PART E - SERVICES REQUIREMENTS

E1. DESCRIPTION OF THE SERVICES

E1.1.0 Purpose

The SCA's Operating Licence refers to the *system design criteria* for Sydney's bulk water supply. The purpose of this project is to independently review Water Supply System Yield as per the requirement under the Part 6 of the SCA's renewed Operating Licence issued in February 2006.

E1.2.0 Background

The Sydney Catchment Authority (SCA) manages 16,000 square kilometers of catchments, a bulk water supply system comprising of eleven major dams and ten small dams with a total storage capacity of 2,600 GL, and associated infrastructure. The SCA is responsible for the provision of bulk water supply to Sydney Water Corporation for treatment and distribution of drinking water to more than four million people in Sydney, Blue Mountains and Illawarra. Water for supply is drawn from four main river systems: the Upper Nepean, the Warragamba, the Shoalhaven and the Woronora, with minor supplies drawn from tributaries of the Grose, Fish and Duckmaloi rivers.

Performance of water supply system is currently evaluated using a generalised simulation and optimisation model WATHNET. This link-node model was developed over a period of several years. Since its development in 1996, the SCA (and Sydney Water) has used the model extensively for system analyses. The use of 2,000 replicates of approximately 100 years of monthly inflow data is a state of the art approach adopted by the SCA.

A number of changes have taken place since the last major yield review was carried out in 2003. The changes include: deepwater access, desalination, groundwater, extension of hydrology, operating rule changes for Shoalhaven transfers, increased environmental flow releases from the dams and new demand restriction regimes.

Under the requirements set out in the Operating Licence (2006; Part 6), the SCA:

- must ensure that the Catchment Infrastructure Works is operated and managed consistent with the Design Criteria (Part 6.1.2).

- the SCA must provide IPART, within 12 months of the Commencement Date, with a report on (Part 6.2.1):

    (a) the current estimate of the Water Supply System Yield;

    (b) the assumptions and inputs, including the Design Criteria used in the model to calculate that Water Supply System Yield; and

    (c) the reasons underlying any material changes to the Design Criteria, the Water Supply System Yield or other assumptions and inputs.

(the SCA has already provided the information to IPART as per Part 6.2.1)

- must re-calculate the Water Supply System Yield on the occurrence of any one or more of the following events (Part 6.2.4):

    (a) the conclusion of any drought event;

(b) the commencement of any major modification or augmentation to the Catchment Infrastructure Works or the Water Supply System Infrastructure which will have a significant impact on the SCA's supply of water; and

(c) any material change to the operating rules of the Catchment Infrastructure

Works (including Design Criteria).

- must, at least once during the term of the Licence, obtain an independent expert to review its model and procedure for calculation of the Water Supply System Yield and to test (Part 6.3.1):

(a) the robustness of the model;

(b) the key assumptions used in the model; and

(c) the process for calculating the yield, including the appropriate frequency of yield calculation and the appropriateness of the trigger events in clause 6.2.4.

- the independent expert must advise the SCA on whether the Water Supply System Yield should be re-calculated, based on the findings of the test in clause 6.3.1.

- During the independent experts' review under clause 6.3.1, the SCA must consult with DNR [DWC], DEC [DECC], Sydney Water Corporation and any other persons reasonably expected to have an interest in the review of the model.

A review by a panel of independent external experts was completed in January 2007 to comply with clause 6.2.1 of SCA's Operating Licence. The primary purpose of the review was to independently assess the yield estimation methodology and the current estimates of the yield following update of the historic hydroclimate data to December 2004, revised restriction regime and updates to the model of the system network as at December 2006.

This review will include the yield assessment methodology, including inflow estimation and generation, system optimisation, drawdown rules and water supply system simulation model WATHNET. Yields reported for a number of different future scenarios as part of Metro Water Planning since January 2007 will also be independently reviewed. Future scenarios include desalination plant triggers, groundwater pumping triggers, Shoalhaven pumping triggers and transfer capacities and proposed environmental flow releases.

E1.3.0 Scope of Work

Scope of work is divided into three main parts, provisional items and project management. Part B & Part C are carried out to meet the Operating Licence requirements of testing the robustness of the model, testing the key assumptions in the model and testing the process for calculating yield, the frequency of the yield calculation and the appropriateness of the trigger events.

It includes the following but is not limited to:

PART A

Review of Water Supply System Model and the Reported Yields for Planning Scenarios since the Last Review in January 2007

1. Obtain all model input files and documentations from the SCA for the selected six yield scenario runs reported after January 2007;
2. Analyse, confirm the correctness of all configuration and input data including evaporation, environmental flows, riparian flows, demand nodal distribution, storages, restrictions, transfer rules and constraints, desalination and groundwater pumping triggers, etc.;
3. Run WATHNET model for the given six scenarios and review the reported yields;
4. Document the above scenario runs and prepare a draft report;
5. Review the draft report internally first and then by the SCA;
6. Incorporate the SCA's comments and finalise report;
7. Submit final report the SCA (Cabinet in Confidence); and
8. The SCA is to provide final report to interested parties.

PART B

Part B has two phases as outlined below. Prior to commencing Part B, the consultant shall organise a workshop involving client and the interested parties to brief the scope of the intended review and to obtain feedback.

Phase 1: Review of Historical and Generated Inflows

1. Review the historical **inflows** incorporating the latest knowledge and information;
2. Review the synthetic inflows incorporating the latest knowledge and developments. Analyse and document the appropriateness of using the synthetically generated **inflows** in the water supply system yield assessment;
3. Document the above and prepare draft report;
4. Review the draft report internally and then by the SCA;
5. Incorporate SCA's comments and prepare final draft for peer review;
6. Engage an independent expert panel for peer review;
7. Peer review by the independent expert panel;
8. Incorporate expert panel's comments appropriately and finalise reports; and
9. Submit final reports as Appendices A & B.

Phase 2: Water Supply System Model Update, Re-optimisation and Yield Assessment

1. Collect the latest information on the system and input data, review all input data, modelling assumptions, system configuration and methodology, and update the WATHNET model;
2. Re-assess yield with the updated model for a given scenario and summarise key system performances;
3. Analyse, document and provide all input files of the updated model and the documentation to the SCA for familiarisation and verification by the SCA;
4. Re-optimise the system to refine the drawdown rule for the updated system configuration;

5. Document optimisation process and the revised drawdown rules;
6. Re-assess yield with the updated model and refined drawdown rules for a given scenario and summarise key system performances;
7. Analyse, document and provide all input files of the updated model and the document to the SCA for familiarisation and verification by the SCA;
8. Re-assess yield for the five scenarios provided by the SCA, tabulate yield and key performances and document;
9. Review the draft reports internally and then by the SCA;
10. Incorporate SCA's comments and prepare the final draft for peer review;
11. Engage expert panel for peer review;
12. Peer review by the expert panel;
13. Incorporate the expert panel's comments appropriately and finalise report;
14. Submit final documentation to the SCA as Appendices C & D and separate documentation for the yield assessment of six planning scenarios (Cabinet in Confidence); and
15. The SCA is to provide final reports to interested parties.

PART C

Review SCA's Water Supply System's Yield Assessment Methodology in Light of Recent Developments and World's Best Practice

1. Analyse the suitability of current security criterion with the recent changes to the SCA's system and drought contingency planning, and recommend a better criterion, incorporating the best practice;
2. Review historical inflow estimation methodology;
3. Review synthetic inflow generation **methodology** and its sensitivity to yield estimate;
4. Review use of WATHNET for water supply system yield assessment and compare with other 'like' water industry practices;
5. Prepare main report incorporating all the above and summaries of reviews covered in Appendices A-D. The main report shall include: introduction, background, discussions, conclusions and recommendations;
6. Review the draft main report internally and then by the SCA;
7. Prepare draft executive summary;
8. Review the executive summary internally and then by the SCA;
9. Incorporate SCA's comments and prepare final draft of the main report and executive summary to SCA for consultation with interested government agencies and stakeholders;
10. Incorporate the SCA's and other interested government agencies comments appropriately and prepare final report;
11. Submit final Main Report to the SCA; and
12. The SCA is to provide final reports to interested parties.

PROJECT MANAGEMENT

1. Organise and coordinate project initiation meetings, workshops, peer reviews and monthly meetings, and prepare and deliver agenda, minutes, progress reports and presentations on time; and
2. Manage the overall delivery of the project.

PROVISIONAL ITEM

Conversion to the Latest Version of WATHNET Software, Verification & Documentation

(A separate quote is to be provided for this item. This item will be awarded only if sufficient funding is available. If awarded, this item shall be carried out in parallel to PART B-Phase 1)

1. Transfer the current model to the latest version of WATHNET, validate the model for a given scenario and summarise key system performances;
2. Provide all input files and software to the SCA with appropriate documentation for familiarisation and verification by the SCA;
3. Document each of the above and prepare a draft report;
4. Review the draft report internally and then by the SCA;
5. Incorporate SCA's comments and submit final draft for SCA's review;
6. Incorporate the SCA's comments and finalise report; and
7. Submit final report as Appendix E.

E1.4.0 Specifications

PART A

E1.4.1 Review of water supply system model and the reported yields for Planning Scenarios, since THE last review in January 2007

E1.4.1-1 Obtain all model input files and documentations from the SCA for the given six yield scenario runs reported after January 2007.

For the yield scenario runs given in **Table 1** obtain all input files and documentation from the SCA.

E1.4.1-2 Analyse, confirm the correctness of all configuration and input data including evaporation, environmental flows, riparian flows, demand nodal distribution, storages, restrictions, transfer rules and constrains, desalination and groundwater pumping triggers, etc.

Review in detailed all input data including: environmental flows, desalination, groundwater, and changes to HEPS, operating storages and Shoalhaven transfers. The SCA is required to release environmental flows and riparian flows as per the Water Management Licence (WML) issued by the regulators.

The WML also specifies run of river transfer limitations. For each of the scenario run review, confirm and document the representation of the Sydney's water supply system in WATHNET, including but not limited to:

- the operating storages of dams;
- starting storages for reservoirs;
- environmental flows used in the yield assessment based on the revised inflows;
- riparian releases, Shoalhaven transfers, HEPS releases etc.;
- evaporation equations for the modelled storages;
- desalination and Shoalhaven transfer triggers using the latest information;
- nodal distribution based on the official demand projections at the time of the analysis (Oct 2007) from SWC, Wingecarribee Shire Council, Shoalhaven City Council and Goulburn-Mulwarree Shire Council;
- Restriction regimes;
- groundwater pumping triggers and the discharge locations;
- Nepean-Avon Tunnel operation; and
- penalty and gain functions.

Detailed documentation should cover the methodology and assumptions used in the simulation process, for complete and thorough reviews and future use and improvements.

E1.4.1-3 Run WATHNET model for the given six scenarios and review the reported yields

Run the WATHNET model for 2,000 inflow replicates for the six scenarios and review the SCA's application of the model for calculation of the reported yields. For each scenario, the review shall include but not limited to the following:

- determine security and reliability yields for each scenario and extract and provide the information identified in **Proforma-1** for the adopted yield.

(Use version 3.03 of the WATHNET software)

E1.4.1-4 Document the above scenario runs and prepare a draft report

Document the above in detail with appropriate graphs, figures and tabulations. The report shall be divided into sections including: background and appropriate sections for the reviews, discussions, conclusions and recommendations.

E1.4.1-5 Get the draft report reviewed internally first and then by the SCA

The draft report should be fully reviewed by the consultant and a quality assurance page included before forwarding for SCA review. The quality assurance page should contain the reviewer's name, designation, signature and date. The SCA will provide consolidated comments.

Allow two weeks for SCA review and consolidated comments.

E1.4.1-6 Incorporate SCA's comments and finalise report

Incorporate SCA's comments and recommendations appropriately and prepare final report.

The final report shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding to the SCA. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.1-7 Submit final report

Submit the final report with title '*Review of Reported Yields for Planning Scenarios - Since the last Review in January 2007*'. The report should be marked as 'Cabinet in Confidence'.

E4.1-8 The SCA is to provide final report to interested parties

The SCA shall provide a copy of the final report to and consult with interested parties.

Any comments from the interested parties are to be addressed in PART B (Phase 2).

PART B

The SCA is required to consult with DWE, DECC, Sydney Water Corporation and any other persons reasonably expected to have an interest in the review of the model.

Prior to commencing Part B, the consultant shall organise a workshop involving client and the interested parties to brief the scope of the intended review and to obtain feedback. Workshop contents and outcomes shall be included in the main report as an annexure. Feedback obtained shall be considered in the review.

Part B has two phases.

E1.4.2 part B - Phase 1: Review of Historical and Generated Inflows

E1.4.2-1 Review the historical inflows incorporating the latest knowledge and information

Given the importance of the historical inflows in yield assessment a complete review of the inflows used in WATHNET is required. Currently, the yield model uses 99 years of historical inflows from Jan 1909 to Dec 2007. The historical data set is derived by a variety of methods including CMCR, HSPF, gauged flows and regression.

There are two estimates of inflows for each storage, namely pre-dam and post-dam. Pre-dam inflow is the natural catchment inflow at the dam location assuming there was no dam or the lake formed by the stored water. Post-dam inflow considers the effect of rain on and the evaporation from the lake, which is considered as 100% impermeable.

Historical inflow for a particular dam, used in synthetic replicate generation, has pre-dam and post-dam inflows. Inflow prior to the dam is based on no lake condition whereas inflow after the dam has additional inflow due to the effect of rainfall on the lake. This modifies the inflow time-series. The modification may be small (negligible) for a dam with large catchment, but significant for a dam with small catchment but with large lake (eg. Wingecarribee Dam).

The principal concern is that the reconstructed historic time series may not be homogeneous in their statistical characteristics.

There is a need to analyse and clarify the appropriateness of the current practice of using pre-dam inflow and post-dam inflow in an inflow time-series for synthetic inflow generation, yield assessment or environmental flow percentile calculations.

Documentation of the consistency of inflow data sequences

- It is known that record reconstruction using regression or rainfall-runoff models underestimates the variability of the true time series. Check and document if heteroscedasticity in variance is evident in composite series.
- Identify and report whether the inflows generated using HSPF underestimates annual variability of the true annual time-series. Given the significance of annual inflows during drought years, it is recommended that the accuracy of the annual HSPF reconstruction be studied and reported on.
- Determine whether there are any discrepancies between portions of the records derived from alternative data sources (eg. potential inconsistencies between inflows derived from gauged river level and rated flow data pre reservoir construction and those derived from the water balance calculations post dam).
- Document how any previous discrepancies have been addressed and that the revised data series do not show any inconsistencies (eg. using appropriate data series plots to give an indication of any inconsistencies in stream-flow variability over time, double mass plots to provide insight into stationarity of data sets and to identify any potential discrepancies in the data series).
- Review the outcomes of any recent work done by the SCA to demonstrate the consistency of the existing inflow series.

Inflow records derived from a reservoir water balance can be inaccurate for low flow sequences because the flow is a small residual derived from changes in storage volume, releases and lake evaporation. Any errors associated with change in storage volume are usually compensated and the residual error may be small. However, the use of pan evaporation to estimate evaporation from reservoirs, particularly deep ones, can be prone to considerable seasonal error. Further, releases from dams also have considerable measurement errors.

The following shall be considered:

Extension of Inflows to 1890

For the climate change study daily rainfall records for the SCA catchments going back to 1890 have been compiled for inflow generation using HSPF model. Appropriateness of extending the inflows back to 1890 should be investigated.

Inflows for Yield Assessment

The current (2008) inflows used in yield assessment are derived using CMCR, except for Woronora and Shoalhaven dams for which inflows from HSPF are used.

For yield assessment purposes, inflow time-series should be produced based on post-dam condition for the entire period (1909-2007 or 1890 -2007). This could be achieved by HSPF model simulation with dam (with current time-series of demand, evaporation and environmental flows).

Inflows for Environmental Flows

For environmental flow percentiles, inflow time-series should be produced based on pre-dam condition for the entire period (1909-2007). This could be achieved by HSPF model simulation without the Dam.

Environmental Flows

Inflow percentile estimates shall be estimated based on revised inflows. Further there can be significant difference between percentile flows calculated using monthly inflows and daily inflows. Analyse the historical inflows and re-estimate environmental flows. Submit the revised environmental flows to the SCA with appropriate documentation for approval from the regulators.

E1.4.2-2 Review the synthetic inflows incorporating the latest knowledge and developments. Analyse and document the appropriateness of using the synthetically generated inflows in the Water Supply System Yield assessment

The integrity of yield estimates is critically dependent on the adequacy of the hydroclimate synthetic flow generator.

The stochastic model currently employed by the SCA uses a two-step process:

1) annual flows are sampled from a multivariate lag-one autoregressive model; and

2) the annual flows are disaggregated using an elementary nonparametric method called 'method of fragments'.

There are three types of uncertainty associated with this process: intrinsic, parameter and model. Intrinsic uncertainty is the most dominant uncertainty affecting the generation of future hydroclimate time series. Presently the SCA only deals directly with intrinsic uncertainty. Parameter uncertainty becomes significant when estimating rare probabilities such as SCA's security criterion (Thyer et al., 2006). Model uncertainty refers uncertainty in the structure of the model itself. SCA's inflow generation uses lag-one autoregressive model. Although there are no strong evidence to reject the annual lag-one model, there are growing concerns that there are low frequency components in hydroclimate data that may not be captured by the lag-one model.

Therefore it is critical that the uncertainties are adequately captured by the stochastic model. Analyses shall include the following but not limited to:

- Intrinsic Uncertainty - Annual disturbance analysis

  If the multi-site lag-one model adequately simulates the historic data, the disturbances would be independently and normally distributed with constant variance.

- Intrinsic Uncertainty - Low flow Analysis

  Use parametric bootstrap to generate sampling distributions for non-overlapping flow statistics. Inspect and confirm that the historic low flows are contained within the 95% and 90% confidence limits for durations ranging from 1 to 10 years. Confirm whether the lag-one

model adequately reproduces low flows. Analyse and report any concern and its sensitivity in yield assessment.

- Intrinsic Uncertainty - Analyse Annual Statistics

  Compare the generated and historic flow statistics. It is recommended to use the parametric bootstrap to assess the significance of departures between historic and generated statistics. Identify, analyse and document any departures and their significance.

- Parameter Uncertainty

  Include parameter uncertainty in the lag-one model and analyse and report the significance in generated replicate statistics and the yield. Make recommendations as to whether the parameter uncertainty should be used in the SCA's yield reporting with sound reasoning.

- Analyse the low frequency variability in the Tallowa and Warragamba runoffs and test the assumption of Markov Order-1 dependence and the impact on the generated flows;
- Analyse and report the implication of the weak evidence of a significance lag-10 correlation in the historic data in the model used;
- Analyse and report the adequacy of the monthly disaggregation model;
- Carry out tests on generated data (eg. multivariate correlation test, partial autocorrelation functions, etc.) and report results;
- Analyse low flows (both historical and generated) and report findings; assess the 'critical periods';
- Analyse replicates with critical droughts and report;
- Discuss recent advances in synthetic data generation and their applicability; and
- Comment on the application of synthetic data for system reliability studies.
-

E1.4.2-3 Document the above and prepare draft reports

Document the above in detail, in two separate reports, with appropriate graphs, tabulations and maps. The reports shall be divided into sections including: background and appropriate sections for the reviews, discussions, conclusions and recommendations.

Prepare separate report for each of the above ('*Review of Historical Inflow*' and '*Review of Synthetic Inflow Generation*').

E1.4.2-4 Get the draft reports reviewed internally first and then by the SCA

The draft reports should be fully reviewed by the consultant and a quality assurance page included before forwarding to the SCA for review. The quality assurance page should contain the reviewer's name, designation, signature and date. The SCA will provide consolidated comments.

Allow two weeks for the SCA's review for each report.

E4.2-5 Incorporate SCA's comments and prepare final draft for peer review

Incorporate SCA's comments appropriately and prepare final drafts for review by the SCA and for peer review by an independent panel of industry experts referred below.

The final draft reports shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding to the SCA or for peer review. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.2-6 Engage expert panel for peer review

- prepare in consultation with the SCA a separate brief to be provided to the expert panel;
- propose independent experts to the SCA;
- engage expert panel;
- coordinate the peer review process;
- **the SCA will pay for the expert panel members including the travel costs separately and do not include in the fees; make separate allowance for this item**;

Allow for four experts from the industry, from within Australia and/or overseas. Also allow additional amounts for possible inter-state or overseas travel costs by independent experts. Allow for each of the experts, eight hours for review of reports, data and models, four hours for workshop presentations and discussions and four hours for consolidated comments.

The SCA will provide the venue for presentations and workshops.

E1.4.2-7 Peer review by an independent expert panel

The historical and generated inflows reviewed and analysed by the consultant shall be examined by the independent expert panel. A separate brief will be provided to the expert panel by the SCA.

Consultant to:

- actively participate in the peer review process by providing all related documentations, models, electronic files etc.; and
- allow time for workshops, sending reports to expert panel members etc.

In expert panel's (peer) review the following issues shall be considered but not limited to:

a) Methodology adopted by the SCA and the Consultants for historical inflow estimates and synthetic inflow generation

b) Inherent assumptions in the methodology

c) Strength and weaknesses of the method adopted by the SCA

d) Accuracy of environmental flow estimates

e) International best practice in inflow estimation

f) Variability of the results and calculation of errors associated with the inflow estimates

g) Recommendations for improvement.

E1.4.2-8 Incorporate expert panel's comments appropriately and prepare final reports

Incorporate expert panel's recommendations appropriately after confirmation with the SCA and finalise the reports.

The final reports shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding to the SCA. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.2-9 Submit final reports as Appendices A & B

Submit report on '*Review of Historical Inflows*' as Appendix A.

Submit report on '*Review of Synthetic Inflow Generation*' as Appendix B.

E1.4.3 part B – Phase 2: water supply system model update, RE-Optimisation and Yield Assessment

E1.4.3-1 Collect the latest information on the system and input data, review all input data, modelling assumptions, system configuration and methodology, and update the WATHNET model

The latest information on the SCA's Water supply System is to be collected and the model updated for Scenario 2010 (use version 3.10, if model is updated to this version as part Provisional Item). This task includes but not limited to:

- collect, review and use the latest information and confirmation on operating storages, particularly of Tallowa, Fitzroy Falls and Wingecarribee dams;
- include Prospect Reservoir with operating storage of 33,000 ML; correctly model the operating rule, inflow and evaporation for this reservoir;
- review and correct the representation of the Sydney's water supply system in WATHNET (eg. the effect of evaporation and other losses from the un-modelled deep storages);
- review and confirm evaporation equations for the modelled storages;
- analyse and determine the appropriate starting storages for reservoirs and use; document the rational for deciding the starting storages;
- obtain from the SCA, and use the revised environmental flows (eg. 80th percentile flows) based on the revised daily inflows;
- obtain and review release capacity constrains of dam outlets, particularly with the future increased environmental flow releases. Release capacity reduces as the reservoir depletes and this should be appropriately modelled and the effects reported;
- assess and quantity the losses from run-of-river and open canal transfers and if significant incorporate these losses in the model. The following transfer losses to be considered:
    a) Shoalhaven to Warragamba

b) Shoalhaven to Nepean

c) Upper Nepean dams to Pheasants Nest and and Broughtons Pass weirs

d) Upper Canal

- correctly model desalination and Shoalhaven transfer triggers using the latest information;
- obtain and correctly model the groundwater pumping triggers and the discharge locations using the latest information;
- obtain and use the latest official demand projection, restriction regimes and nodal distributions data from Sydney Water, Wingecarribee and Goulburn-Mulwarree Shire councils and Shoalhaven City Council and correctly distribute the nodal demands;
- correctly model the gravity and pumped transfers via Nepean-Avon Tunnel;
- check and verify that all environmental flow releases, Shoalhaven transfers, HEPS releases etc. are simulated correctly;
- review and use model penalty and gain functions for correct and optimal operation;
- update historical inflow up to December 2008;
- extend inflow back to 1901 or to 1890 from 1909, if good quality data is available for all dams; and
- use the updated historical inflow for generation of synthetic inflows.

Detailed documentation of each of the above is required covering the methodology and assumptions in the modelling process, for complete and thorough review by the expert panel.

E1.4.3-2 Re-assess yield with the updated model for a given scenario and summarise key system performances

Yield is to be re-assessed for the Scenario 2010 (Run S1), after detailed review and update of all input data and model configuration. The information identified in **Proforma-2** shall be extracted from model simulation and documented.

E1.4.3-3 Analyse, document and provide all input files of the updated model and the documentation to the SCA for familiarisation and verification by the SCA

- Compare the scenario outcomes with the previous simulations, assess the performance of the updated model, analyse and discuss;
- Document all changes to the water supply system model, simulation outcomes, analyses and discussions;
- Title of the documentation shall be: *Updated Model and System Performance for Scenario 2010*;
- Provide the documentation, input files for the updated model for the above scenario to the SCA;
- Allow two weeks for the SCA to familiarise with the model, run simulation and verify the model performance;
- Provide support to SCA staff if required to carry out simulations; and

- The SCA should be satisfied with model performance prior to moving to the next stage.

E1.4.3-4 Re-optimise the system to refine the drawdown rule for the updated system configuration

Re-optimisation and development of new drawdown rules are required due to the changes that have taken place since the last optimisation in 1996. The main changes to system since 1996 include deep storage access at Warragamba, Nepean and Prospect, environmental flows, introduction of desalination plants, reduction in operating window at Tallowa and the increase in Shoalhaven pump mark.

This will require use of the optimisation module in WATHNET and may require high powered computer.

The optimised drawdown rules should be verified by carefully analysing the simulations, particularly during critical droughts. It is important to confirm that the drawdown rules are set so that the system is operated to provide the same level of security of supply for all demand zones.

E1.4.3-5 Document optimisation process and the revised drawdown rules

Complete documentation of the revision of optimisation and the drawdown rules are required together with the documentation of impact of the revised drawdown rules on yield and system performance.

Documentation should cover the theory, methodology and assumptions used in the system optimisation process, for complete and thorough review by expert panel.

Title of the documentation shall be: *Re-Optimisation and Revised Drawdown Rules*.

E1.4.3-6 Re-assess yield with the updated model and refined drawdown rules for a given scenario and summarise key system performances

Re-assess yield for Scenario 2010 (Run S1), after the optimisation and review of drawdown rules. The information from model simulation identified and listed in **Proforma-2** shall be extracted and documented.

E1.4.3-7 Analyse, document and provide all input files of the updated model and the documentation to the SCA for familiarisation and verification by the SCA

- Compare the scenario outcomes with the previous simulations, assess the performance of the updated model, analyse and discuss;
- Document all changes to the water supply system model, simulation outcomes, analyses and discussions;
- Title of the documentation shall be: *Yield Assessments with the Updated Model and Revised Drawdown Rules*;
- Provide the documentation, input files for the updated model for the above scenario to the SCA;
- Allow two weeks for the SCA to familiarise with the model, run simulation and verify the model performance;
- Provide support to SCA staff if required to carry out simulations; and

- The SCA should be satisfied with model performance prior to moving to the next stage.

E1.4.3-8 Re-assess yield for the five scenarios provided by the SCA, tabulate yield and key performances and document

- Run the WATHNET model for 2,000 inflow replicates for five scenarios (Run S2 to Run S6) and review the reported yields;
- For each scenario determine security and reliability yields and extract and provide the information identified in **Proforma-1** for the adopted yield;
- Compare the scenario outcomes with the previous simulations, assess the performance of the updated model, analyse and discuss; and
- Document all, simulation outcomes, analyses and discussions and include in the document titled '*Yield Assessments for Planning Scenarios with the Updated Model and Revised Drawdown Rules*'. The report should be marked 'Cabinet in Confidence'.

E1.4.3-9 Get the draft reports reviewed internally first and then by the SCA

The draft reports shall be fully reviewed by the consultant and a quality assurance page included before forwarding to SCA review. The quality assurance page shall contain the reviewer's name, designation, signature and date. SCA will provide consolidated comments.

Allow two weeks for the SCA's review of each of the reports.

E1.4.3-10 Incorporate SCA's comments and prepare final draft reports for peer review

Incorporate SCA's comments appropriately and prepare final drafts for further review by the SCA and for peer review by an independent panel of industry experts referred below.

The final draft reports shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding for SCA review. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.3-11 Engage expert panel for peer review

- prepare in consultation with the SCA a separate brief to be provided to the expert panel;
- propose independent experts to the SCA;
- engage expert panel;
- coordinate the peer review process; and
- **the SCA will pay for the expert panel members including the travel costs separately and do not include in the fees; make separate allowance for this item.**

Allow for four experts from the industry, from within Australia and/or overseas. Also allow additional amounts for possible inter-state or overseas travel costs by independent experts. Allow for each of the experts, eight hours for review of reports, data and models, four hours for workshop presentations and discussions and four hours for consolidated comments.

The SCA will provide the venue for presentations and workshops.

E1.4.3-12 Peer review by an independent expert panel

The review will initially concentrate on the general overview of the WATHNET model and then investigate in detail the simulation and the optimisation modules. The review will concentrate on the application of the WATHNET model to the Sydney's water supply system.

Consultant to:

- actively participate in the peer review process by providing all related documentations, models, electronic files etc.; and
- allow time for workshops, sending reports to expert panel members etc.

The estimate of water supply system yield as determined by the consultant shall be examined by the expert panel. A separate brief shall be provided to the expert panel. In the review the following shall be considered but not limited to:

a) Robustness of the methodology adopted, particularly with the re-optimisation and the revised drawdown rules, in the yield estimate
b) Review of assumptions, strength and weaknesses of the method adopted
c) Performance/Design criteria and their limitations
d) Impacts of initial storage levels, environmental flows and desalination plants on the yield
e) Appropriateness of the monthly time step for yield estimation, particularly in relation to operation of environmental flows
f) Possible changes in system yield by alternative operational policies
g) International practice in yield estimation and alternative methods and packages that can be used
h) Variability of the results and calculation of errors associated with the yield estimate
i) Recommendations for improvements.

Recommendations shall be made about the appropriateness and the ability of the methodologies to accurately simulate the Sydney's water supply system.

E1.4.3-13 Incorporate the expert panel's comments appropriately and prepare final reports

Incorporate expert panel's reviews and recommendations appropriately after confirmation with the SCA.

Incorporate SCA's comments and finalise the reports.

The final reports shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding to the SCA. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.3-14 Submit final reports as Appendices C & D and separate documentation for the yield assessment of six planning scenarios

- Submit report on '*Updated Model and System Performance for Scenario 2010*' as Appendix C.

- Submit report on 'Re-*Optimisation and Revised Drawdown Rules*' as Appendix D.
- Submit report on '*Yield Assessments for Planning Scenarios with the Updated Model and Revised Drawdown Rules*'. The report should be marked as 'Cabinet in Confidence'

E1.4.3-15 The SCA is to provide final reports to interested parties

The SCA is to provide copies of the final reports to and consult with DWE, DECC, Sydney Water Corporation and/or any other persons reasonably expected to have an interest in the review of the model.

Any comments from the interested parties are to be considered in the main report.

PART C

E1.4.4 Review SCA's Yield Assessment Methodology in Light of Recent Developments and World's Best Practice

E1.4.4-1 Analyse the suitability of current security criterion with the recent changes to the Sydney's water supply system and drought contingency planning and recommend a better security criterion, incorporating the best practice

Current security criterion is defined as the SCA's operating storage is not to fall below 5% of full operating storage on average more often than 0.001% of the time, which is equal to, on average, one month in 100,000 months. This criterion is controlled by just 3 or 4 synthetic replicates out of 2,000 replicates. Further, 5% storage is very small and there will be not enough time to implement drought contingency measures once 5% storage is reached. In practice the SCA and its customers will be seriously thinking about implementing some form of drought contingency measures when storage is reaching 40%.

If drought contingency measures (eg. desalination) using risk management approach, can be introduced at a relatively affordable cost without affecting supply continuity, the yield from the current SCA's system may be increased without costly supply augmentations.

It is proposed to investigate and recommend, considering other best practices around the world, a possibly better security criterion for the Sydney's water supply system. The following are the SCA's operating storage responses for the current yield (based on synthetically generated inflows) limited by security criterion:

5% storage reached 0.001% of seasons

10% storage reached 0.004% of seasons

20% storage reached 0.017% of seasons

30% storage reached 0.11% of seasons

35% storage reached 0.25% of seasons

40% storage reached 0.48% of seasons

In recommending the security criterion consider the available and/or feasible drought contingency measures and their lead time, to ensure supply continuity.

Fully document the reasons and the logic behind the recommended criterion.

Analyse and report benefits, including yield increase or high confidence in yield estimates.

E1.4.4-2 Review historical inflow estimation methodology

Based on the outcome of the "*4.2-1: Review of Historical Inflows*", the expert panel's reviews and world's best practice, critically review SCA's historical and current inflow estimations methodologies and recommend the best approach. The considerations shall include but not limited to:

- Adequacy of hydrological modelling using HSPF; criteria for HSPF calibrations; use of other hydrological software and methods;
- Continued use of CMCR;
- Monitoring, model calibration and estimation of low flows;
- Rainfall, evaporation and flow monitoring requirements;
- Data requirements for climate change monitoring and predictions;
- Discussion with the relevant SCA staff to gather system and monitoring information, clarify limitations etc.;
- Discussions with the other major bulk water supply utilities; and
- Recommend the best approach for the SCA to adopt as part of continuous improvement and to be a leader.

E1.4.4-3 Review synthetic inflow generation methodology and its sensitivity to yield estimate

Based on the outcome of the "*4.2-2: Review of Synthetic Inflows*", the expert panel's reviews and world's best practice, critically review SCA's synthetic inflow generation methodologies and recommend the best approaches. The considerations shall include but not limited to:

- Stochastic generation model used and their uncertainties and adequacy for meeting SCA's requirements in a robust way;
- Comments on the applicability of the methodology of synthetic data generation for system reliability studies;
- A review of methods adopted in low flow analysis methods; and
- Recommend the best approach for the SCA to adopt as part of continuous improvement and to be a leader, taking into account current and emerging trends.

E1.4.4-4 Review use of WATHNET for water supply system yield assessment and compare with other 'like' water industry practices

SCA's yield assessment using synthetically generated inflow replicates and WATHNET software is considered to be a robust, state-of-art methodology.

Based on the outcomes of this study, the expert panel's reviews and world's best practices, critically review Sydney's water supply system yield model and methodologies, and recommend the best approaches or improvements. The considerations shall include but not limited to:

- strengths and weaknesses of WATHNET;
- approach used in simulation (Network Linear Programming, NetLP)
- review of the WATHNET package and its methodologies;
- review of the simulation module and methodology used;
- review of the optimisation module and methodology used;
- review of model formulation and penalty structure;
- review and comment on optimisation and revised drawdown rules;
- an assessment of impact of asset reliability on yield;
- comments on methods using only historic data for system reliability studies;
- an assessment of the 'critical period' in the analysis;
- accuracy of yield estimates;
- comparison with tools and methodologies used in other 'like' jurisdictions both in Australia and overseas;
- impacts of recent developments, changes to traditional methods, introduction of drought contingency measures (desalination) etc. in yield assessment methodologies; and
- recommend the best approach for the SCA to adopt as part of continuous improvement and to be a leader.

E1.4.4-5 Prepare main report incorporating all the above and summaries of reviews covered in Appendices A-D. The main report shall include: introduction, background, discussions, conclusions and recommendations.

The main report shall include: introduction, background, outcomes of the all the above reviews, study outcomes covered in the other documents (Appendices A-D) in summary level, discussions, conclusions and recommendations.

The report shall be titled: '***SCA Water Supply System Yield Review - 2009***'.

E1.4.4-6 Get the draft main report reviewed internally first and then by the SCA

The draft report shall be fully reviewed by the consultant internally and a quality assurance page included before forwarding for SCA review. The quality assurance page shall contain the reviewer's name, designation, signature and date.

Allow three weeks for the SCA's review of the report and provide consolidated comments.

E1.4.4-7 Prepare draft executive summary

Prepare a stand alone executive summary for the entire study.

E1.4.4-8 Get the draft executive summary reviewed internally first and then by the SCA

The draft executive summary shall be fully reviewed by the consultant internally and a quality assurance page included before forwarding for SCA

review. The quality assurance page shall contain the reviewer's name, designation, signature and date.

Allow two weeks for the SCA's review and provide consolidated comments.

E1.4.4-9 Incorporate SCA's comments and prepare final draft of the main report and executive summary to SCA for consultation with interested government agencies and stakeholders

Incorporate SCA's comments appropriately and prepare final drafts for

consultation with DWE, DECC, Sydney Water Corporation and any other persons reasonably expected to have an interest in the review of the model.

Allow three weeks for comments from interested government agencies and stakeholders and provide consolidated comments.

E1.4.4-10 Incorporate the SCA's and other interested government agencies' comments appropriately and prepare final report

Incorporate SCA's and other government agencies comments and finalise the report and the executive summary.

The final report and the executive summary shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding to the SCA. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.4-11 Submit final Main Report

Submit the final main report: '***SCA Water Supply System Yield Review - 2009***' (see Deliverables).

The final main report shall include Appendices A-D.

E1.4.4-12 The SCA is to provide final reports to interested parties

The SCA is to provide copies of the final reports to and consult with DWE, DECC, Sydney Water Corporation and/or any other persons reasonably expected to have an interest in the review of the model.

E1.4.5 Project Management

E1.4.5-1 Organise and coordinate project initiation meetings, workshops, peer reviews and monthly meetings, and prepare and deliver agenda, minutes, progress reports and presentations on time.

- Arrange monthly meetings regularly to report progress, resolve any outstanding issues hindering progress; prepare and send agenda and minutes of meetings on time; invite required attendees; and organise venue;
- Minutes of meetings finalised and sent within one week after the meeting;
- Deliver presentations if required as part of progress meetings;
- Allow for two hours meeting every month;
- Alternate monthly meetings to take place in the SCA head office (Penrith); the other meeting to take place at the consultant's office; or at a place agreed by both parties; and

- Provide monthly project update both in the form of management control plan (MCP) and financial summary.

E1.4.5-2 Manage the overall delivery of the project

- Communicate informally with the client representative and stakeholders to obtain information for the project;
- Manage the project to complete within the agreed time frame by efficient coordination with the client and the stakeholders;
- Ensure quality assurance of all work carried out and the documentations; and
- Provide monthly invoicing with supporting documentations (summaries of task completed, payment history etc.).

PROVISIONAL ITEM

E1.4.6 Conversion to Latest Version of WATHNET Software, Verification & Documentation

(A separate quote is to be provided for this item. This item will be awarded only if sufficient funding is available. If awarded, this item shall be carried out in parallel to PART B - Phase 1)

E1.4.6-1 Transfer the current model to the latest version of WATHNET, validate the model for a given scenario and summarise key system performances

The SCA water supply system is currently modelled using WATHNET version 3.03, which was released in 2005. Latest version (3.10) of the software with enhanced features (eg. script writing) is available. It is believed that the new version is more flexible in modelling complex scenarios. There is a need to convert the SCA's water supply system model to the latest and tested version of WATHNET. The scope of work includes the following but not limited to:

- Convert the existing water supply system model (Scenario 2010 or Run S1) to the latest version of WATHNET;
- Test and confirm its validity by reproducing the simulations for Scenario 2010 or Run S1. The SCA has yield calculation with documentations for this scenario, carried out in 2008 as input to Metro Water Planning and independently verified (in PART A) as part of this project. The information identified in Proforma-2 shall be extracted from model simulation and documented; and
- Compare the scenario outcomes with the previous simulations with the earlier version of WATHNET, assess the performance of the new software, discuss and document.

E1.4.6-2 Provide all input files and software to the SCA with appropriate documentation for familiarisation and verification by the SCA.

- Document all changes to the water supply system model, simulation outcomes, analyses and discussions;
- Provide the documentation, input files for the above Scenario 2010 (Run S1) to the SCA;
- Provide the latest version (3.10) of the software to the SCA;
- Allow two weeks for the SCA to familiarise with the model, run the scenario and verify the model performance;
- Provide support to SCA staff if required to carry out simulation; and
- The SCA should be satisfied with model performance prior to moving to the next stage.

E1.4.6-3 Document the above and prepare a draft report

Document the above in detail with appropriate graphs, tabulations and figures. Prepare report for the above ('*Conversion to WATHNET Version 3.10 and Verification – Scenario 2010'*).

The reports shall be divided into sections including: background and appropriate sections for the reviews, analyses, discussions, conclusions and recommendations.

E1.4.6-4 Review the draft report internally and then by the SCA

The draft report shall be fully reviewed by the consultant and a quality assurance page included before forwarding to SCA review. The quality assurance page shall contain the reviewer's name, designation, signature and date. SCA will provide consolidated comments.

Allow two weeks for the SCA's review of the report.

E1.4.6-5 Incorporate SCA's comments and prepare and submit final draft for SCA's review

Incorporate SCA's comments and recommendations appropriately and prepare final draft for further review by the SCA.

The final draft report shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding for SCA review. The quality assurance page shall contain the reviewer's name, designation, signature and date.

Allow two weeks for the SCA's review and provide consolidated comments.

E1.4.6-6 Incorporate SCA's comments and prepare final report

Incorporate SCA's comments and recommendations appropriately and prepare final report.

The final report shall be fully reviewed by the consultant internally and an updated quality assurance page included before forwarding to the SCA. The quality assurance page shall contain the reviewer's name, designation, signature and date.

E1.4.6-7 Submit final report as Appendix E

Submit report on '*Conversion to WATHNET Version 3.10 and Verification – Scenario 2010*' as Appendix E.

E1.5.0 Exclusions

There are certain areas, which do not have significant impact in yield assessment and/or still in research and development stages. The following topics are identified to be excluded from this study. Some of these topics are or will be carried out by the SCA as long term research projects.

- Synthetic Data Generation Model Uncertainty – Annual Time Series;
- Synthetic Data Generation Model Uncertainty - Disaggregation to Monthly Time Step;
- Is Lag 1 AR model sufficient? Should we move to Hidden Marcov Model; and
- Climate change impact.

E1.6.0 Deliverables

The Consultant shall provide:

- Three bound copies and an electronic copy for each draft report for SCA reviews;
- Three bound copies and an electronic copy for each final draft report for SCA and expert panel reviews; and
- Three bound copies and electronic copy of Final Reports.

E1.7.0 Outcomes

The outcome of the project will be as follows, but not limited to:

- A complete documentation of the inflow estimation and generation, WATHNET model and yield estimation as applied to the SCA's system;
- Peer review and high confidence in the yield estimate;
- Recommendations for future improvement;
- Comparison and summary of methodologies and tools used in other 'like' jurisdictions.
- Adoption of the latest version of WATHNET software; and
- Meet the Operating Licence requirement.

E1.8.0 Timing

Final report is required by December 2009. A Management Control Plan is to be provided with the tender proposal, assuming the project will be awarded in January 2009.

E1.9.0 Tenderer's Response

The Tenderer's response shall include the following:

(a) Tender price including schedule of rates;
(b) Past experience in the provision of similar services;
(c) Information supplied covering technical and commercial aspects of the contract including explanation of methodologies proposed to be utilized in this study and information on how the results will be presented to the SCA management and other organizations such as Sydney Water Corporation and IPART;

(d) Qualifications and experience of staff proposed for the project (please provide CV's and any appropriate details);
(e) Sub-contractors' qualifications and experience;
(f) Management Control Plan to meet the SCA time constraints (Project Programme) showing all key activities, milestones, client meetings and reports to be presented;
(g) Ability to complete the project within the time-frame; and
(h) Quality Assurance systems and Procedures.

The Tenderer's proposal should cover all costs including costs of accessing data and interactions with SCA personnel. It is anticipated that this Commission could be best executed by an organization(s) with a strong background in urban water resource management investigations, an appreciation of the Sydney's water supply system and a demonstrable understanding of issues related to water supply reliability and security.

E1.10.0 References

1. Water Resources Investigation Final Report - Water Supply Strategy Review Phase II, Sydney Water, SMEC Australia, December 1996
2. WATHNET Generalised Water Supply Headworks Simulation using Network Linear Programming, George Kuczera, Department of Civil, Surveying and Environmental Engineering, University of New Castle, 1997
3. IPART (2001) Sydney Catchment Authority Operational Audit 2000/2001
4. SCA's Submission in response to Water Demand and Supply Issues Paper - IPART's End-of-Term Review of the Operating Licences for SWC and SCA.
5. SCA Operating Licence 2006
6. Water Management Licence
7. Review of Sydney Water Supply System Yield Study 2006, by a panel of independent external experts consisting of Paul Pretto, Pavel Kozarovski, Ashish Sharma and George Kuczera
8. Verification of the Sydney Catchment Authority's WATHNET Model - Verification of WATHNET Model, June 2007, SMEC.
9. Verification of the Sydney Catchment Authority's WATHNET Model – Addendum CMCR and Demand Review, June 2007, SMEC.
10. Past Yield Review Reports (1991, 1996 and 2003)
11. CMCR Review Report
12. Report on Parameter Uncertainty 2008

Table 1: Yield Scenario Runs

Run	Scenario	Description
S1	Scenario 2010	**System Configuration as per January 2007;** • Extended hydrology to 2007; • Modified triggers for desalination (250 ML/d @ 70-80%, 500 ML/d @ 30-80%); • Environmental flows (Tallowa and Upper Nepean dams 80/20, Warragamba releases replaced with Western Sydney recycle); • Current Shoalhaven transfer constraints (200/400/600 ML/d); • Current Upper Canal capacity (400/600 ML/d); • Shoalhaven pump mark 75% - 80%; and • Tallowa minimum operating level -1.0m. (Also refer to Conditions for Base case 2010)
S2	Scenario 2015a	**Scenario 2010;** and • Warragamba environmental flows 95/20.
S3	Scenario 2015b	**Scenario 2015a;** and • Shoalhaven Pump mark 85% - 90%.
S4	Scenario 2015a and No Shoalhaven Transfer	**Scenario 2015a;** and • No Shoalhaven Transfer.
S5	Shoalhaven Transfer Scenario 1	• **Scenario 2015b**; • 700 ML/d pipeline to Avon (no Shoalhaven transfer to Nepean); • Wingecarribee run-of-river transfers capped at 200 ML/d; • Wingecarribee transparent release of all inflows; and • Burrawang pumping for Bowral and Goulburn.
S6	Shoalhaven Transfer	• **Shoalhaven Transfer Scenario 1**;

	Scenario 2	• 1800 ML/d pipeline to Avon (instead of 700 ML/d); and • Upper Canal capacity 1200 ML/d.

PROFORMA-1

RUN	Reliability Yield			Security Yield			Adopted Yield* (GL/a)
	Yield (GL/a)	Average Seasonal Restrictions (%)	Number of Times Total Storage was below 5%	Yield (GL/a)	Average Seasonal Restrictions (%)	Number of Times Total Storage was below 5%	
S1							
S2							
S3							
S4							
S5							
S6							

RUN	Avearge Annual Values (GL/a)						
	Adopted Yield*	Flow in Upper Canal	Shoalhaven Transfer to Avon (or Nepean)	Shoalhaven Transfer to Warragamba	Desalination Plant-1 Production	Desalination Plant-2 Production	Groundwater Pumping
S1							
S2							
S3							
S4							
S5							
S6							

RUN	Average Annual Values (GL/a)				
	Adopted Yield*	Total Inflow	Flow to Waste Node	Supply	Estimated Evaporation
S1					
S2					
S3					
S4					
S5					
S6					

For each scenario complete the following table for the adopted yield:

Scenario:					**Adopted Yield (GL/a)**				
	Annual Average Flows (GL/a)								Months Storage Below 5%
	Inflow	Environmental Flows			Spills	Riparian	Hydro Power	Supply	
		Transparent	Translusant	Contingency					
Warragamba Dam									
Woronora Dam									
Tallowa Dam									
Wingecarribee Dam									
Nepean Dam									
Avon Dam									
Cordeaux Dam									
Cataract Dam									
Pheasants Nest weir									
Broughtons Pass weir									

PROFORMA-2

RUN	Reliability Yield			Security Yield			Adopted Yield* (GL/a)
	Yield (GL/a)	Average Seasonal Restrictions (%)	Number of Times Total Storage was below 5%	Yield (GL/a)	Average Seasonal Restrictions (%)	Number of Times Total Storage was below 5%	
S1							

RUN	Avearge Annual Values (GL/a)						
	Adopted Yield*	Flow in Upper Canal	Shoalhaven Transfer to Nepean	Shoalhaven Transfer to Warragamba	Desalination Plant-1 Production	Desalination Plant-2 Production	Groundwater Pumping
S1							

RUN	Average Annual Values (GL/a)				
	Adopted Yield*	Total Inflow	Flow to Waste Node	Supply	Estimated Evaporation
S1					

Scenario:					**Adopted Yield (GL/a)**				
	Annual Average Flows (GL/a)								Months Storage Below 5%
	Inflow	Environmental Flows			Spills	Riparian	Hydro Power	Supply	
		Transparent	Translusant	Contingency					
Warragamba Dam									
Woronora Dam									
Tallowa Dam									
Wingecarribee Dam									
Nepean Dam									
Avon Dam									
Cordeaux Dam									
Cataract Dam									
Pheasants Nest weir									
Broughtons Pass weir									