SECTION 3: Project Operations

3.1 Objectives

The aim of the project is to optimise the impact of large-scale revegetation on the water resources of the Coarse Sandy Hilly Region of the Loess Plateau of western China, and in the Middle and Upper Murrumbidgee Catchment of southeast Australia.

The objectives of the project are:

(A) To develop software tools to predict the impact of revegetation strategies on the two regions. This will require the development of:
1. regional databases
2. suitability assessments
3. GIS-based software tool

and,

(B) To make available and communicate the capacity of the tools developed by the project as decision aids for revegetation strategies by:
4. establishment of web-based systems
5. communication activities to promote the use of the tools.

For each sub-project there are several outputs; these are introduced in the following table. More detailed information on output is presented as activities documenting the research methodologies needed to complete each output.

3.2 Outputs

Subprojects	Outputs	Assumptions	Applications
1 Assemble the regional databases of climate, river flow, land use and DEMs.	1.1 Database of monthly climate and stream flow from 1980 to 2005, and soil, land use and topography, for YHB assembled. 1.2 Database of annual rainfall and runoff from 1980 to 2005, and land use and topography, for CSHR collated. 1.3 As in 1.1 except for MUMC from 1980 to 2005, with the addition of a composite 1-km resolution AVHRR database when acquired being collated.	1 Data for YHB, CSHR and MUMC are readily available for the study areas for the length of study. 2 Access to high temporal resolution AVHRR data for MUMC made available through the CSIRO ESS PDP.	Databases developed that will be used in all the subsequent modelling and validation for the YHB, CSHR and MUMC.

2 Map suitability assessments for trees, shrubs and perennial grasses, taking into account changes to equilibrium soil moisture.	2.1 For YHB maps showing the longevity of the proposed re-veg schemes, taking into account rainfall, potential ET, landscape position and changes to the equilibrium soil moisture. 2.2 Within YHB, soil moisture data for 'paired sites' documented. 2.3 Simple rules for CSHR developed from knowledge gained from YHB.	1 Assessments performed for most likely selected species from each of the main vegetation classes (trees, shrubs, perennial grasses, annual grasses). 2 ISWC collected soil moisture data available. 3 For the MUMC suitability maps derived from analysis performed by CSIRO Forests and Forestry Products will be used.	Maps of suitability that will be used in the GIS model, incorporating an understanding of the impact to long-term equilibrium soil moisture, and how this feedbacks to longevity assessment.
3. Develop a GIS tool to predict the impact of re-vegetation schemes (e.g. types of vegetation and its spatial distribution) on annual flow and seasonal stream flow distribution curves (FDCs) for 200 years from the time of re-vegetation.	3.1 GIS tool using monthly data to calculate the impact of re-vegetating catchments with mixes of trees, shrubs and perennial grasses (using the maps from Output 2.1), accounting for the need to preserve local productive agricultural areas, on annual stream flow and seasonal FDCs for the YHB. 3.2 As Output 3.1 except using annual climate and flow data, and Output 2.3, the CSHR. 3.3 GIS tool for MUMC, as for output 3.1, except use AVHRR ETa and LAI estimates.	Hardware (disk space, processing speed, network connection) and software are available using a mid-range PC. Input data and validation data are readily available, per Outputs 1.1, 1.2 and 1.3. Longevity maps from Outputs 2.1 and 2.3 finished.	Impacts of re-vegetation schemes on stream flow duration curves modelled and validated at a monthly time-step for the YHB and annually for the CSHR. Models developed in VBA that can be easily served to the Web using the CRC_CH Toolkit.

4 Develop a Web-based interactive scenario modelling tool using the CRC_CH Toolkit to 'port' the GIS tool.	4.1 Web-based GIS tool that ISWC will 'serve' to allow scenario modelling by regional policy makers for both YHB and CSHR. 4.2 As 4.1 except for MUMC and served by the CRC_CH.	1 Dedicated hi-end PC available for each group to serve the model to the WWW. 2. For ISWC site on-line documentation is in Chinese. 3 Both ISWC and CLW have access to CRC_CH Toolkit.	Provide policy and decision makers the opportunity to model the impact of re-vegetation on stream-flow. Provide guidelines for optimal location for re-veg and species selection.
5 Perform ongoing communications of project developments with potential users and other scientists.	5.1 Meetings with agricultural policy makers during the course of the project. 5.2 Results published in international peer reviewed journals.	1 That relevant policy makers recognise the value of the tools.	Tools for senior decision makers of the YDA, CSHR and MUMC to optimise revegetation efforts

3.3 Research methodologies and project travel
The following headings are the activities corresponding to the outputs identified in section 3.2, above. Here, we document the research methodology (or activity) needed to meet each of these outputs. Following this detailed description, a flow chart of Methodologies (Table 3.3.a) and a Travel timetable (Table 3.3.b) are provided.

Activity 1.1 Assemble monthly model driving databases of climate and monthly validation stream flow data from 1980 to 2005, and soils, topography, and land use databases for the YHB.
For the entire YHB, monthly rainfall and potential evaporation surfaces will be interpolated from point measures recorded from January 1980 until December 2005, see Figure 4. The data from January 1990 onwards must be purchased. Stream flow data will be acquired from five hydrology stations (see Figure 4) within the YHB for the same period as the meteorological data; again, the data from January 1990 onwards must be purchased. The development of interpolated meteorological surfaces and runoff databases will be added to the GIS data held by ISWC. Soils maps are currently held in digital format within ISWC, the main attributes mapped are type, and some chemical and physical properties. The soil map scale is 1:100 000 for the entire YHB, and for the entire 7,673 km^2 YHB, a 40m resolution DEM already exists. By the start date of the project (Jan 2003) land cover attributes will be available for 1980, 1990 and 2000 derived from remotely sensed data for the entire YHB. Currently, 1990 and 2000 are available and the 1980 map is work in progress at ISWC. The 1980 map is being derived from 80 m resolution Landsat MSS data, whereas 1990 was derived from 30 m resolution Landsat TM, and 2000 from 15 m Pan channel on Landsat-7. There are 8 main classes (each with some sub-classes) mapped consistently to Chinese Central Government specifications for the 3 dates. Potential land cover maps for re-vegetation will become available by December 2004. A map of land cover will be developed early in the summer of 2005 (May-June), will be ground truthed and will be available for GIS

modelling in the final review / workshop to be held in late 2005. This means landcover will be available from 1980 to 2005 for the final workshop held in late 2005. Using current data will mean the simulations are more appealing to regional agricultural policy makers. This 2005 landcover map will be generated as a direct result of this ACIAR project. The development of GIS data for 25 years is an extensive undertaking, and is based upon much longer-term developments of DEM and soils maps that ISWC have heavily invested in over many years.

Monthly modelling will be performed for the 707 km^2 Yan'an Demonstration Area (YDA see Figure 1), where a 20m resolution DEM is available, using the same model that has been validated using the five hydrographic stations located in the YHB. There will be some monthly modelling at two smaller catchments located entirely in the YDA. The two catchments are the 8.27 km^2 Zhifanggou Catchment (ZFGC) and the 47 km^2 Yanggou Catchment (YGC); 5m-grid size DEMs are available for both. Since January 2000, flumes have been established for both the ZFGC and YGC measuring runoff for each rainfall event. As monthly modelling is the smallest time-step we plan to examine in LWR1/2002/018, ISWC may wish to pursue event based modelling external to this project.

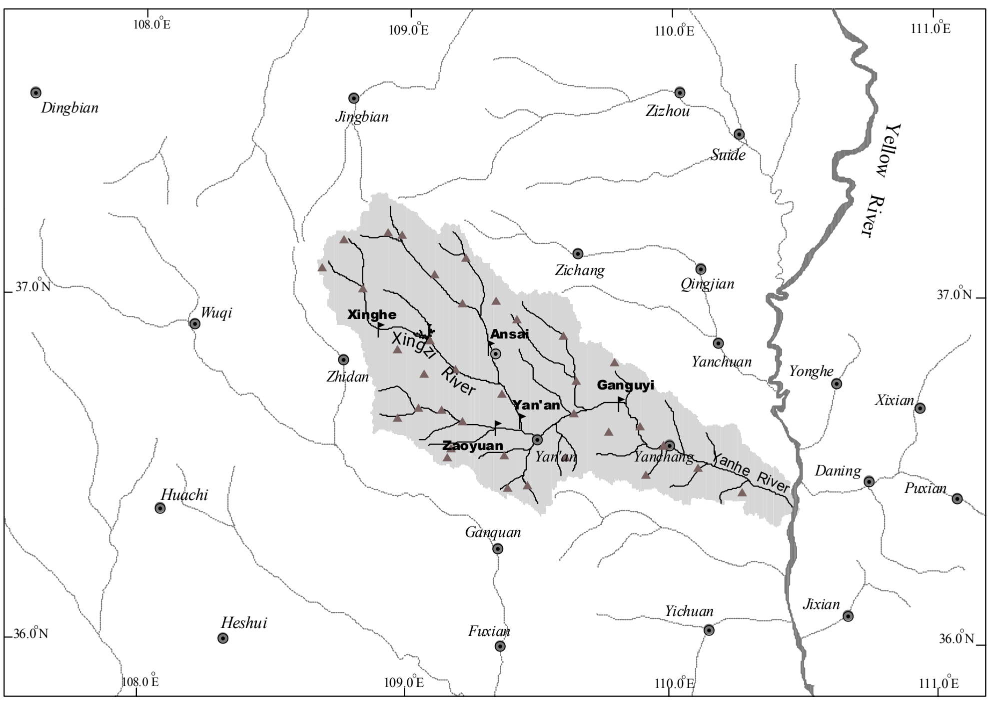

Figure 4. Locations of meteorological, rainfall and hydrological stations within the vicinity of the Yanhe Basin (YHB 7,673 km^2). Circles show the locations of the 22 meteorological stations, where air temperatures, rainfall, some measure of atmospheric water vapor (either relative humidity or vapor pressure), and some measure of solar radiation (either incoming shortwave, or sunshine hours). Flags show the locations of the 5 hydrological stations, where runoff (GL / month) and sediment content (T / month) are measured. The area contributing to each hydrology station is: Ansai 1,334 km^2, Ganguyi 5,891 km^2, Xinghe 479 km^2, Yan'an 3,208 km^2 and Zaoyuan 719 km^2. Triangles show the locations of the 35 stations measuring monthly rainfall within the YHB.

Activity 1.2 Assemble annual rainfall and runoff data from 1980 to 2005, and topography and land cover databases for the CSHR.

The Coarse Sandy Hilly Region (CSHR) of the Loess Plateau (see Figure 5) covers 134,050 km^2, straddling eastern Shaanxi and western Shanxi Provinces, and is comprised of 45 main sub-catchments. For the entire CSHR, annual precipitation will be interpolated from 90 stations, and annual river flow will be purchased for the 23 catchments where 62 stations exist. To avoid errors of winter snowmelt, we plan the annual period to be from 1 April to 31 March the following year. This allows 'snow-melt' to contribute to runoff in the year the precipitation fell. ISWC already have 100m resolution DEM obtained from 1:250,000 data for the CSHR. They also hold a 1:100,000 land-use map that can be used to map the current area of trees / no-trees for the 45 catchments of the CSHR.

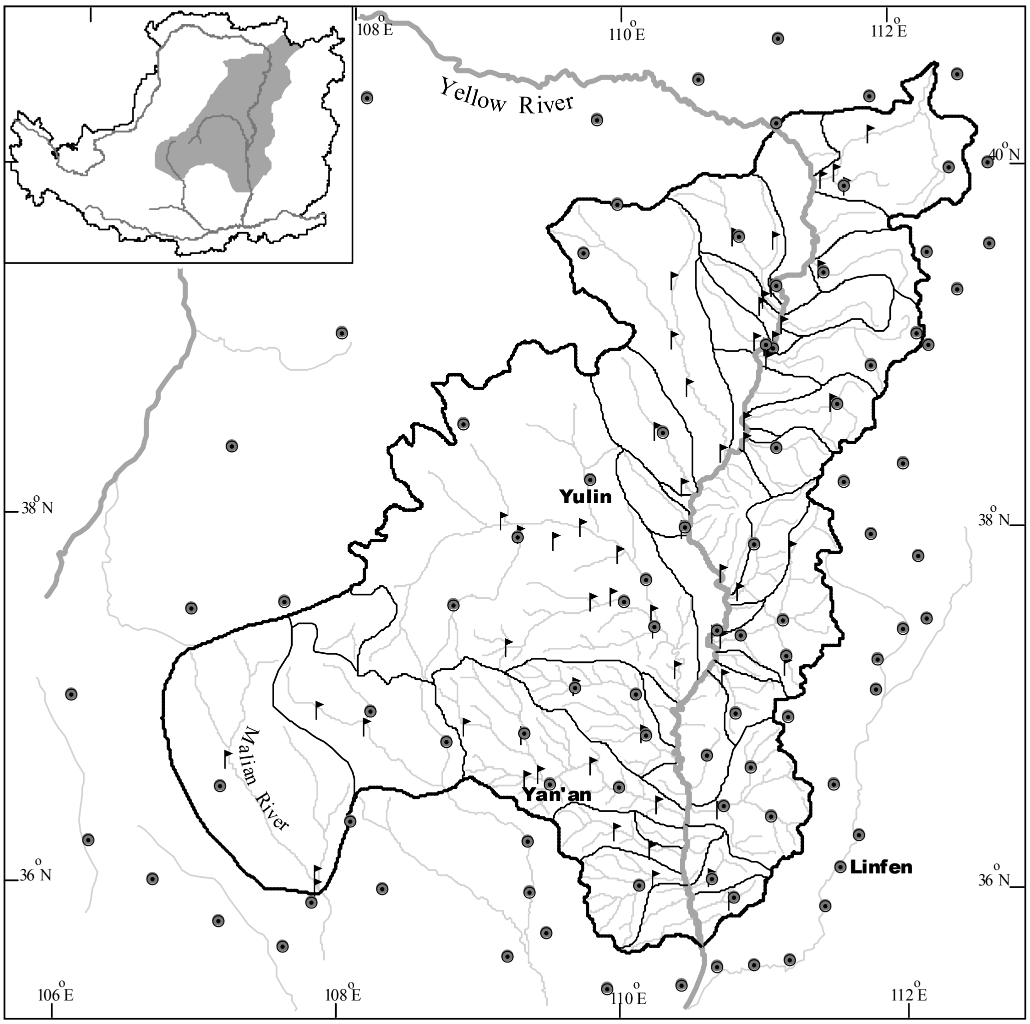

Figure 5. Locations of the 45 sub-catchments, ranging from 130 km^2 to 30,111 km^2, contained within the 134,050 km^2 Coarse Sandy Hilly Region (CSHR) shown in the dark line of the main map. The 7,673 km^2 Yanhe Basin (YHB) contains Yan'an in the southern portion of the CSHR. Flags show the locations of the 62 hydrographic stations, located in 23 of the 45 sub-catchments. Circles show the locations of the 90 meteorological stations. The location of the CSHR within the Loess Plateau is shown in the insert map.

Activity 1.3 As in 1.1 except for MUMC from 1980 to 2005, with the addition of a composite 1-km resolution AVHRR database when acquired.

In the MUMC, similar monthly meteorological surfaces and stream flow will be developed for its 27 sub-catchments, see Figure 6. A suitable DEM, soils data and land-cover map (from 1995) already exist. It is anticipated that fortnightly AVHRR composite remotely sensed data would be made available through the ESS PDP from April 1992 until 2005. This will provide information on surface temperature that can be used to map daily actual evapotranspiration (ETa) and reflectance used to measure LAI. The ETa will be scaled from the specific day of remotely sensed observation to monthly totals using the network of meteorological stations. Given the surfaces of precipitation, we will determine the residual that is partitioned into changes in the soil store, runoff, or deep drainage. The flow data obtained from the PINNEENA database, managed by the NSW Department of Land and Water Conservation, a member organisation of the CRC_CH, will be used to validate the modelling.

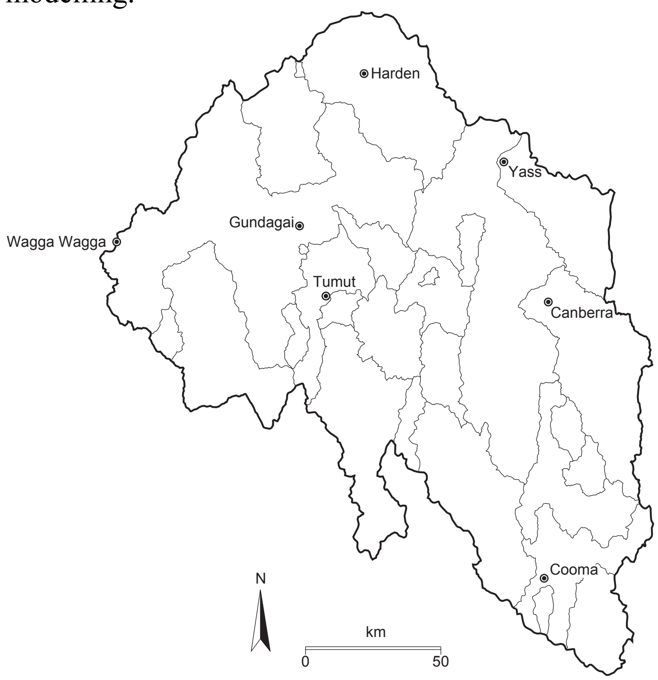

Figure 6. Location of the 27 MUMC sub-catchments (ranging from 10 km^2 to 5033 km^2), each has monthly flow recorded. Note that Lake George sub-catchment, to the north-east of Canberra in Figure 2, is not included as no surface water drains from it into the MUMC; it is connected by groundwater only.

Activity 2.1 For YHB maps showing suitability and longevity of the proposed re-vegetation schemes, taking into account rainfall, potential ET, landscape position and changes to the soil moisture.
Suitability maps showing optimal vegetation types (trees, shrubs perennial grasses) of the proposed re-vegetation schemes will be developed by overlaying monthly rainfall and ETp maps with knowledge of the water requirements of the three different vegetation types, including deep-rooted perennials such as lucerne. Landscape position and soil characteristics will also be taken into account. For example, we do not expected to plant trees on the tops of hills or on the steep slopes where much of the rainfall will flow away from the root zone. This modelling will be performed for the most likely species of trees, shrub and perennial grasses suggested for the re-vegetation schemes, including lucerne. The outputs from activity 2.1 will be maps, suitable for inclusion in activity 3.1. For the MUMC, suitability maps derived from analysis performed by CSIRO Forests and Forestry Products will be used.

Activity 2.2 Within YHB soil moisture data collected and analysed for 'paired sites'.
ISWC will measure soil moisture for the upper 5 m of the soil for paired sites, one being forested the other being nearby crops in a similar landscape position. Measures will be made on the same day, macro climatic conditions are assumed identical, differences are assumed to be attributable to differences in vegetation types and amounts. Measures will be taken from

May to October 2003 every month for 6 months at the same locations. These locations are planned to be close to where rainfall is recorded. Measurements would also be taken thrice (May, July and October) of deeper 10 m samples. This data will be used to provide some validation of the longer-term changes in equilibrium soil moisture.

Activity 2.3 Simple suitability rules for CSHR developed from knowledge gained from YHB.
The knowledge gained from activities 2.1 and 2.2 will be simplified into a set of rules of suitability for implementation for the entire CSHR, see activity 3.2. We anticipate developing rules based on distance to rivers, slope classes, soil attributes, and ratios of average annual precipitation to ETp to propose the location of the optimal vegetation types and densities. The simplified rules will be limited to only use data readily available for the entire 134,050 km^2, given the spatial and temporal resolutions.

Activity 3.1 Develop GIS tool, modifying the Holmes-Sinclair relationship, to include trees, shrubs, perennial grasses, and lucerne, to calculate the impact of re-vegetation on annual stream flow and seasonal FDCs. Weighted overlay methods will used to integrate these data with the suitability maps, for the YHB, accounting for the need to preserve local productive agricultural areas.
Methods to integrate these data are based on the Holmes-Sinclair relationship. The data will be integrated in ArcView, specifically developing a Visual Basic Application (VBA). In the modified Holmes-Sinclair curves of runoff as a function of rainfall and the three main re-vegetation types (tree, shrub and grass) and current annual grasses / crops will be developed. Knowledge of the areal extent of the three vegetation types will allow stochastic distributions of stream flow to be calculated. Vegetation growth will be estimated, enabling modifications for factors such as drought to effect plant growth curves, especially during establishment. Time since re-planting will be a key variable to take into account, as recently re-vegetated areas transpire more water, due to rapid growth rates, when compared to areas that have been re-planted for longer. The highest producing agricultural land will be identified by combining the polygon data from the land use maps with the tabular data from land capability assessments conducted by the Bureau of Land Resources Management of Shaanxi Province in the 1995 and expert knowledge. These areas will be excluded from re-vegetation schemes, though some re-vegetation in the riparian zone may be acceptable.

Activity 3.2 Apply Holmes-Sinclair style model, with modifications to include assessment of simplified suitability (Activity 2.3) and current trees to the CSHR.
The method will use readily available annual data for the entire CSHR and will be developed in VBA in ArcView. It will be based on annual precipitation and validated using annual river flow data, as developed from activity 1.2. This will illustrate the impact of re-vegetation, combined with the natural climate variability captured in 25 years of input rainfall data. Future modelling can be based on average conditions, or will use the same variability captured in the 25 years of data, hence the impact on river flows drought and flood will be seen. As in the YHB we will build a constraint into the model that the highest producing agricultural land (most likely that on flat land close to water supply) will be simulated to be re-vegetated last, however policy makers will be allowed to simulate 100% re-vegetation of catchments to understand the boundaries of the policy actions.

Activity 3.3 For MUMC perform similar modelling as for activity 3.1, except integrate AVHRR data estimates of ETa and LAI into the model.
For the MUMC modelling will be similar to that performed in activity 3.1 for the entire YHB, however, we will ingest estimates of ETa developed from frequent spatially-dense AVHRR data for the entire MUMC. It is anticipated that including the remotely sensed data will better close the monthly water balance, when compared to modelling that does not include this type of data. This will be confirmed, as the modelling will be performed both with and without use of time series remotely sensed data as input.

Activity 4.1 Web-based GIS tool that ISWC will 'serve' to allow scenario modelling by regional policy makers.
We will develop a Web-based GIS modelling tool providing mid and senior agricultural policy makers the ability to assess the impact of different scenarios of re-vegetation. The tools developed in Activities 3.1, 3.2 and 3.3 will be 'ported' from ArcView VBA using the CRC_CH Toolkit modelling environment, which allows generation of Web-based tools. The scenario modelling framework is planned to be very visual. For example, one output will plot changes in runoff, as a function of time, according to an interactive percent catchment vegetation-type 'sliding-bar'. The percentage of catchments re-planted with a mix of trees, shrubs and grasses is the primary 'lever' available to policy makers. The policy makers will interactively set these variables for the simulations. Maps of the optimal locations to plant the proposed re-vegetation (trees, shrubs and grasses) will also be used, see Activities 2.1 and 2.3 above. The user interface will be modified to include Chinese internal documentation and a Chinese manual will be available for download from the Web-site, to be served by ISWC. The constraint of percent of a catchment suitable for trees, shrubs and perennial grasses would be taken into account, as would the need to maintain high agriculturally productive areas. Given these constraints, maps showing zones of possible location to re-plant likely species of the different life-forms would be generated for planning use. All output from the Web-modelling would include metadata about the versions of the databases and model used.

A prototype Web-based GIS modelling tool will be available for comment by users by half way through the third year of the project (by June 2005). The users will be encouraged to comment on potential improvements, especially with respect to visualisation of model outputs. That is, we will develop a tool that people can understand and digest the outputs from. The Web-based GIS will allow senior policy makers and managers access to a tool to simulate impacts of different proposed re-veg strategies. This tool will be an example of Web-based technology transfer for other research and educational institutions in China. Keeping the data on the Web reduces database version control issues, that is, simulations will be performed on standard databases of known quality.

It is not envisaged that senior policy makers will be interested in obtaining the input databases; we assume senior policy makers are interested in information, not data. ISWC may make the databases available to other researchers, in Shaanxi and Shanxi Provinces, China and internationally as ISWC sees fit.

Activity 4.2 As 4.1 except for MUMC and served by the CRC_CH.
A monthly re-vegetation – flow impact analysis tool will be served for MUMC from the CRC_CH Web-site. The main difference between the modelling for the YHB and MUMC, is for the MUMC, we will use previously defined suitability maps, not those developed in this project (as will be done for the YHB see activity 2.1). CLW will make similar decisions about databases developed for the MUMC.

Activity 5.1 Conduct meetings with relevant policy makers during the course of the project.

In China, both Australian and Chinese scientists will have meetings with relevant policy makers every time the Australians scientists visit ISWC. There are three trips planned: Year 1, month 3, Year 2, month 7 and Year 3, month 8. In the first meeting we plan to hold discussions to assist agricultural scientists better understand the agricultural policy decision frameworks to better aide the targeting of the simulation models. In the final two meetings the agricultural policy makers will see demonstrations of our maturing simulation tool. At the meeting held in conjunction with the mid-term review, initial results from the ArcView model will be shown. LWR1/2002/018 project team will solicit suggestions and advice from the high-level policy makers to better design the user interface for the Web-based modelling tool. To increase awareness of the outcomes from LWR1/2002/018, we plan to distribute a near-final version of the Web-based GIS modelling with some example datasets by midway of the third year of the project to county, local and National policy makers on CD. This version is "near-final" as suggestions requested by policy-makers will be implemented in the final 6-months of the project. The aim of the 'CD mail-out' is to ensure that the output from LWR1/2002/018 reaches as many relevant Chinese policy-makers and natural resource managers as possible. ISWC will organise the production of the CD, with associated Chinese documentation, the mail list and the mail-out. We plan to perform this in June 2003, after Zhao Yong'an returns home to China; he visits CLW in Year 3, month 5. The CD will increase awareness of the project at all levels and will serve to advertise the final workshop, to be associated with the final project meeting.

Chinese scientists will be encouraged to have more regular meetings, and telephone conversation to update users on progress. The policy-makers we plan to discuss LWR1/2002/018 progress with are:

1. Managers of the Yanhe River Basin Management Committee (Academician Qin Dahe, Director General of National Weather Bureau, Wang Shusen, Stakeholder of Shaanxi Province, Liu Xiaowen, Secretary General of Shaanxi Province, and Dr Tang Junchang Vice Director of Scientific and Technical Department);
2. The steering committee of the YDA (Chen Yiyu, CAS Vice President, Wang Shouseng, Vice-Governor Shaanxi Province, Zhou Wanlong, Director of Bureau of Shaanxi Soil Conservation, Li Ruizhi, Vice Mayor of Yan'an City, Liu Xiaowen, Vice Secretary of Shaanxi Province, Zhang Yi, Director of Yanhe River Project Office and Prof Li Rui); and
3. The Demonstration CAS West Action Program includes upper level CAS and Central Government Ministry policy makers and managers.

Beyond the CSHR, YHB and YDA, we will communicate results with the Yellow River Management Committee located in Zhengzhou (Henan Province) and, particularly, their sub-agency, the Bureau of the Middle-Upper Reaches of Yellow River Management Authority located in Xi'an (Shaanxi Province). The Bureau is directly responsible for policy setting and managing engineering works to enhance soil and water conservation of the entire Loess Plateau.

In China land management is conducted through a strong hierarchy of government involvement; from National (or Central) through Provincial, County, Township, Village and individuals holdings. For the areas being studied in LWR1/2002/018, broad scale re-vegetation plans were produced by the Committee of the Yellow River, in consultation with the relevant provinces. The State Planning Committee issued the final plan on the 14th July

2002. The plan mainly sets targets for the management and engineering of large water supply dams in the Yellow River Basin. The smallest administrative unit (or geographic unit) discussed in the plan is the County, though it is discussed only in very general terms. Slightly more specific figures being provided at the Provincial level. This plan is the basis for the initial 10-year period of the "Clean River: Green Hills" re-vegetation policy, a 50-year policy from 2000 to 2050. Following the State Planning Committee re-vegetation plans, County governments will produce plans that aggregate to the Provincial re-vegetation targets. County government plans are produced by consultation between several Bureaus – usually Forestry, Agricultural and Water Resource Bureaus. LWR1/2002/018 aims to impact the technical staff in these County-level Bureaus. Staff from the County level Bureaus will use their existing communication pathways to provide technical guidance at the Township and Village level. At the Township and Village level there are no technical Bureaus.

While individual farmers in China do not own their land, the local land-use decision-making process is often a pragmatic combined decision by the farmer and Village level Government officials, that is, the village leader. So there will be extensive discussions between the County level technical staff through Township and Village level Government staff to the individual farmer. LWR1/2002/018 will link to the County level technical staff, as they will be centrally involved in these discussions. As noted earlier, farmers will receive government subsidies for land they re-vegetate. To ensure that the re-planting schemes are successful, village leaders will annually assess the health of the vegetation that farmers have re-planted under the auspices of the "Clean River: Green Hills" re-vegetation scheme. In short, farmers should not receive subsidies for plants that have died during the previous year.

In LWR1/2002/018 we are working primarily on two study sites: the 7,673 km^2 YHB and the 134,050 km^2 CSHR. We will model the YHB at a monthly time-step, and annually for the CSHR. Given the above knowledge of how the technical staff from County level Bureaus will influence the local re-vegetation planning, these are the staff that LWR1/2002/018 will target in our communication. However, to fully understand the end-to-end communication network, we will assess the links from the County level Bureaus to the Township and Village level officials in the in 707 km^2 YDA. ISWC have already developed strong links at the County, Township and Village level for this important demonstration area. It is envisaged that the County level technical staff in the Forestry, Agricultural and Water Resource Bureaus will use the Web-site to perform simulation modeling to obtain guidelines on different re-vegetation suitability (trees, shrubs and grass) and their optimal planting densities. These will be communicated to the local level through the existing official Chinese government hierarchy.

It should be noted that the outputs from LWR1/2002/018 will assist Provincial and Central governments in target setting for the "Clean River: Green Hills" re-vegetation policy. That is, the outputs from the model will feed to policy makers who make decisions about areas larger than a County. For the YHB and CSHR some basic statistics are provided in Table 2.

Table 2. Number of Counties, and the average, standard deviation, maximum and minimum County size falling within the two study areas. In the first column for each study area, only Counties with greater than 10% of the County area contained in the study site are reported; in the second column all Counties are included. However, it should be noted for the “All Counties” statistics that the areas used in the calculations are only those that overlay with the YHB or CSHR. That is, in the YHB the smallest County is not 33.6 km^2, for one County only 33.6 km^2 if it falls within the YHB. This is also why the average size decreases when comparing the “All Counties” statistics to the “If > 10% of County are overlaps” statistics for both study sites.

	YHB		CSHR	
	If > 10% of County area overlaps	All Counties	If > 10% of County area overlaps	All Counties
Number	5	7	57	73
Avg (km^2)	1535.1	1096.5	2324.6	1822.0
Std (km^2)	876.4	1019.4	1784.8	1841.2
Min (km^2)	458.3	33.6	175.3	31.6
Max (km^2)	2624.3	2624.3	7039.4	7039.4

In the following calculations the average statistics are generated from the “If > 10% of County are overlaps” values presented in the Table above. In the YHB the DEM resolution is 40m (Activity 1.1), so each grid-cell is 1600 m^2, with the average size of each county being 1,535,100,000 m^2 (or 1535.1 km^2), hence on average there are 959,437 pixels per County. Similarly, for the CSHR the DEM resolution is 100m (Activity 1.2), so each grid cell is 10000 m^2, with the average county size being 2,324,600,000 m^2 (or 2324.6 km^2), hence on average there are 232,460 pixels per County.

In Australia, communication will be primarily undertaken through the network established and maintained by the CRC_CH. The MUMC is one of the CRC_CHs focus catchments, with an appointed Focus Catchment Coordinator, Ms Carolyn Young, from New South Wales Department of Land and Water Conservation, who is aware of LWR1/2002/018. The use of an extensive time series of remotely sensed imagery will be incorporated into the CRC_CH Toolkit, and developments from LWR1/2002/018 will be updated on the CRC_CH Web-site. LWR1/2002/018 will be a collaborative, associate project to the CRC_CH. When appropriate CLW staff involved in LWR1/2002/018, will make presentations to policy makers involved with the CRC_CH MUMC focus catchment workshops.

Activity 5.2 Publish results in International Peer Reviewed Journal Papers.
The project scientists will publish appropriate peer reviewed journal paper from LWR1/2002/018. It is envisaged that several papers will be written as the project is being conducted, with a few final summarising papers written in the final 6 months of the project.

3.3.a. Flow Chart (Methodologies)

(PC = partner country A = Australia)

Sub-Project	**Activity**	**Time line (Yr and m)**	**Milestone**
1 Assemble the regional databases of climate, river flow, land use and DEMs.	1.1 Assemble monthly model driving databases of climate and monthly validation stream flow data from 1980 to 2005, and soils, topography, and land use databases for the YHB. (PC).	**Yr 1, m 1 to Yr 1, m 9** **YQK, ZXP, WZM, LR, TBA, TMcV**	**Regional databases for YHB ready to use. Data quality assessed and documented.**
	1.2 Assemble annual rainfall and runoff data from 1980 to 2005, and topography and land cover databases for the CSHR. (PC).	**Yr 1, m 1 to Yr 1, m 9** **YQK, ZXP, WZM, LR, TBA, TMcV**	**Regional databases for CSHR ready to use. Data quality assessed and documented.**
	1.3 As in 1.1 except for MUMC from 1980 to 2005, with the addition of a composite 1-km resolution AVHRR database when acquired. (A)	**Yr 1, m 1 to Yr 1, m 12** **TBA, TMcV, TVN**	**Regional databases for MUMC ready to use. Data quality assessed and documented.**
2 Map suitability assessments for trees, shrubs and perennial grasses, taking into account changes to equilibrium soil moisture.	2.1 For YHB maps showing suitability and longevity of the proposed re-vegetation schemes, taking into account rainfall, potential ET, landscape position and changes to the soil moisture. (PC).	**Yr 1, m 10 to Yr 2, m 6** **MXM, LWZ, GP, WZM, TMcV, LZ**	**Maps of vegetation type longevity for tree, shrubs and grasses, assuming no irrigation. Trends in long term equilibrium soil moisture defined.**
	2.2 Within YHB soil moisture data collected and analysed for 'paired sites'. (PC).	**Yr 1, m 6 to Yr 1, m 12** **MXM, LWZ, GP, LZ, TMcV**	**New soil moisture data collected (May to Oct 2003) and available by Dec 2003.**
	2.3 Simple suitability rules for CSHR developed from knowledge gained from YHB. (PC)	**Yr 2, m 1 to Yr 2, m 6** **MXM, LWZ, GP, WZM, YQK, ZXP, TMcV, LZ**	**Maps of long-term suitability for re-veg of trees, shrubs and perennial grasses available for entire CSHR.**

3. Develop a GIS tool to predict the impact of re-vegetation schemes (e.g. types of vegetation and its spatial distribution) on annual flow and seasonal stream flow distribution curves (FDCs) for 200 years from the time of re-vegetation.	3.1 Develop GIS tool, modifying the Holmes-Sinclair relationship, to include trees, shrubs, perennial grasses, and lucerne, to calculate the impact of re-vegetation on annual stream flow and seasonal FDCs. Weighted overlay methods will used to integrate these data with the suitability maps, for the YHB, accounting for the need to preserve local productive agricultural areas. (PC)	**Yr 2, m 3 to Yr 2, m 12** **YQK, ZXP, ZYA, WZM, TMcV, LZ, TBA, TVN**	**Model developed based on different amounts of vegetation types using VBA in ArcView for YHB annually and monthly. Validated with month and annual flows.**
	3.2 Apply Holmes-Sinclair style model, with modifications to include assessment of simplified suitability (Activity 2.3) and current trees to the CSHR (PC).	**Yr 2, m 4 to Yr 3, m 3** **YQK, ZXP, ZYA, WZM, TMcV, LZ, TBA, TVN**	**Model developed based on different amounts of vegetation types using VBA in ArcView for CSHR annually and monthly. Validated with annual flows.**
	3.3 For MUMC perform similar modelling as for activity 3.1, except integrate AVHRR data estimates of ETa and LAI into the model. (A).	**Yr 2, m 1 to Yr 2, m 12** **TBA, TMcV, TVN, LZ**	**Model developed based on different amounts of vegetation types using VBA in ArcView for MUMC annually and monthly. Validated with month and annual flows.** **Compare results with and without inclusion of remotely sensed data.**
4 Develop a Web-based interactive scenario modelling tool using the CRC_CH Toolkit to 'port' the GIS tool.	4.1 Web-based GIS tool that ISWC will 'serve' to allow scenario modelling by regional policy makers (PC).	**Yr 3, m 1 to Yr 3, m 12** **ZYA, TBA, YQK, LR, ZXP, HH, TMcV, LZ**	**Purpose built Web-based software, with Chinese on-line documentation, complete and refined based on user consultation performed during the third year of the project.**

	4.2 As 4.1 except for MUMC and served by the CRC_CH. (A)	**Yr 3, m 1 to Yr 3, m 12** **TBA, HH, TMcV, TVN, LZ**	**Purpose built Web-based software based on user consultation performed during the third year of the project.**
5 Perform ongoing communications of project developments with potential users and other scientists.	5.1 Conduct meetings with relevant policy makers during the course of the project. (PC and A)	**Throughout the project, especially when CLW staff visits China.** **LR, TMcV, LZ, YQK, MXM**	**Project development and progress workshops held during the course of the project.**
	5.2 Publish results in International Peer Reviewed Journal Papers. (PC and A)	**Yr 3, m 6 to Yr 3, m 12** **All Hands on Deck**	**Publication accepted by appropriate agricultural international peer reviewed journals.**

3.3.b. Travel table

PC = Partner Country, A = Australia

Person(s) or position travelling	Approximate date of travel	From / to	Purpose	Duration (days Travel Allowance)
Project scientists TMcV and LZ (A)	Yr 1, m 3	CLW to ISWC	Project planning, finish database design and discuss data progress.	10 days each
Project scientists, YQK and ZXP (PC)	Yr 1, m 9	ISWC to CLW	Database construction complete, copy provided to CLW, discuss data integration and perform literature review.	30 days each
Project scientists LWZ, MXM and WZM (PC)	Yr 2, m 4	ISWC to CLW	Discuss model integration methods and suitability maps.	30 days each
Project scientist LR (PC)	Yr 2, m 6	ISWC to CLW	Prepare detailed presentation for mid-term review.	10 days
Project scientists TMcV, LZ and TVN (A)	Yr 2, m 7	CLW to ISWC	Mid-term review and finish suitability maps and FDC analysis.	15 days each
Project scientist TBA (A)	Yr 3, m 3	CLW to ISWC	Develop Web-based GIS tool.	30 days
Project scientist, ZYA (PC)	Yr 3, m 5	ISWC to CLW	Finish Web-based GIS tool.	30 days
Project scientists TMcV and LZ (A)	Yr 3, m 8	CLW to ISWC	Final review in Yan'an City.	15 days each

A mid-term review is planned for Y2, m 7 and a final review meeting, held in Yan'an City with a launch of the Web-site to relevant senior policy makers, is planned for Yr3, m 8.

3.4 Intellectual Property and other regulatory compliance

There will be no use of Genetically Modified Organisms, and no experiments using animals will be conducted during the course of this project. Additionally, there will be no germplasm transfer, no plant, soil or animal movement, and no recombinant DNA release.

The standard ACIAR agreement will be used as the basis for international arrangements for intellectual property (IP). Use of commercial software will be restricted as per the commercial licensing agreements, geo-spatial databases of China will remain property of ISWC, and geo-spatial databases of Australia will remain property of CLW. Web-based software developed in the project will be made available, and scientific reporting in International peer reviewed Journals will be conducted.

3.5 Project personnel

(i) List of participants involved in the project

Australian Commissioned and collaborating organisations

Name	Sex M/F	Agency	Position	Time in project (%)	Funded by
Tim McVicar (TMcV)	M	CLW	Project Leader and Regional RS/GIS	50	20 CLW 30 ACIAR
Lu Zhang (LZ)	M	CLW	Regional Hydrology	40	20 CLW 20 ACIAR
Tom Van Niel (TVN)	M	CLW	Regional GIS/RS	30	15 ACIAR 15 CLW
Harold Hotham (HH)	M	CLW	Web Programmer	10	CLW
Tanya Jacobson (TJ)	F	CLW	Admin Support	5	CLW
To Be Appointed (TBA)		CLW	Web Programmer and GIS/ RS Database Developer	100	ACIAR

Partner country (or country research institutions)

Name	Sex M/F	Agency	Position	Time in project (%)	Funded by
Li Rui (LR)	M	ISWC	Project Leader	35	ISWC
Yang Qinke (YQK)	M	ISWC	Daily Manager and Regional GIS	70	ISWC
Liu Wenzhao (LWZ)	M	ISWC	Catchment Modelling	70	ISWC
Mu Xingming (MXM)	M	ISWC	Regional Eco-hydrology	50	ISWC
Zhang Xiaoping (ZXP)	F	ISWC	GIS and Data Management	70	ISWC
Wen Zhongming (WZM)	M	ISWC	Land Suitability Assessment	70	ISWC
Zhao Yong'an (ZYA)	M	ISWC	WWW Software Development and Hardware Support	40	ISWC
Gao Peng (GP)	M	ISWC	Hydrology	70	ISWC

(ii) Description of the comparative advantage of the institutions involved

ISWC and CLW have a long and successful history of performing eco-hydrologic and regional spatial research together. This began in 1984 with a visit by Li Rui to the then CSIRO Division of Land and Water Research. More recently both institutes were involved in a successful ACIAR-funded project conducted July 1997 to June 2001 (LWR1/1995/007) that assessed aspects of regional sustainable agricultural activities.

ISWC have developed close links with local, provincial and National policy makers and scientific managers (see the list presented in Activity 5.1 in Section 3.3 above). It is envisaged that ISWC will use this close relations to disseminate the research results and impact policy makers. ISWC have also developed close working relationships with other agencies, especially at the Shaanxi Provincial level, involved in the collection of the primary databases needed to successfully complete this project. ISWC have already purchased some of the required regional databases required by this project.

Scientists from ISWC and CLW have long experience in assessing the hydrologic impacts of land use change, including re-vegetation. Both groups have considerable experience in applying spatial information systems (GIS and remote sensing) to regional agricultural and eco-hydrologic issues.

(iii) Summary details of the research capacity, skills and role of each participant involved

Professor Li Rui is Director of ISWC. He has extensive regional spatial information systems experience and more recently has been intensively involved in project management and scientific administration. Li Rui will coordinate Chinese scientists, ensuring resource availability, and will work on project reporting and coordination with Dr Tim McVicar.

Dr Yang Qinke leads the Spatial Information (GIS / Remote Sensing) group of ISWC. He has extensive experience in modelling regional soil erosion and regional database development. In this project he will perform the daily management and regional GIS modelling. Yang Qinke also has the important role of being the day-to-day manager and the Chinese point of contact for communication between the two research teams.

Dr Liu Wenzhao, leads the eco-hydrology and catchment management group of ISWC and is vice-director of Ansai station. He has extensive research experience in soil moisture and hydrology processes modelling. In this project he will undertake catchment hydrologic modelling.

Dr Mu Xingming, is a member of the regional soil conservation and environment group, and leads a group to assess the impact of regional soil conservation within ISWC. He has extensive eco-hydrological experience and soil moisture modelling for the entire Loess Plateau. In this project he will perform regional hydrologic modelling.

Mrs Zhang Xiaoping, is a member of the Spatial Information (GIS / Remote Sensing) Group of ISWC and is undertaking her PhD studies. There she has experience in land-use change survey and assessment using remote sensing and GIS analysis, and expert system development. In this project she will develop regional climate, land-use, runoff databases and be involved in spatial modelling.

Dr Wen Zhongming, is a member of the Spatial Information (GIS / Remote Sensing) Group of ISWC. He has conducted research mapping re-vegetation from remotely sensed data and has a background in plant physiology. He will be involved in producing maps of planned re-vegetation by matching plant type (trees, shrubs, and grass) suitability with water resource constraints.

Mr Zhao Yong'an is the leader of the ISWC Technical Internet Management Group. He has installed and maintained the computing resources for ISWC, including computer, printer and network facilities. He has extensive knowledge and experience of programming, mainly in FORTRAN, C++ and the Web-based language JAVA. In this project he will ensure that there are suitable hardware and network facilities to 'serve' the Web-based GIS tool.

Mr Gao Peng, is a Masters Student of Dr Mu Xingming, in 1997 he completed his Bachelor Degree of Engineering from Northwest Agricultural University.

Dr Tim McVicar, a Senior Research Scientist, has extensive experience in developing spatial information to address natural resource management issues at the whole of catchment scale. He has developed methods to better use the high spatial and temporal variability inherent in time-series remote sensing for regional hydrology applied research. He will be involved in the spatial modelling in both Australia and China. Tim McVicar will coordinate the overall project, ensuring project reports and milestones are delivered on-time and on-budget.

Dr Lu Zhang, a Senior Research Scientist, has extensive experience in hydrology modelling, using both 'top-down' and 'bottom-up' approaches. Previously Lu Zhang has modelled the change to average annual runoff as a function of land-use change, reducing (clearing) and increasing (re-vegetation and plantations) the area of catchments planted with trees.

Mr Tom Van Niel, is a highly experienced environmental spatial modeller, with a Masters Degree in Watershed Science from Utah State University. He has skills in regional spatial information system development (both remote sensing and GIS) and is an experienced ArcView programmer, currently developing Visual Basic Applications experience. In the project he will assist developing the spatial models tools (especially the prototypes developed in ArcView) and will provide supporting GIS skills when needed.

Mr Harold Hotham, is an experienced software engineer, with extensive experience in Web-based development using JAVA and Delphi. In the project Harold will provide expertise and guidance to the specifically appointed Support Scientist to ensure delivery of the Web-based scenario modelling tool.

To Be Appointed (TBA) will be a person with skills in development of spatial databases, from both GIS and remote sensing sources. He or she will have programming skills with object-orientated languages such as JAVA, Delphi, and experience in database programming. The ability to communicate in Chinese, both verbally and in writing, would be a considerable advantage. The person will be funded 100% by ACIAR, working 70% on the Australian component and 30% on the Chinese, see the spilt of the salary between Part A1 and Part A2 of the attached budget.

Ms Tanya Jacobson, is a highly experienced and effective Personal Assistant, she is organised and often books accommodation, international travel (often requesting ancillary information before others think of the issue) and can assist, if required, in mail outs.