Chapter 7
Audit Recommendations

7.1 Overview

The purpose of this concluding chapter is:

- to record the outcomes of recommendations from the 2007 audit
- record new recommendations arising out of the 2010 audit
- compile all the above recommendations into a single summary that can support the successful delivery of future catchment audits.

7.2 Review of the 2007 recommendations

The 2007 audit made a number of recommendations aimed at improving knowledge and the assessment of Catchment Health. The SCA provided a detailed response on how these recommendations have been addressed over the subsequent audit period. The SCA's response to these recommendations has been included in Table 7.2.1.

The Auditor notes the significant amount of work that the SCA has undertaken in addressing the recommendations in the intervening time period since the last audit. The SCA has indicated that many of the 2007 recommendations are now 'complete'. The Auditor's view is, however, that in relation to catchment management using an adaptive management approach, management actions are rarely ever complete. Continued monitoring and research inform and feed back into the adaptive management assessment and help focus the next round of management responses. Most problems in the catchment have been known for a considerable period of time and require a long-term approach to their solution (e.g. erosion control, riparian rehabilitation). New or changing pressures also necessitate a change in management response, particularly where recent monitoring suggests changes are occurring and that these changes are moving in an undesirable direction (e.g. declining trend in water quality).

Audits also need to take account of changing pressures and the state of the catchment and the level of knowledge that has been gained over the intervening audit period. This has led to new or more specific recommendations in Chapters 2 to 7 above. These recommendations are summarised in Section 7.3.

Table 7.2.1: SCA's response to the 2007 audit recommendations

Catchment audit recommendations	Status at 30 June 2010
2005/3 (carried over to 2007) – The SCA examine the potential for, and benefits of, integrating ecosystem water quality, macroinvertebrate, fish (when developed) and riparian vegetation condition monitoring programs. 2007/8 – The SCA should review its water quality and macroinvertebrate monitoring program to ensure that appropriate integrated ecosystem monitoring is undertaken in all sub-catchments.	In progress. In 2009 the SCA undertook a review of the SCA's water monitoring program as required under its Operating Licence. The review was finalised in December 2009 and the 2010–2015 Water Monitoring Program was implemented in January 2010. A number of changes were made at this time to the program and its monitoring and analytical contracts. The program is to be reviewed after one year from implementation. This review will include a thorough risk assessment of each site and will be informed by the Catchment to tap risk assessment and Catchment Decision Support outputs. Any monitoring undertaken by other agencies within the SCA area of operations will be documented to avoid duplication. The review of the macroinvertebrate monitoring program (MMP) undertaken by SKM in 2009 provided recommendations on improvements to the program and integrated monitoring options which may provide better insight into changes and trends in river health. Action is now underway to: ▪ commence the first annual review of the 2010–2015 Water Monitoring Program which will be complete in early 2011 ▪ revise the MMP in line with the SKM review recommendations. ▪ integrate the macroinvertebrate monitoring contracts and data storage into the broader water monitoring program. Further consideration will be given to the cost effectiveness and benefits of integrating the water quality and macroinvertebrate monitoring programs.
2005/5 (carried over to 2007) – The SCA focus its programs for nutrient reduction from diffuse sources on the Wingecarribee River (priority), Wollondilly River (priority), and Mulwaree River (priority) sub-catchments, and encourage other organisations undertaking related programs to focus on these same sub-catchments where possible.	Complete. The SCA is focusing on the Wingecarribee, Wollondilly and Mulwaree rivers as priorities for nutrient reduction. The SCA has developed the Healthy Catchments Strategy (HCS) which identifies the top 100 pollution sources in the Catchment, and uses a CDSS to prioritise responses and focus resources on catchment issues that pose the highest risk to water quality (with particular focus on nutrients and pathogens). The HCS, implemented through the Healthy Catchments Program (HCP) includes programs for nutrient reduction from diffuse sources and programs working in partnership with other organisations. The SCA's rural lands and sewage programs include actions to reduce nutrients from diffuse sources in the Wingecarribee, Wollondilly and Mulwaree sub-

Catchment audit recommendations	Status at 30 June 2010
	catchments. Under the rural lands program, the SCA is: ▪ working with dairy farmers and the dairy industry to target dairy waste in the Wingecarribee sub-catchment ▪ providing assistance to landholders in the Wollondilly and Wingecarribee sub-catchments as part of the SCA's Riparian Management Assistance Program (RMAP) ▪ promoting sustainable grazing in the Wingecarribee, Wollondilly and Mulwaree sub-catchments, in conjunction with the Department of Industry and Investment (formerly the Department of Primary Industries). Under the SCA's Sewage Program, the SCA is: ▪ working with Wollondilly and Wingecarribee councils to improve sewer performance in the Wollondilly and Wingecarribee sub-catchments ▪ providing grants and training to Wingecarribee Council to improve management of on-site wastewater management systems.
2005/6 (carried over to 2007) – The SCA identify the cause of exceedance of the Bulk Water Supply Agreement for turbidity, pH and algae at water filtration plants.	Complete. The SCA, NSW Health and Sydney Water investigated the cause of exceedances. The prevailing drought conditions were responsible for some exceedances and increased algal activity can result in high pH at Prospect. The SCA's Warragamba Blue–green Algal Action Plan includes a range of actions to prevent, minimise, manage and respond to algal activity. Raw water turbidity can increase due to heavy rainfall carrying sediments washed in from catchment land. Turbidity spikes may occur during rainfall although compliance monitoring by the SCA indicates that turbidity levels generally remain within the required site-specific standards. Guideline values in the BWSA are based on water filtration capacity. The quality of the water supplied did not compromise the ability of the water filtration plants to produce water to meet drinking water guidelines.
2005/16 (carried over to 2007) – The SCA and Department of Planning prepare a detailed land use map at five year intervals. The resolution and categorisation should be sufficient so that change from the previous map can be determined.	Complete. The SCA has undertaken a land use mapping project to map changes from 2004 to 2009. The latest aerial photography (2008–09) and satellite imagery were used as datasets. The outcomes from this project will be: ▪ a 2009 land use dataset ▪ a comprehensive dataset of land use history from 2000 to 2009 ▪ knowledge of emerging land use issues in the catchments. Land use mapping was completed in 2010.

Catchment audit recommendations	Status at 30 June 2010
2005/18 (carried over to 2007) –The SCA develop pollution prevention or rehabilitation programs at sites identified at very high, high and medium risk to water quality based on catchment audit, in consultation with relevant agencies, operators and landholders.	Complete. The SCA has developed the HCS, which utilises the CDSS to assess all known pollution sources and prioritise them for action, then develop a range of initiatives to address the top 100 priorities over the next three years. Catchment audit outcomes are considered in the priority setting for the HCS. The HCS was finalised in 2010. The Healthy Catchments Program (HCP) provides details of the initiatives and projects that were implemented in 2009/10. Relevant agencies, operators and landholders are consulted as part of the development of the HCS and HCP.
2005/19 (carried over to 2007) – The DNR [NOW] develop systems in consultation with the SCA for recording the location, nature and extent of actual cases of soil erosion and land salinity in the Catchment.	Complete. Southern Rivers CMA and Hawkesbury–Nepean CMA have partnered with DECCW to undertake a comprehensive assessment of salinity impacts and risks. This analysis is complete and provides detailed analysis of salinity risks and understanding of groundwater and surface water interactions in the Catchment.
2005/24 (carried over to 2007) – The NSW DPI [I&I NSW] in consultation with SCA, develop a fish community monitoring program for the Catchment to assist the management of aquatic ecosystem health.	Complete. The Department of Industry and Investment has several current projects collecting fish community data in the Catchment. The NSW Government's Monitoring Evaluation and Reporting (MER) has collected data on fish communities from 36 randomly selected sites in the Hawkesbury–Nepean Catchment in November 2007, followed by 14 sites in the Sydney–Wollongong Coast regions and 10 sites in the Shoalhaven Catchment in November 2008. The design of the freshwater fish MER can report at the zone (coastal fringe, lowlands, slopes, uplands and highlands), catchment and CMA scales. Sites are selected randomly from a modelled stream network representing available freshwater fish habitat in NSW. Sampling in each CMA area is repeated every three years. Field teams sample each site between 1 October and 30 April and apply standardised sampling protocols to collect fish community data. In conjunction with this, the SCA provided funding for the Pheasants Nest Fishway assessment project, the Tallowa Dam High Fishway assessment project and the Nepean River fish passage improvement assessment project to address the issue of fish passage in SCA catchment areas and to monitor the response of fish populations to fish passage facilities at a number of SCA-managed weirs and dams.

Catchment audit recommendations	Status at 30 June 2010
2005/25 (carried over to 2007) – The DNR, DEC (DECCW) and SCA jointly undertake vegetation condition mapping of areas outside the Special Areas.	Complete. The SCA developed a Vegetation Condition Index (VCI) to map the condition of vegetation in the catchments. The VCI uses satellite imagery to calculate relative healthiness of vegetation, taking into account changes over time to determine an average condition that can be mapped. A negative deviation from the average condition suggests some sort of disturbance to the vegetation. The SCA's VCI has a water quality and quantity focus.
2007/1 – The operators and regulator(s) of the sewage treatment systems in the Catchment should continue efforts to reduce current levels of nutrient loads discharged into the Catchment.	Complete. DECCW continues to actively regulate licensed sewage treatment systems in the catchment. The SCA has established a targeted inspection program for Sewage Treatment Plant (STP) effluent disposal and package STPs. The SCA is working with councils to upgrade of STPs and effluent reticulation systems through the Accelerated Sewerage Program. Improvements in the levels of nitrogen and phosphorus are tracked and identified as plants are completed and commissioning is completed. Construction, investigation and design works on STPs in the catchments included Braidwood, Bundanoon, Taralga, Lithgow, Wallerawang, Kangaroo Valley, Robertson and the upper Blue Mountains.
2007/2 – The SCA should continue the process of understanding the causes of the high incidences of algal blooms in the water storages of the Kangaroo River (priority), Wingecarribee River (priority) and Lake Burragorang sub-catchments, to help ensure that specific management strategies are in place for the short, medium and long term in each sub-catchment.	Complete. The SCA has had an ongoing commitment to understanding the causes of algae in reservoirs. Following the algal bloom in Lake Burragorang in August 2007, the SCA developed the Warragamba Dam Blue–green Algal Action Plan. The plan includes actions to prevent or minimise algal blooms across the catchments, including: ▪ investigations into the causes of the 2007 blue–green algal bloom in Lake Burragorang, which identified the main factors as moderate inflow having optimal timing (winter cooling cycle) and a low initial storage volume relative to inflow volume. Comprehensive technical reports were prepared and externally reviewed ▪ investigations into alternative control options, including solar powered water mixing devices ▪ hazard assessment and prioritisation of catchment actions under the Healthy Catchment Strategy involving pollution source hazard ranking (catchment decision support system) ▪ a comprehensive research program has been established to investigate the environmental factors leading to blooms and the release of toxins and the factors that mediate the breakdown of toxins, and taste and odour-

Catchment audit recommendations	Status at 30 June 2010
	producing compounds in the SCA reservoirs ▪ extension of the SCA's reservoir management system into storages in the Shoalhaven system. The reservoir model incorporates water quality modelling capability. Whilst the algae plan was focused on Lake Burragorang, the SCA is developing a broader Cyanobacteria Strategy building upon the work undertaken under the Warragamba Dam Blue–Green Algae Action Plan, and relevant to all reservoirs including Wingecarribee Reservoir and Lake Yarrunga.
2007/3 – The SCA should investigate the causes of the continuing presences of pathogens in the Nattai River (Gibbergunyah Creek), and the Wollondilly River, Mid Coxs River and Werriberri Creek (priority) sub-catchments.	Complete. In 2008–09 a 10-year review of all available data from Cryptosporidium and Giardia monitoring sites was undertaken. Monitoring sites in the Nattai River, Wollondilly River, Mid Coxs River and Werriberri Creek sub-catchments were included. The review found that all catchment sites, other than Gibbergunyah Creek, indicated negligible to low levels of Cryptosporidium. Braemar STP discharges treated effluent upstream of the Gibbergunyah Creek monitoring site. The STP includes ultraviolet disinfection as part of the treatment process, which renders Cryptosporidium oocysts non-infective. Protozoa continue to be detected immediately downstream of the plant however these are unlikely to be viable live oocysts. Current laboratory tests for identifying Cryptosporidium are unable to distinguish between living and non-living oocysts. Targeted investigations into the causes of periodically elevated pathogen levels in Gibbergunyah Creek to confirm the source and validate the UV disinfection efficacy of the STP have occurred. These found that the continuing presence of Cryptosporidium is a direct result of the STP discharge and that as long as the plant is functioning effectively, Cryptosporidium is being treated effectively. The SCA has undertaken hazard assessments of all potential pathogen sources across its catchments (CDSS) as part of the HCS, and provided a grant to UNSW researchers to undertake a relative STP pathogen risk assessment. The SCA will now be undertaking a monitoring needs study of pathogen loads downstream of selected STPs.
2007/4 – The SCA should undertake sampling for the presence of pathogens in the Kangaroo River (priority) sub-catchment.	Complete. The SCA, NSW Health and Sydney Water revised the joint Cryptosporidium and Giardia monitoring program which focuses on monitoring raw water at supply points and treated water. There is no routine monitoring for Cryptosporidium and Giardia in the Kangaroo River sub-catchment. The program

Catchment audit recommendations	Status at 30 June 2010
	includes a wet weather auto sampler for Cryptosporidium and Giardia within the Kangaroo River sub-catchment. Bacterial pathogens are routinely monitored at various sampling sites in Lake Yarrunga under the SCA's Water Monitoring Program.
2007/6 – The SCA, DECC [DECCW] and CMAs should undertake programs that address soil erosion and salinity in the areas with identified and observed risk, and integrate them with other programs for riparian and vegetation management where possible.	Complete. The SCA is working with the Department of Industry and Investment to deliver education and training to graziers on best management practices through the Sustainable Grazing Program (SGP). The SGP addresses grazing management practices, including a number that reduce soil erosion and salinity. Over 1400 graziers will have now participated in the SGP. An ongoing evaluation of outcomes from the program is being conducted. The evaluation focuses on learning outcomes, intention to adopt new practices and practices that have been adopted for participants in the PROGRAZE and LANDSCAN courses. Evaluation progress reports have been completed. The SCA has commenced a pilot grants program in partnership with the Hawkesbury–Nepean and Southern Rivers CMAs to implement learnings from the SGP. The SCA also provides financial support to graziers through the Department of Industry and Investment to provide tools to assess improvements in pasture cover. The SCA is working with the CMAs to deliver the Catchment Protection Scheme (CPS). The CPS is designed specifically to address soil erosion. The SCA jointly funds the program, along with the catchment management authorities, Department of Lands and landholders As part of the CPS, Hawkesbury–Nepean Catchment Management Authority addressed severe gully, stream bank and stream bed erosion in priority areas across the Warragamba catchment. These projects also integrated riparian and vegetation management programs and outcomes. Outputs and outcomes of current and past projects can be found in SCA's Annual Catchment Management Reports. Through the CPS, the Southern Rivers Catchment Management Authority worked closely with the SCA on implementing river restoration projects in the Kangaroo Valley. They also partnered with the DECCW to undertake a comprehensive assessment of salinity impacts and risks. The Southern Rivers Catchment Management Authority wetland and native vegetation projects are complementary to SCA objectives, delivering on both water quality and biodiversity outcomes.
2007/7 – The SCA should investigate the reasons and drivers for declines in	Complete. An independent review of the macroinvertebrate

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both water quality and macroinvertebrate health in those sub-catchments where declines have been documented.	monitoring program (MMP) has been undertaken and has found that the ecological condition of the majority of the 27 sub-catchments is highly variable in both temporal and spatial scales. However, long-term averages for core sites indicate that all of SCA's sub-catchments are generally in good ecological condition with the poorest sub-catchments only scoring marginally below the reference condition threshold. Trend analyses of the ecological condition at each site indicate that very few sites show a consistent decline in macroinvertebrate health. Due to lack of water quality data at those sites that do have a consistent decline in macroinvertebrate health (Reedy Creek, Coxs River at Lidsdale, Nattai River at the causeway and Wollondilly River at Goonagulla) it is difficult to ascertain the drivers behind the decline. The MMP review has provided some recommendations regarding the implementation of an integrated monitoring approach which may provide a better insight into the drivers. The following are potential pollutant sources upstream of these locations: ▪ Reedy Creek – Gully and streambank erosion, (total suspended solids (TSS)) ▪ Nattai River above the Causeway – STP (Pathogens), intensive animals (total phosphorous(TP)), On-sites (TP) ▪ Upper Wollondilly River above Goonagulla – Horticulture (TP, total nitrogen (TN), and TSS) ▪ Coxs River above Lidsdale – Only rated as moderate risk areas for (TP, TN, TSS). Actions under the HCS to address potential causes of the decline in water quality and macroinvertebrate health in the identified sub-catchments are being undertaken. These include: ▪ riparian works at Reedy Creek as part of the CPS ▪ a planned upgrade to the sewage treatment plant at Wallerawang in the Upper Cox's ▪ training and inspections to improve nutrient and effluent management on dairy farms ▪ continued assistance to Wingecarribee Shire Council to inspect on-site wastewater management systems in the Nattai catchment ▪ working collaboratively with DECCW to assess the source and fate of metals and salinity in the Upper Coxs River ▪ assessment of the pathogen risk from Braemar STP is underway.

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2007/9 – The SCA should undertake follow-up monitoring at macroinvertebrate monitoring locations that have significantly impaired or severely impaired AusRivAS ratings.	In progress. The MMP samples all core sites, including those which have recorded lower AusRiVAS ratings. The MMP review found some bias in the selection of roaming sites and this may have skewed the results for some sub-catchments. The review recommended replacing roaming sites with more randomly selected core sites. Monitoring of existing core sites will continue. The SCA is currently considering the recommendations from the review, and has suspended the monitoring of roaming sites in the interim.
2007/12 – The SCA, DECC [DECCW] and CMAs should work together to establish a spatial information system to track and record information on all on-ground works being undertaken or funded by Government for the purposes of water quality and ecosystem health management in the Catchment.	Complete. The SCA and Hawkesbury–Nepean and Southern Rivers CMAs have been working to share data stored on the DECCW Land Management Database. The database tool was developed with combined input from the CMAs, DECCW and in consultation with the SCA. It has been adopted state wide by all CMAs, DECCW and the Department of Industry and Investment. All paper records on the CPS works carried out in the Hawkesbury–Nepean Catchment Management Authority area of operations since around 1960 have been stored in the Land Management Database and shared with the SCA. The SCA has provided $60K to the Southern Rivers Catchment Management Authority to complete the same work for their area of operations. In November 2008 the NSW Government launched the Spatial Centre of Excellence, which via programs such as Common Spatial Information Initiative, C2Si, includes a focus on how spatial frameworks can be developed or extended to promote shared services.

7.3 Recommendations from the 2010 audit

The following 28 recommendations have arisen in the preceding chapters and sections of this report, and from the overall conduct of the 2010 audit. Where relevant, particular sub-catchments to which the recommendations apply are identified. The Auditor commends these recommendations to the Minister, for subsequent referral to the relevant parties for their consideration and appropriate action.

Audit Methodology

Recommendation 1: The SCA investigate ways to achieve effective Aboriginal community engagement in the audit prior to the commencement of the next Sydney Drinking Water Catchment audit.

Land Use and Human Settlements

Recommendation 2: The Department of Planning should undertake detailed consideration of the potential ***cumulative*** impacts of all mining activities within the SCA Special Areas.

Recommendation 3: Where significant streams and wetlands in the Catchment are impacted by longwall mining there should be a requirement that these impacts are remediated at the expense of the mining company.

Recommendation 4: DECCW review licence limits in the Upper Coxs River sub-catchment for all licensed discharge points with a view to reducing the heavy metal and salinity concentrations and loads being discharged to the Coxs River catchment.

Recommendation 5: The SCA, HNCMA and SRCMA develop a consistent baseline map of gully erosion for the Catchment.

Biodiversity and Habitats

Recommendation 6: The SCA continue to undertake follow-up monitoring at macroinvertebrate monitoring locations that have scored an AusRivAs rating of *significantly impaired, severely impaired* or *extremely impaired* where there is no obvious driver for an impacted rating.

Recommendation 7: DECCW, in collaboration with SCA, develop a consistent, uniform and integrated vegetation dataset that covers the entire Sydney Drinking Water Catchment.

Recommendation 8: The Rural Fire Service, in cooperation with SCA and DECCW, integrate their spatial datasets across all sub-catchments so that a single, consistent estimate for the area burnt by hazard reduction burns and bushfires can be reported.

Recommendation 9: Lithgow City Council and Centennial Coal should ensure that water transfers from the Clarence Water Transfer Scheme are piped around, rather than flow through, Farmers Creek Swamp.

Recommendation 10: DECCW finalise its *Draft Upland Swamp Environmental Assessment Guidelines* in order to achieve consistency in the application of risk assessment methodology for swamps over areas of longwall mining in the Catchment.

Recommendation 11: DECCW and the SCA should finalise their classifications of wetlands to produce a complete and consistent coverage of wetlands in the Catchment.

Water Availability

Recommendation 12: NOW should investigate the reasons behind the recent decline in flow in Werriberri Creek.

Recommendation 13: The SCA reinstate the flow gauging station in the Little River at Fire Road W4I.

Recommendation 14: DECCW, SCA, I&I and NOW investigate the possibility of establishing a collaborative research program aimed at providing a better understanding of the surface water and groundwater hydrology of Thirlmere Lakes and its catchment.

Recommendation 15: NOW should investigate the reasons behind the apparent long-term decline in flow in Reedy Creek.

Recommendation 16: NOW should finalise the *Draft Water Sharing Plan for the Greater Metropolitan Region* as soon as practicable.

Recommendation 17: NOW and SCA undertake research aimed at understanding the extent, connectivity and interaction between sub-surface aquifers (confined and unconfined), perched aquifers and surface waters within the Catchment.

Water Quality

Recommendation 18: The SCA undertake a targeted survey of pesticide usage and application in the catchments of Cascade Dam and Wingecarribee Reservoir.

Recommendation 19: The SCA continue to investigate the cause of persistent detections of *Cryptosporidium* and *Giardia* oocysts/cysts in the Catchment.

Recommendation 20: The operators and regulators of sewage treatment systems in the Catchment should continue efforts to reduce nutrient loads.

Recommendation 21: Estimates of nutrient loads from diffuse sources should be included in future audits in order to understand the full context of nutrient loading in the Catchment.

Recommendation 22: The SCA should continue to investigate the risk of mixing of cyanobacteria between water bodies in the Shoalhaven system during periods of low flow.

Recommendation 23: The SCA should investigate trends and long-term patterns in the community composition of cyanobacteria and phytoplankton in the dams and reservoirs.

Recommendation 24: The SCA should look very closely at including monitoring sites in sub-catchments that currently have no long-term water quality or flow gauging sites.

Recommendation 25: The SCA collate all recent work undertaken on water quality trend assessments and provide a unifying summary of trends in water quality across the Catchment.

Integration of Water Quality and Ecosystem Health Indicator Monitoring

Recommendation 26: The SCA in cooperation with other state and local government agencies explore ways to integrate individual monitoring programs into a broader ecosystem health monitoring program for the entire Catchment.

Recommendation 27: The SCA in cooperation with other state and local government agencies investigate ways of integrating their respective ecosystem health databases so that a common comprehensive database on ecosystem health indicators is developed for the Catchment.

Recommendation 28: The SCA ensure these combined databases are readily available to be used in future catchment audits and/or other programs relying on assessments of catchment health.