. Several models are quoted as both being satisfactory and requiring additional development to meet current requirements, whereas a few others indicated the need for additional development and also better data.

The vast majority of the users surveyed (80%) indicated that they have not experienced problems with operation of the model, with the rest stating that they rarely experience problems.

Users were asked about loss of data if the program fails. Most replied that the recovery of data requires appropriate skills, whilst a few others stated that data must be re-entered. In general, where comments were provided on this question, it indicated that most models have provisions to allow easy recovery of data in case of model failure.

Model support is considered an important factor in deciding the adoption of a particular software. Either in-house staff or a commercial supplier provides support for all the models surveyed. This was not identified as a problem by any of the responses.

There is general satisfaction with the reliability and capability of the models identified by the survey. Most responses also indicate that models have adequate provisions for data recovery in case of model failure. All the replies also indicated that adequate support is available either in house or by commercial suppliers.

5.8 Model Output

Quality of output is one of the important criteria to judge the utility of a model. Users' perception of the quality of model output was surveyed by asking about the need for model calibration and post-processing of the model output. This question is only relevant for those models that include the simulation of physical hydrologic process such as rainfall-runoff and groundwater flow, and is not relevant to other models used for routine calculation such as asset management and tallying of irrigation orders which do not require calibration. An almost equal number of models are quoted as having calibration and checking facility within the model itself, were still being tested to ensure reliable outputs or needed calibration after model runs. In general, simulation models that include hydrologic processes have been calibrated against actual data and a few are recalibrated every few years.

Most models (80%) produce output that can be used directly for the intended use. The remainder require the output to be post-processed through another program before use. About 10% of users stated that while models are useable for the intended purpose, the output needs to be reworked by skilled staff before use. Moreover, a further 10% of models needs both post-processing of output and intervention by skilled staff.

An almost equal number of soil-water hydrologic process models are quoted as having built-in checking or calibration facilities as those needing calibration after runs and those that the model output is still being tested. A total of 80% of the models are quoted as producing output that can be used directly. The remaining 20% of models require users indicated that some degree of post-processing is required.

5.9 Model Improvements and Modelling Gaps

One important objective of this survey is to identify the need for additional modelling investment in the irrigation and water resources industry. In this context, it is important to understand that the needs for further modelling effort is highly dependent on the problems that the industry must address and these are constantly changing. Whilst the survey questions were designed to capture the perceived need for further modelling at present, additional modelling needs may arise in future requiring new models or further adaptation and expansion of existing ones.

The questionnaire addressed two aspects related to this area: (a) the size of the changes needed for the intended purpose of the model; and (b) the main area in which improvements or additional modelling would be required.

Appendix 3 summarises the changes suggested for each model. Some models registered no suggestions for changes or improvements. A large number of those surveyed stated that only minor changes were required with major changes only suggested in two replies. A similar number of responses indicated no need for improvement or the addition of new modules. It is important to note that often the addition of new modules can also be considered as a major change.

The main area of improvement relates to data quality and reliability and usefulness of output. Consistent with the answers obtained in relation to the form and quality of output of the models, a similar number of responses indicated that accuracy of output and usefulness of output are two important areas of improvement in existing models.

About half of the models surveyed were said to require minor changes whilst a similar number of models are quoted as requiring improvement or the addition of new modules. The main areas of changes and improvements relate to the quality of data and usefulness of output.

5.10 Adoption of Models

The adoption of each of the 48 models surveyed is very limited. Only one model (MODFLOW) was listed in three replies while three others (AIM, PRIDE and WATERNOW) were listed twice in replies. Table 4 lists all the models surveyed and their use. The rest of the models, which include all the application software for automation of routine tasks, are commercial software. The limited adoption of commercial software is unexpected as there is a large development cost with the applications and they can usually be adopted “off-the-shelf” by other users with little need for modification.

The respondents to the survey fall into two categories:

- Original developers of the model.
- Regular users.

Application software for automation of routine tasks is in all cases purchased from software developers.

Twenty six soil-water-hydrologic models (70%) are only used by the model developer(s). In most cases, the model was originally developed for research purposes and continuess to be used by the original developer in a research context. With the remaining 30% of the soil-water-hydrologic models, the respondent was not the developer of the model.

The low rate of adoption of individual models can be ascribed in part to lack of awareness by industry stakeholders of the range of models available and their capabilities.

Large number of models used by developers only implies that models are developed and used for a single purpose.

Table 4 .Adoption of models identified in survey

Model	Uses
MODFLOW[2]	3
AIM	2
PRIDE	2
WaterNow	2
APSIM	1
Asset Management renewals	1
AssetLife	1
Attache Business Partner	1
BASINMAN	1
BICADM	1
Bigmod	1
BILL	1
Coleambally Groundwater Model	1
CWPR1-Water Entitlement	1
CWPR2-Water Delivery	1
CWPR3-Bulk Water	1
EPANet	1
GRADE	1

[2] Used in combination with SMILE in one case.

Model	Uses
IMSOP	1
Integrated Quantity and Quality Model (IQQM)	1
MEDLI	1
METMAN	1
Mike-SHE	1
(MDBC) Monthly Simulation Model	1
Murkey	1
Murrumbidge Infrastructure Pricing Model	1
NRM Net Recharge Management	1
Optnet model: Salinity application	1
OSI – Ordering System for Irrigation	1
RART (Right Amount, Right Time)	1
REALM	1
REG – Share registry	1
RUSTIC	1
Saltflo	1
SAM – Asset Management System	1
SCADA	1
SIRMOD	1
Snowy River Catchment Model	1
SWAGMAN-Destiny	1
SWAGMAN-Farm	1
SWAGMAN-Policy	1
SWAGMAN-Whatif	1
SWAGSIM	1
SWIM	1
WAL – WaterLink	1
WATERSHED	1
Waterways IMS	1
Waterworks	1

5.11 Discarded and other models

Some users indicated that they had used several models in the past but were later discarded. In some cases the models were superseded by updates of the same or a similar model. Some of the other discarded models are no longer supported by their original developers. Among these models are:

- Wat Ord
- SIRAGFIELD
- RENWAT
- Water Scheduling SA Water
- WR46i

In addition to the models identified by the general survey, information on the status of other models known to the consultants, but with application to the irrigation industry was sought. These models are listed in Table 5.

Table 5. Models directly identified by the consultants

Model	Status
HARSD	No user or developer found
DIRESM	No user or developer found
DSSAT	No user or developer found
APSIM	Description included
HYDROLOGIC	No user or developer found
IRRIPAK	No user or developer found
WAVES	No user of developer found
SWIM	Description included
TOPOG	Not used in irrigation industry
DRAINMOD	Developed overseas, no user found in Australia.

6 Conclusions:

6.1 Conclusions from survey

The main conclusions to be drawn from the scoping study are:

- The models identified by the survey which are in use in the irrigation industry fall into two main categories:
  a. Simulation of soil-water processes (37) ; and,
  b. Software application for automation of routine tasks (11).
- Commercially available models comprise approximately the same proportion in both categories of models listed above.

- The number of models developed in-house is slightly greater than those obtained from commercial sources. The group of commercially available models include both soil-water hydrologic applications and software applications

- Most software applications are used by irrigation authorities to operate the water supply system and assist with accounting tasks. The applications have often developed externally to meet the specific needs of the organisation.

- The cost of models surveyed is either very low (<$1,000) or very high (>$20,000). Commercially available applications and purpose-built applications account for the high cost of model acquisition.

- Most models surveyed are operated on PC platforms. The few models still based on mainframe platforms include several early models that have not yet been adapted to run of PCs.

- There is general satisfaction with the reliability and capability of the models identified by the survey. Most responses also indicate that models have adequate provision for data recovery in the event of model failure. The replies also indicated that adequate support is available either in house or from commercial suppliers.

- Almost equal numbers of soil-water hydrologic process models are stated to have built-in checking or calibration facilities or needing calibration after runs or that the model output is still being tested. About 80% of the models are quoted as producing output that can be used directly. The remainder of the respondents indicated that some degree of post-processing is required.

- One quarter of all respondents pointed out difficulties associated with the availability of data needed to run the models. Most of these were raised by users of soil-water hydrologic process models comprising both on-farm and models for simulation of watershed and river systems.

- Respondents identified need for improvements and modifications in about 50% of the models surveyed. Improvements ranged from minor modifications to the additional of new modules to simulate additional processes.

- The rate of adoption of individual models identified in this survey across the irrigation industry is very low. Only one model is quoted by three users, three models register two users and all the remaining models register a single user.

- The impression was gained that many models were organisation specific or developed in house to meet particular needs perceived as being different from other organisations. As a result there is little sharing and adaptation of models to meet the needs of another organisation. Rather organisations tend to start from basics. As a result, the industry as yet does not identify key or essential models that are of particular utility to the industry. This may represent an immature phase of modelling in the industry.

- All the models surveyed have been either fully developed in Australia, or developed in Australia using pre-existing modules developed overseas.

- Use of models seems to be quite fragmented and there are few models, which can be identified as having particular merit over others or recognised by large sections of the irrigation industry as a model which could be regarded as the standard for the industry. It was therefore not possible to identify a number of key models that could be adopted by the industry. The processes adopted by NPIRD from this scoping study should assist to begin to identify what should become key models.

6.2 Conclusions related to the Terms of Reference

- Establish a reference group of key industry stakeholders:

  A reference group was identified. See Section 5.2. of the report for the listing of those who agreed to become part of the reference group.

- Ascertain the information on modelling requirements needed by a broad cross section of the irrigation industry.

  The survey indicated that most organisations contacted in the survey had adequate modelling capability for the tasks that they wish to carry out at the present time. Some users indicated that existing models could be improved to undertake the tasks desired. None indicated that there were unfulfilled modelling tasks for which new models were required.

- Obtain a listing and brief description of models related to irrigation/water resources management.

  A listing of the models is given in Appendix 3. This includes all models identified as in current use in the irrigation industry.

- Review in consultation with the Reference Group, the information needs against the list of existing models to identify those models that are most relevant and for which further information would be useful.

  This was not undertaken, as the conclusion from the survey is that users did not identify significant information needs, or models for which they would like further information.

- Document all outcomes of this scoping for NPIRD and industry considerations.

  This report contains the information and the outcomes based on the terms of reference.

- Provide recommendations to NPIRD on the proposed format and extent of a workshop (series of workshops). These are addressed in Section 8.2 below.

7 Recommendations

7.1 General

The key aim of the scoping study is to make recommendations on the modelling information that is considered most useful to industry stakeholders and propose a mechanism for delivery of this information.

The conclusion can be drawn from the survey that the irrigation industry has now reached a state of maturity in use of computer models that most of its current modelling needs are now being met. The limited adoption of models would indicate that it should be possible to make much greater use of selected models, which work effectively and are also cost effective for the same task.

It is also clear that there are other models in use by the industry in addition to those revealed by this survey or other industry organisations that may be using some of the models listed in this survey.

In view of the low level of adoption of currently available models by the industry and their use of a diversity of models, NPIRD should develop a strategic plan to facilitate better modelling outcomes in the irrigation industry. This should encourage wider adoption of selected models, which are technically good and cost effective. The selected models may need to be made more generic to encourage wider use by the industry. A key aim of the strategy must be the increased awareness in the industry of the modelling capability available and the expertise available to meet its modelling needs.

The strategy needs to include a database of models that are currently used in the industry. There must also be a mechanism for updating the list of models and deleting those no longer in use. The establishment of the database must ensure that an appropriate updating mechanism is put in place designed to capture a large proportion of models in use by model users and developers through an electronic on-line facility. The facility could also provide additional services such as on-line forums designed to facilitate communication between models developers and users.

The other part of the strategy needs to be a workshop where the results of the survey are discussed and made aware of what modelling is available. The present philosophy that the problem of the organisation is unique and requires a special model needs to be confronted and the industry develop an approach that looks to adapt existing proven models in a cost effective way. Hence we see the need for a workshop as an essential part of the communication process to a more mature approach to modelling and the identification of models that can be regarded as industry standard models. The workshop should also enable NPIRD to set appropriate protocols in consultation with industry stakeholders for funding new modelling initiatives.

7.2 Workshop

An important element of the adoption strategy should comprise a workshop involving key users and developers of models with appropriate representation from all States and stakeholders. High priority should be given to those who have indicated changes or enhancements to models in this survey. The aims of the workshop will be to:

- Explore the possibility of expanding selected models that are currently purpose-built into generic simulation tools that are applicable to a wider

range of situations. This applies primarily to models designed for simulation of catchment and river basin systems.

- Develop a mechanism to identify a common set of functional requirements to commercially available applications used for processing routine tasks such as asset management, billing, etc.
- Identify in more detail, the future need for soil-water hydrologic processes requiring model simulation in order to help define priority areas for funding of further model development. This will require a major industry overview seeing model users in the irrigation industry did not identify major future modelling needs.
- Define the types of modelling which would require NPIRD funding on the basis of comparative advantage to commercial developers.
- Consider establishing a database of models similar to existing research databases. The database could also include modelling capability available in various research institutions and Universities. Alternatively a WebPage supported by NPIRD that would allow irrigation industry users access to current and supported models when they are looking for new or improved modelling. Adequate arrangements must be implemented for on-going update of the database to ensure that it captures the most recent advances in modelling.
- Discuss intellectual property issues arising from further development of existing models with NPIRD funding. This also applies to any model or module developed overseas.
- Identify a process whereby NPIRD can consider new modelling requirements in future. For example, for groundwater modelling NPIRD should identify the modelling process or model, which could be accepted as the standard in the industry. Any future application to NPIRD for model development should have a clear indication that the database has been examined and the reasons why existing standard or key models are not capable of adaptation. Applicants should also indicate if their proposal allows for their model to be made more generic and capable of accepting readily accessible data – lack of acceptance of readily accessible data is often the reason for models remaining developer specific.

8 Appendices

APPENDIX 1. PROFORMA QUESTIONNAIRE

a. Cover sheet

Name of Organisation:		**Short title is sufficient**
Contact person		**The person who fills in this form**
Telephone		**Include extension number if appropriate**
Email		
As a guide, the models should be used for one of the following purposes		
	Asset management	
	Irrigation system planning and operation	
	Drainage system operation	
	Economic evaluation of irrigation options for planning and operation	
	Irrigation scheduling	
	Water entitlements and water transfer	
	Shallow groundwater modelling	
If models fall in another category list here	Other, **List below**	
1		

Please list here the computer based models that are used in your business, research or operations.

Use the common name or acronym of the model		
Model 1		
Model 2		

Model 3		
Model 4		
Model 5		
Are there models, which you have used in the past and have discarded?		
Please list those programs	Name:	
Model 1		
Model 2		
Model 3		
Why were they discarded?		
Hard to use		
Expensive to use		
No backup		
Not as well adapted to tasks		
Hard to get the right data		

Please click the next sheet, Model 1 to enter information on the first model listed above. Use the number 1 in the appropriate boxes. If the choices given do not match your situation fill in under Other.

b. Model Information

1	Name of model or program:	See listing in column E	
2	For what purpose is the model used?	Asset management	
	Tick the appropriate box or list	Irrigation system planning and operation	
		Drainage system operation	
		Economic evaluation of irrigation options for planning and operation	
		Irrigation scheduling	
		Water entitlements and water transfer	
		Shallow groundwater modelling	
		Other**, List below**	
	1		
	2		
	3		

3	What is the source of the program(s)?	Commercial	
		Public domain	
		Developed in house	
		Adaptation of another model	
		Specially developed by another source for your use	
		Other, **List below**	
	1		
	2		
	3		
4	What was the cost of the program(s)?	Up to $1000	
	Estimate if not a commercial program, and include development costs, etc	$1000 to $5000	
		$5000 to $10000	
		$10000 to $20000	
		Over $20000	

	What is the main cost from?	Purchase	
		Development	
		Operation	
		Other	
5	For how long has the program(s) been used?	Less than one year	
		One to five years	
		Five to ten years	
		More than ten years	
6	What are the basic processes simulated by the model?		
	If known, list the process(es) in the boxes adjacent.		

7	What type of computer is needed to run the model?	Mainframe	
		Stand alone PC	
		Other, **List below**	
	1		
	2		
	3		
8	What disk capacity is needed?		
9	What type of staff do you need to normally operate the model (program)?	Specialist staff trained for this model	
		Administrative staff familiar with computers	
	Do you need trained or specially skilled staff?	Administrative staff or technical staff trained for this program	
		Other, **List below**	
	1		

	2		
	3		
10	Is data readily available or accessible for entering in the model?	Data always available when needed	
		Data difficult to obtain in quantity, quality or format	
		Other, **List below**	
	1		
	2		
	3		
11	What is the source of data for the model?	Generated by your organisation	
		Generated by other organisations	
		Other, **List below**	
	1		

	2		
	3		
12	In what format is the data?	Data in electronic format and in the right form for direct use in the model.	
	Is the data in a form that can be entered electronically into the model?		
		Data in electronic format but needs to be converted to another format to use in the model.	
		Data has to be manually entered into the model	
		Other, **List below**	
	1		
	2		
	3		

13	What is the cost of obtaining data, either by purchase or in collection?	Up to $5000	
		$5000 to $10000	
	Cost on an annual basis if possible	More than $10000	
		Other, **List below**	
	1		
	2		
	3		
14	Capability of model and program	Satisfactory	
	Does the model allow you to simulate all the scenarios that you are interested in?	Needs more development to meet requirements	
		Needs better data	
		Other, **List below**	
	1		
	2		

	3		
15	Is the program reliable to operate, i.e. is it stable under normal conditions?	No problems	
		Once per session	
	How often are there problems with operation of the model?	Two to 5 times per session	
		Rarely	
		Other, **List below**	
	1		
	2		
	3		
16	Loss of data if the program fails.	Requires skills to recover lost data	
	If the program fails is there a loss of data or can it be recovered easily?	Data has to be re entered	
		Other, **List below**	

	1		
	2		
	3		
17	What is the utility of the output from the model?	Has calibration or checking facility	
		Needs calibration after model runs	
		Model still being tested to ensure reliable outputs	
		Not sure	
		Other, **List below**	
	1		
	2		
	3		

18	Output from the model	Immediately usable for the purposes intended	
	Is the output in a form that can be readily used by staff and decision makers or does it need more work?	Needs skilled staff to rework the output so that it can be used	
		Needs to be run through another program to be used	
		Other, **List below**	
	1		
	2		
	3		
19	Is there sufficient technical backup for the model to operate properly?	Yes - in-house	
		Yes - commercial supplier	
		No	
		If no please comment:	
	1		

	2		
	3		
20	Could the model be improved for its intended purpose or its task expanded?	No improvement needed	
		Minor changes	
		Additional modules	
		Major changes	
		Rendered more cost/effective	
		Other tasks	
		Other, **List below**	
	1		
	2		
	3		

21	The main area where improvement is needed	Reliability	
		Data quality and reliability	
		Accuracy of output	
		Usefulness of output	
		Other, **List below**	

APPENDIX 2. LIST OF PEOPLE AND ORGANISATIONS CONTACTED

ORGANISATIONS:	Location	Contact	Telephone	E-mail
Research Organisations and Universities				
CSIRO	Griffith	Liz Humphreys	02 69 60 1500	Liz.humphreys@grf.csiro.au
DNRE Victoria	Tatura	Belinda Bush	03 58335222	Belinda.bush@nre.gov.au
DLWC NSW	Leeton	Ari van der Leli	02 69 530700	Alely@dlwc.nsw.gov.au
DLWC NSW	Parammatta	Daren Barma	02 98 95 6211	Dbarma@dlwc.nsw.gov.au
DNR Queensland	Indoorapilly	Tony Turner	07 3822 3053	Turnert@dnr.qld.gov.au
			0419 742 641	
		John Hillier	07 389 696 21	John.hillier@dnr.qld.gov.au
			07 389 698 45	
			07 340 621 52	
Agriculture Western Australia	Perth	Bill Russell	08 9752 1308	
			08 9780 6100	
ABARE	Canberra	Rosalyn Bell	02 6272 2029	rbell@abare.gov.au
University of Melbourne	Melbourne	Hugh Turral	03-9344 6645	hnt@devtech.unimelb.edu.au

ORGANISATIONS:	Location	Contact	Telephone	E-mail
University of Western Sydney	Sydney	Basant Maheshwari	02 4570 1235	b.maheshwari@uws.edu.au
University of Queensland	Towoomba	Rod Smith	07 4631 2510	Smithrod@usq.edu.au
Water Supply and River Authorities				
Goulburn Murray Water	Tatura	Derek Poulton	58 33 5690	Derekp@g-mwater.com.au
Sunraysia Rural Water	Irymple	Andrew Sinn	50219777	Sinna@srwa.org.au
First Mildura Irrigation Trust	Mildura	Ray Byrnes	50 21 1811	Fmit@ruralnet.net.au
Wimmera Mallee Water	Horsham	Max Burns	53 62 0213	maxb@wmwater.org.au
Murray Irrigation	Deniliquin NSW	Charlie Robinson		Joyt@murrayirrigation.com.au
Murrumbidgee irrigation	Griffith NSW	Cedric Hoare	02 69530120	Hoarec@mirrigation.com.au
Coleambally Irrigation Area	Coleambally	Mark Bramston	0269544003	Mbramston@colyirr.com.au
Centre for Water Policy Research	Armidale	Mike Bryant	02 6773 2420	Mbryant@metz.une.edu.au
Central Irrigation Trust	Barmera SA	Jeff Parish	08 85 80 7100	Brian.martin@sawater.sa.gov.au
Renmark Irrigation Trust	Renmark, SA	David Morris	08 85 86691	Ritrust@riverland.net.au
South West Irrigation	Harvey	Geoff Calder	08 9729 0100	Swimail@geo.net.au
Murray Darling Basin Commission	Canberra	Andy Close	02 62 790 100	Andy.close@mdbc.gov.au
		Tony McLeod		

Consultants				
Sinclair Knight Merz	Melbourne	Peter Erlanger Matt Potter Geoff Linke	9248 3100	Glinke@skm.com.au
AquaTech	Narrabri	Jim Purcell	02-6792 1265	Bpa@mpx.co

APPENDIX 3. DESCRIPTION OF MODELS IN USE IN THE IRRIGATION INDUSTRY AND THEIR PURPOSE

AIM

Aim:	Modelling of farm surface irrigation systems
Type:	Soil-water-hydrologic processes
Main processes simulated:	Advance and recession characteristics and overall performance of irrigation events.
User:	Mr Derek Poulton Goulburn Murray Water Tel: 03 5833 5690 Email: derekp@g-mwater.com.au
Scale:	Single irrigated border check
Data requirements:	Soil infiltration characteristics Field geometry
Known limitations:	None
Suggested potential improvements:	Presentation and usefulness of output.

APSIM[3] – Agricultural Production System SIMulator

Aim:	To integrate models derived in fragmented research efforts to simulate soil fertility, soil erosion, crop growth and economic processes.
Type:	Soil-water- hydrologic model
Main processes simulated:	Integrated crop-soil-economic modelling framework
Developer:	Dr Brian Keating[4] Tel: 07-3214 2373 email : Brian.Keating@tag.csiro.au
Scale:	Farm
Data requirements:	Depends on processes simulated
Known limitations:	None reported
Suggested potential improvements:	None reported

[3] Information obtained from model website: http://www.apsim-help.tag.csiro.au/

Asset Management Renewals Profiles

Aim:	Management of infrastructure assets
Type:	Software application
Main processes simulated:	Determining useful life, and replacement costs of assets, determine net present value and create graphs of renewal profiles by district or asset type
User	Sunraysia Water Authority Andrew Sinn Tel: 03-5021 9 777 Email: sinna@srwa.org.au
Scale:	Water supply system
Data requirements:	Asset description and condition
Known limitations:	None
Suggested potential improvements:	Improving audit trail and documentation

AssetLife

Aim:	Management of infrastructure assets
Type:	Software application
Main processes simulated:	Asset management information system including condition, cost of assets ownership, maintenance and operation.
User	First Mildura Irrigation Trust Mr Ray Byrnes Tel: 03 5021 1811 Email: fmit@ruralnet.net.au
Scale:	Water supply system
Data requirements:	Asset description, condition and costs
Known limitations:	None reported
Suggested potential improvements:	None reported

Attache Business Partner

Aim:	Management of infrastructure assets
Type:	Software application
Main processes simulated:	Asset management information system including condition, cost of assets ownership, maintenance and operation.
User	First Mildura Irrigation Trust Mr Ray Byrnes Tel: 03 5021 1811 Email: fmit@ruralnet.net.au
Scale:	Water supply system
Data requirements:	Asset description, condition and costs
Known limitations:	None reported
Suggested potential improvements:	Billing module

BASINMAN

Aim:	Drainage system operation
Type:	Soil-water-hydrologic processes
Main processes simulated:	On-farm drainage storage (basins), water and salt balance, drainage to tile drains, interaction with shallow watertable
Developer:	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Single farm system
Data requirements:	Soil hydraulic parameters and water quality
Known limitations:	None reported
Suggested potential improvements:	Minor not specified.

BICADM

Aim:	Modelling of farm border irrigation systems
Type:	Soil-water-hydrologic processes
Main processes simulated:	Advance, recession and system performance
Developer:	Dr Basant Maheshwari Tel: 02-45701235 Email: b.maheshwari@uws.edu.au
Scale:	Single irrigated border check
Data requirements:	Soil infiltration characteristics Field geometry
Known limitations:	None reported
Suggested potential improvements:	Better user interface and graphics

BIGMOD

Aim: River salinity modelling

Type: Soil-water-hydrologic processes

Main processes simulated: Flow and salinity routing and storage operation

Developer: Mr Andrew Close
Murray Darling Basin Commission
Tel: 02 6279 0102
Email: andy.close@mdbc.gov.au

Scale: Regional

Data requirements: Reservoir data, river and salinity flows.

Known limitations: None reported

Suggested potential improvements: Add ability to model demand and resource assessment

BILL

Aim:	Access customer information, billing and reporting
Type:	Software application
Main processes simulated:	Various accounting processes
User:	South West Irrigation Mr Geoff Calder Tel: 08- 9729 0100 Email: swimail@geo.net.au
Scale:	Supply system
Data requirements:	Customer data
Known limitations:	None reported
Suggested potential improvements:	None reported

COLLEAMBALLY GROUNDWATER MODEL

Aim:	Management of net groundwater recharge
Type:	Soil-water-hydrologic processes
Main processes simulated:	Recharge, regional groundwater dynamics, interaction of different layers including pumping from wells.
Developer	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Regional
Data requirements:	Aquifer hydraulic parameters and piezometric information
Known limitations:	None reported
Suggested potential improvements:	None reported

CWPR1-Water Entitlements

Aim:	Water entitlements and water transfer
Type:	Soil-water-hydrologic processes
Main processes simulated:	Volumetric license and off-allocation allowances are translated into storage and tributary Capacity Shares to provide similar volumes and reliability
Developer	Centre for Water Policy Research Mr Mike Bryant Tel: 02 6773 3998 Email: mbryant@metz.une.edu.au
Scale:	Regional
Data requirements:	Hydrologic and water use data
Known limitations:	None reported
Suggested potential improvements:	User friendliness

CWPR2 – Water Delivery

Aim:	Modelling of water delivery costs
Type:	Soil-water-hydrologic processes
Main processes simulated:	Calculates water supply delivery costs to each part of an irrigation system. Costs are apportioned into Fixed and Variable cost components
Developer	Centre for Water Policy Research Mr Mike Bryant Tel: 02 6773 3998 Email: mbryant@metz.une.edu.au
Scale:	Regional
Data requirements:	Water demand, infrastructure costs and crop prices
Known limitations:	None reported
Suggested potential improvements:	User friendliness

CWPR3 – Bulk water

Aim:	Modelling of bulk water pricing
Type:	Soil-water-hydrologic processes
Main processes simulated:	Calculates water pricing on the basis infrastructure operating and capital costs and hydrology data
Developer or known user	Centre for Water Policy Research Mr Mike Bryant Tel: 02 6773 3998 Email: mbryant@metz.une.edu.au
Scale:	Regional
Data requirements:	
Known limitations:	None reported
Suggested potential improvements:	Improvement is not needed for the intended task, but the model could be further developed to perform additional tasks

EPANet

Aim:	Modelling of pipeline systems
Type:	Pipe hydraulic modelling
Main processes simulated:	Hydraulic assessment of pipeline systems
Developer or known user	Sunraysia Water Authority Mr Andrew Sinn Tel: 03 5021 9777 Email: sinna@srwa.org.au
Scale:	Supply system
Data requirements:	Pipe system configuration and flow data
Known limitations:	None reported
Suggested potential improvements:	None reported

GRADE

Aim:	Simulation of land grading design
Type:	Soil-water-hydrologic processes
Main processes simulated:	Calculation of earth movement by using laser and non-laser methods
Developer	Dept. of Natural Resources – Queensland John Hillier / Jerome Arunakumaren Tel: 07 38969847 Arunakj@dnr.qld.gov.au
Scale:	Farm system
Data requirements:	Topographic elevations
Known limitations:	Data requires conversion and manipulation by CIVILCAD or TERRAIN program
Suggested potential improvements:	None reported

IMSOP

Aim:	Simulation of delivery system operation
Type:	Soil-water-hydrologic processes
Main processes simulated:	Crop water requirements and canal operation
Developer	International Technologies Centre Department of Civil and Environmental Engineering University of Melbourne Tel: 03-9344 7839 Email: hnt@devtech.unimelb.edu.au
Scale:	Regional
Data requirements:	Cropping areas, climatic data and canal hydraulic data
Known limitations:	Linkage to a GIS and use of GIS type displays will be developed
Suggested potential improvements:	Direct input of weather data from Automatic weather station and direct input of remote sensed data for crop areas.

Integrated Quantity and Quality Model (IQQM)

Aim:	Water resource management and planning
Type:	Soil-water-hydrologic processes
Main processes simulated:	Water movement and water balance in rivers, soil moisture deficit driven irrigation demands. Water sharing rules and water use accounting systems.
Developer	Department of Land and Water Conservation Dr Dugald Black Tel: (02) 9895 7421 Email: dblack@dlwc.nsw.gov.au
Scale:	Regional
Data requirements:	Climate, streamflow, cropping areas and river data.
Known limitations:	None reported
Suggested potential improvements:	Water quality and catchment response modelling

MEDLI

Aim:	Effluent disposal
Type:	Soil-water-hydrologic processes
Main processes simulated:	Evapotranspiration, percolation through soil strata, runoff, waste production estimator and nutrient calculations
Developer	Department of Natural Resources Mr Tony Turner Tel: 07 38969621 Email: turnert@dnr.qld.gov.au
Scale:	Single system
Data requirements:	Weather and soil data,
Known limitations:	None reported
Suggested potential improvements:	Neater broader applications.

METMAN

Aim:	Weather data processing
Type:	Soil-water-hydrologic processes
Main processes simulated:	Process and collate weather data to estimate Et.
User	Goulburn-Murray Water Mr Derek Poulton Tel: 03 58 335 690 Email: derekp@g-mwater.com.au
Scale:	Farm system
Data requirements:	Climate data
Known limitations:	Program developed in Paradox dos environment and few people with skills in this area. Model needs urgently to be upgraded probably not Y2k compliant
Suggested potential improvements:	Make it Windows and Y2k compliant

MIKE-SHE

Aim:	Simulation of river-flood plain flow routing (Mike). Simulation of soil-water-atmosphere hydrologic processes (SHE)
Type:	Soil-water-hydrologic processes
Main processes simulated:	Unsteady-state flow in river and flood plain. Watershed hydrologic processes including groundwater, evapotranspiration, rainfall/runoff
User	Department of Land and Water Conservation Dr Dugald Black Tel: (02) 9895 7421 Email: dblack@dlwc.nsw.gov.au
Scale:	Regional
Data requirements:	Water movement and water balance in rivers, soil moisture deficit driven irrigation demands. Water sharing rules and water use accounting systems.
Known limitations:	None reported
Suggested potential improvements:	None reported

MODFLOW

Aim:	Groundwater aquifer simulation
Type:	Soil-water-hydrologic processes
Main processes simulated:	Unsteady-state flow in river and flood plain. Watershed hydrologic processes including groundwater, evapotranspiration, rainfall/runoff
User	Department of Land and Water Conservation Dr Dugald Black Tel: (02) 9895 7421 Email: dblack@dlwc.nsw.gov.au
Scale:	Regional
Data requirements:	Water movement and water balance in rivers, soil moisture deficit driven irrigation demands. Water sharing rules and water use accounting systems.
Known limitations:	None reported
Suggested potential improvements:	None reported

MDBC – Monthly Simulation Model

Aim:	Water allocation
Type:	Soil-water-hydrologic processes
Main processes simulated:	Interstate water accounting and resource assessment
Developer:	Mr Andrew Close Murray Darling Basin Commission Tel: 02 6279 0102 Email: andy.close@mdbc.gov.au
Scale:	Regional
Data requirements:	River flows, reservoir operation data, water allocation and use.
Known limitations:	None reported
Suggested potential improvements:	None reported

MURKEY

Aim: River salinity modelling

Type: Soil-water-hydrologic processes

Main processes simulated: Flow and salinity routing

Developer: Mr Andrew Close
Murray Darling Basin Commission
Tel: 02 6279 0102
Email: andy.close@mdbc.gov.au

Scale: Regional

Data requirements: River flows, reservoir operation data, water allocation and use.

Known limitations: None reported

Suggested potential improvements: None reported

Murrumbidgee Infrastructure Pricing Model

Aim:	Evaluate the role of constraints imposed by storage and distribution infrastructure on the value of water during the irrigation season.
Type:	Soil-water-hydrologic processes
Main processes simulated:	Evaluation of storage access rights which allow trade between irrigation seasons.
Developer:	ABARE Ms Rosalyn Bell Tel: 02 6272 2029 Email: rbell@abare.gov.au
Scale:	Regional
Data requirements:	Hydrologic, crops and infrastructure data
Known limitations:	None reported
Suggested potential improvements:	Conversion of water use and hydrological data into format to be used by model could be simplified.

NRM Net Recharge Management

Aim:	On-farm cropping systems to manage groundwater recharge
Type:	Soil-water-hydrologic processes
Main processes simulated:	Leakage to groundwater mound from crop irrigation
User:	Coleambally Irrigation Corporation Mr Mark Bramston Tel: 269502820 Email: mbramston@colyirr.com.au
Scale:	Single farm
Data requirements:	Soil, crop and climate data
Known limitations:	None reported
Suggested potential improvements:	None reported

Opnet model: Salinity Application

Aim:	Determine impact of salinity on agricultural producers
Type:	Soil-water-hydrologic processes
Main processes simulated:	Evaluate impact and overall effectiveness of salinity management options
Developer:	ABARE Ms Rosalyn Bell Tel: 02 6272 2029 Email: rbell@abare.gov.au
Scale:	Regional
Data requirements:	Not provided
Known limitations:	None reported
Suggested potential improvements:	To date, the model has been used to assess the effectiveness of policy options to correct externalities in resource use networks. Application of the model to examine the options for alleviating the costs of salinity is desired.

OSI-Ordering System for Irrigation

Aim:	Management of irrigation orders
Type:	Application software
Main processes simulated:	Capture and confirmation of irrigation orders, and provision of water use information to customers
User:	South West Irrigation Mr Geoff Calder Tel: 08-97290100 Email: swimail@geo.net.au
Scale:	Supply system
Data requirements:	Customer orders
Known limitations:	None reported
Suggested potential improvements:	None reported

PRIDE

Aim:	Irrigation system planning and operation
Type:	Soil-water-hydrologic processes
Main processes simulated:	Estimation of irrigation demand at the farm gate is estimated based on crop factors, climatic data and farm practices
User:	Sinclair Knight Merz Ms Wendy Smith Tel: 9248 3338 Email: wsmith@skm.com.au
Scale:	Regional
Data requirements:	Climatic and crop data available, farm practices
Known limitations:	None reported
Suggested potential improvements:	User friendliness

RART (Right Amount, Right Time)

Aim:	Farm irrigation scheduling
Type:	Soil-water-hydrologic processes
Main processes simulated:	Simulates crop water use from Et and forecasts the amount and date of application of irrigation by using Et and know soil moisture reservoir in root zone.
User:	Dept Nat Resources & Environment Mr David Boughton Tel: (03)5051 4500 Email: David.Boughton@nre.vic.gov.au
Scale:	Single farm
Data requirements:	Climatic and crop data available, farm practices
Known limitations:	None reported
Suggested potential improvements:	More features, greater flexibility, ironing out of bugs. Some utilities malfunction.

REALM

Aim:	Water allocation planning
Type:	Soil-water-hydrologic models
Main processes simulated:	Water supply operation including transfers and storages.
User:	Sinclair Knight Merz Ms Wendy Smith Tel: 9248 3338 Email: wsmith@skm.com.au
Scale:	Regional
Data requirements:	System configuration, streamflow and water demand.
Known limitations:	None reported
Suggested potential improvements:	None reported

REG-Share register

Aim:	Management of cooperative shareholders
Type:	Application software
Main processes simulated:	Database and processing of shareholder details
User:	South West Irrigation Mr Geoff Calder Tel: 08-97290100 Email: swimail@geo.net.au
Scale:	Supply system
Data requirements:	Shareholder data
Known limitations:	None reported
Suggested potential improvements:	None reported

RUSTIC

Aim:	Water sizing and reliability
Type:	Soil-water-hydrologic processes
Main processes simulated:	Water balance and reservoir simulation
Developer:	Department of Natural Resources Mr Tony Turner Tel: 07 38969621 Email: turnert@dnr.qld.gov.au
Scale:	Regional
Data requirements:	Daily runoff and crop water requirements, pumped volume from generated and recorded flows.
Known limitations:	None reported
Suggested potential improvements:	Windows 95/32 bit format in development along with minor improvements.

SALFTFLO

Aim:	River salinity management
Type:	Soil-water-hydrologic processes
Main processes simulated:	Flow and salinity routing
Developer:	Mr Andrew Close Murray Darling Basin Commission Tel: 02 6279 0102 Email: andy.close@mdbc.gov.au
Scale:	Regional
Data requirements:	Reservoir data, river and salinity flows.
Known limitations:	Extent of river modelled
Suggested potential improvements:	Slated for replacement by BIGMOD.

SAM

Aim:	Management of infrastructure assets
Type:	Application software
Main processes simulated:	Record asset location, condition and works. Link asset database with GIS.
User:	South West Irrigation Mr Geoff Calder Tel: 08-97290100 Email: swimail@geo.net.au
Scale:	Supply system
Data requirements:	Asset location, condition, characteristics and costs.
Known limitations:	None reported
Suggested potential improvements:	None reported

SCADA

Aim:	Management of water release and flow control
Type:	Application software
Main processes simulated:	Aggregation of water orders and schedule of releases
User:	South West Irrigation Mr Geoff Calder Tel: 08-97290100 Email: swimail@geo.net.au
Scale:	Supply system
Data requirements:	Water orders and hydraulic description of the system.
Known limitations:	None reported
Suggested potential improvements:	None reported

SIRMOD

Aim:	Design of surface irrigation layouts & management of surface irrigation applications
Type:	Soil-water-hydrologic processes
Main processes simulated:	Infiltration and unsteady overland flow
User:	University of Southern Queensland Professor Rod Smith Tel: 07 46312510 Email: smithrod@usq.edu.au
Scale:	Single farm irrigation unit
Data requirements:	Soil infiltration, farm inflows, farm geometry and Et data.
Known limitations:	None reported
Suggested potential improvements:	Improvement required – in particular addition of automatic optimisation – new model (FIDO) with improved capability due to be released by USQ early in 2000.

Snowy River Catchment Model

Aim:	Evaluation of environmental flows or alternative minimum release options for storages in Snowy Hydro-Electric Scheme
Type:	Soil-water-hydrologic processes
Main processes simulated:	Operation of storages for release of water for irrigation and electricity generation
Developer:	ABARE Ms Rosalyn Bell Tel: 02 6272 2029 Email: rbell@abare.gov.au
Scale:	Regional
Data requirements:	Hydrologic data, stream flows, environmental requirements
Known limitations:	None reported
Suggested potential improvements:	None reported

SWAGMAN-Destiny

Aim:	Crop water and salt simulation
Type:	Soil-water-hydrologic processes
Main processes simulated:	Crop growth, water balance, nitrogen balance, aeration and salt balance.
Developer:	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Farm
Data requirements:	Climate, soil
Known limitations:	None reported
Suggested potential improvements:	None reported

SWAGMAN-Farm

Aim:	Crop water and salt simulation (Version of SWAGMAN-Destiny designed for farmers use)
Type:	Soil-water-hydrologic processes
Main processes simulated:	Crop growth, water balance, nitrogen balance, aeration and salt balance.
Developer:	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Farm
Data requirements:	Climate, soil
Known limitations:	None reported
Suggested potential improvements:	None reported

SWAGMAN-Policy

Aim:	Net recharge management
Type:	Soil-water-hydrologic processes
Main processes simulated:	Gross margins, water pricing policy options, resource allocation.
Developer:	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Farm
Data requirements:	Climate, soil and crop prices
Known limitations:	None reported
Suggested potential improvements:	None reported

SWAGMAN-Whatif

Aim:	Net recharge management
Type:	Soil-water-hydrologic processes
Main processes simulated:	Recharge, surface runoff, unsaturated flows, regional groundwater
Developer:	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Farm
Data requirements:	Climate, aquifer properties, pump extractions, piezometric data.
Known limitations:	None reported
Suggested potential improvements:	None reported

SWAGSIM

Aim:	Net recharge management
Type:	Soil-water-hydrologic processes
Main processes simulated:	Recharge, surface runoff, unsaturated flows, regional groundwater hydrodynamics, interaction of different layers, pumping from wells etc
Developer:	CSIRO Land and Water Griffith Dr. Shahbaz Khan Tel: 02-6960-1500 Email: shahbaz.khan@grf.clw.csiro.au
Scale:	Regional
Data requirements:	Climate, aquifer properties, pump extractions, piezometric data.
Known limitations:	None reported
Suggested potential improvements:	None reported

SWIM[5] – Soil Water Infiltration and Movement

Aim:	To simulate water infiltration and movement in soils and solute balance movement
Type:	Soil-Water-Hydrologic model
Main processes simulated:	Simulation of soil water balances using numerical solutions of the basic soil water flow equations
Developer:	Scientific Software Group P.O. Box 23041 Washington, DC 20026-3041 Email: info@scisoftware.com
Scale:	Farm
Data requirements:	Soil characteristics and water application regime
Known limitations:	None reported
Suggested potential improvements:	Note reported

[5] Information obtained from model website:

http://www.ssg-int.com/swim_overview/swim_overview.html

WALL-Water Link

Aim:	Process water orders
Type:	Application software
Main processes simulated:	Allows Water controllers to access orders placed in OSI and registered in BILL
User:	South West Irrigation Mr Geoff Calder Tel: 08-97290100 Email: swimail@geo.net.au
Scale:	Supply system
Data requirements:	Farmers water orders
Known limitations:	None reported
Suggested potential improvements:	None reported

WaterNow

Aim:	Assist with planning of water supply services
Type:	Application software
Main processes simulated:	Not reported
User:	Central Irrigation Trust Mr Jeff Parish Tel: 08 8580 7100
Scale:	Supply System
Data requirements:	Not reported
Known limitations:	None reported
Suggested potential improvements:	None reported

WATERSHED

Aim:	Irrigation scheduling
Type:	Soil-water-hydrologic processes
Main processes simulated:	Field water balance
User:	Dr Basant Maheshwari The University of Western Sydney, Hawkesbury Tel: 02-4570 1235 Email: b.maheshwari@uws.edu.au
Scale:	Supply System
Data requirements:	Crop, climate and soil data
Known limitations:	None reported
Suggested potential improvements:	None reported

Waterways IMS

Aim:	Irrigation system operation
Type:	Soil-water-hydrologic processes
Main processes simulated:	System management linked to SCADA – Forward prediction of water demand for reservoir releases
User:	Colleambally Irrigation Corporation Mr Mark Bramston Tel: 02 69502820 Email: mbramston@colyirr.com.au
Scale:	Regional
Data requirements:	Annual plantings and past water ordering
Known limitations:	None reported
Suggested potential improvements:	None reported

Waterworks

Aim:	Irrigation system design
Type:	Soil-water-hydrologic model
Main processes simulated:	Linear programming to simultaneously optimise on- farm and irrigation system design.
User:	Centre for Water Policy Research Mr Mike Bryant Tel: 02 6773 3998 Email: mbryant@metz.une.edu.au
Scale:	Regional
Data requirements:	Crop yields, prices and water demand
Known limitations:	None reported
Suggested potential improvements:	User friendliness

Waterways IMS

Aim:	Irrigation system operation
Type:	Soil-water-hydrologic processes
Main processes simulated:	System management linked to SCADA – Forward prediction of water demand for reservoir releases
User:	Coleambally Irrigation Corporation Mr Mark Bramston Tel: 02 69502820 Email: mbramston@colyirr.com.au
Scale:	Regional
Data requirements:	Annual plantings and past water ordering
Known limitations:	None reported
Suggested potential improvements:	None reported