5 Identification and Evaluation of Options

5.1 Water supply options

Consideration of options for additional water supply sources has been part of HWC's ongoing water resource planning process. In August 2007, HWC released the report *Why Tillegra Now?* that provides a detailed comparison of both supply augmentation options and climate independent options. The report also provides justification for the preferred Tillegra Dam option.

5.1.1 Options considered

Supply augmentation options (refer Figure 5.1) considered in the report comprise Williams River schemes including Tillegra Dam and a new Chichester Dam, further upgrade of Grahamstown Dam, the Karuah Scheme (Mammy Johnsons Dam) and the Paterson River Scheme (Lostock Dam). Climate–independent options considered identifies desalination and indirect potable reuse (the recycling of highly treated effluent to the bulk raw water sources for later treatment and distribution for general consumption purposes). New groundwater supplies were not considered as the current systems are already operating at their reliable limits and the only potential new source at North Stockton, while valuable as a drought reserve, is too small in volume to be used as an ongoing supply.

Selection criteria applied to each option included additional yield, environmental and social impacts (in a qualitative sense), and source diversity. A variety of technical issues considered included an assessment of both the capital and operating costs that would be incurred for the additional yield achieved.

A comparison summary of the considered options is provided in Table 5.1.

5.1.2 Preferred option

The proposed Tillegra Dam with a storage capacity of 450 GL is HWC's preferred augmentation option. The dam would increase the reliable yield of the system to around 120 GL per year, meeting projected demand in the lower Hunter region for approximately the next 60 years. The scheme offers many benefits, including improved source diversity (ie a new dam in an alternative catchment), increased drought security and the ability to connect to existing distribution infrastructure via the CTGM. The capital cost of the scheme is approximately $300 million with an ongoing annual operational cost of $600,000.

The dam would inundate around 2,100 ha of predominantly cleared farming land. As of September 2007, HWC had acquired approximately 70 per cent of land within the inundation area.

The proposed Tillegra site is located in the valley immediately to the southwest of Chichester, some five kilometres upstream of the Williams River confluence with the Chichester River. First identified as a potential dam site in the 1950s, Tillegra has previously been the preferred augmentation option with extensive exploratory drilling, geotechnical surveys and soil testing carried out in the 1950s. This testing indicated the technical viability of such a proposal. Additional geotechnical investigations are being undertaken to provide further information to feed into the design process.

Table 5.1 Summary of water supply options

Option	Capital Cost	Annual Operating Cost	Additional Yield (GL)	Comment
Tillegra Dam	$300 million	$600,000	52.5	▪ Provides recreational opportunities ▪ No impact on other operational assets during construction ▪ Inundation of approximately 2,100 ha of farmland ▪ Provides source diversity over existing water supply system
New Chichester Dam	$330 million	$600,000	48.5	▪ Provides recreational opportunities ▪ Known geological issues ▪ Significant operational impacts (not yet costed as existing dam has to be emptied during construction period) ▪ Inundation of 1,600 ha of farmland ▪ Inundation of 270 ha of Barrington Tops Wilderness Area, 80 ha of World Heritage area
Grahamstown Dam Upgrade – Ultimate	$410 million	$400,000	30.0	▪ Does not provide additional recreational opportunities ▪ Located immediately upstream of major population centre ▪ Offers no source diversity ▪ More susceptible to evaporation and water quality issues – higher surface area
Paterson River Scheme – Lostock Dam	$260 million	$750,000	9.5	▪ Provides recreational opportunities (but limited due to size) ▪ Inundation of additional 400 ha of farmland ▪ Offers source diversity over existing system ▪ Interbasin water transfers with environmental risks ▪ Energy intensive as requires all water to be pumped
Karuah River Scheme – Mammy Johnsons Dam	$340 million	$800,000	27.5	▪ Provides recreational opportunities ▪ Inundation of 1,700 ha of farmland/forest ▪ Energy intensive as requires all water to be pumped ▪ Provides source diversity over existing system ▪ Interbasin water transfers with environmental risks
Desalination	$500 million	$25 million	32.5	▪ Provides a climate independent source and improves system diversity ▪ Energy intensive (although costs based on use of renewable energy) ▪ Environmental risks ▪ No new recreational opportunities

Option	Capital Cost	Annual Operating Cost	Additional Yield (GL)	Comment
Indirect potable reuse	$400 million	$22 million	32.5	▪ Provides a climate independent source and improves system diversity ▪ Energy intensive (although costs based on use of renewable energy) ▪ Environmental risks ▪ No new recreational opportunities ▪ Community acceptance of drinking recycled water

The proposal would complement HWC's existing water supply network. Tillegra Dam would have the dual purpose of river flow regulation to improve the reliability of supply to Grahamstown Dam as well as the potential to provide water directly via the CTGM. Flows would be released from Tillegra Dam into the Williams River, collected at Seaham Weir and transferred to Grahamstown Dam. Tillegra Dam would also be linked to the CTGM securing flows down the pipeline to the major growth areas west of Tarro.

Historical data indicates the streamflow at the Tillegra site is favourable, benefiting from a relatively large catchment receiving reliable rainfall. On average, the site records a streamflow of 90-100 GL per year. Tillegra Dam would increase current system yield by about 50 GL per year to around 120 GL a year, meeting projected demand for approximately 60 years. Importantly, a larger storage would significantly improve the drought security of the lower Hunter system (HWC 2007b).

Tillegra Dam would increase the diversity of HWC's supply system as it would offer a new storage in an alternative catchment. This would provide good protection against future uncertainties such as the impacts of climate change and water quality events in surface water storages. With respect to climate change uncertainties, modelling undertaken by HWC indicates that with 10 per cent less rain falling in the catchment, system yield would fall to 100 GL per year.

The preferred option would result in both tributaries of the upper reaches of the Williams River being dammed, impacting on the natural flow regime of the river. There would be direct environmental and social implications of flooding approximately 2,100 ha of already cleared and farmed land.

The feasibility of transferring water to Tillegra Dam which would otherwise spill from Chichester Dam has been considered as part of the Project. The two general options examined for transfer of water were:

- Gravity transfer via a tunnel approximately three kilometres long and 1.8 m diameter between the two storages.
- A pump station to transfer flows between storages via the pipeline connecting Tillegra Dam to the CTGM, ie the pipeline would be used to move water in both directions.

The analysis concluded that in the short to medium term, such a transfer facility would not provide a significant advantage in terms of security of supply. As a consequence, intercatchment transfers do not form part of the Project but may be revisited at a later date with any necessary investigations and assessments to be undertaken at that time.

5.2 Dam options

Four types of dam are under consideration for development to concept design process, namely:

- Concrete faced rockfill dam (CFRD).
- Earth core rockfill dam (ECRD).
- Zoned earthfill dam.
- Roller compacted concrete dam (RCCD).

The CFRD and RCCD options are considered the most likely constructions and would receive the more detailed assessment. The ECRD option is generally more expensive than the CFRD option and more likely to be used in situations where the topography does not suit the CFRD option. The zoned earthfill dam option is included to complete the assessment but is not expected to be competitive with respect to the planned height and foundation. A cost estimate, making reasonably optimistic assumptions on material availability would be completed for the ECRD option and the zoned earthfill dam option as a check. These designs would not be further developed unless initial estimates showed promise.

Development of the options would take into account the following operational requirements:

- Scenarios for transfer of flows to Grahamstown Dam.
- Transfer of water via the CTGM to the Dungog water treatment works.
- Environmental releases.
- Emergency dewatering.

5.3 Relocation of affected roads

The proposed dam would cut a section of around 15 kilometres of Salisbury Road between Tillegra and Underbank (HWC 2007a). It would also impact on a number of smaller roads that currently provide access to properties above the dam and in the Underbank and Quart Pot Creek areas. Alternative routes would need to be provided prior to commencement of construction of the dam wall. Subject to obtaining the necessary approvals, construction of the new roads is expected to take around 12 months depending on the route chosen and any bridgework needed. The various options considered are shown in Figure 5.2.

5.3.1 Options considered for relocation of Salisbury Road

Six potential road relocation options were developed and advertised for public comment. These represent three variations of a ‘high’ road option and three variations of a ‘low’ road option. In developing the options, HWC consulted local landholders, Dungog Shire Council, relevant government agencies and the CRG to identify constraints and opportunities within the area.

A road link from Chichester Dam Road at Dusodie to the high road option was investigated. A review of current road design requirements and standards indicates that the grades required to climb Sheltons Road would be too steep for heavy vehicles. In view of this issue, this route was discounted from the options.

Key features

- All options have a common connection point at the eastern end of Salisbury Road. It should be noted that options for the road to the ridgeline are indicative only at this stage and are currently being discussed with landowners.
- All options would involve a new intersection with Upper Chichester Road in the vicinity of the northwestern part of the storage area.
- The new section of road would be designed to Dungog Shire Council’s design parameters for a rural ‘collector/distributor’ with a desirable design speed of 80 km/hr. The design would also appropriately address relevant matters in AustRoads *Rural Road Design: Guide to the Geometric Design of Rural Roads* 8th ed, 2003).
- For all options the incline and decline have been generally limited to eight per cent (ie 8 metres in every 100 metres) to allow heavy vehicles reasonable speed along the route.

- Following construction, it is proposed that the Department of Lands would own the road reserve. Dungog Shire Council would assume ownership and management of the actual road.

Table 5.2 Comparison of Salisbury Road relocation options

High Road Options	
General	▪ All high road options traverse the natural ridgeline at a high level giving views to the east of farmlands and to the west of the storage water in the dam ▪ Approximate travel time for all high road options is 12 minutes ▪ All high road options pass through the ridge close to Chichester Gap ▪ All high road options will require an additional road to link to the water for recreation and tourism
Option A	▪ 17.9 km ▪ This is the most northern option, connecting back to Salisbury Road at the same point as High Road Option B
Option B	▪ 17.7 km ▪ This option takes an alternate route from High Road Option A down a different ridgeline but connecting back into High Road Option A at the same connection point with Salisbury Road
Option C	▪ 17.9 km ▪ This option takes an alternate route from High Road Option A down a different ridgeline. It connects back into Salisbury Road approximately 800 metres south-east of the connection point of High Road Options A and B near the existing Underbank Telephone Exchange
Low Road Options	
General	▪ All low road options follow the northern ridgeline from the eastern end of the proposed dam, offering views of both the proposed dam and rural areas ▪ All low road options deviate from the ridgeline approximately 6.7 kilometres from the eastern end down a ridge to follow the northern edge of the dam and access to the water's edge for recreational users ▪ All low road options would have a speed limit of 80 km/h ▪ Approximate travel time for all low road options is 13 minutes
Option A	▪ 18.0 km ▪ This option connects back to Salisbury Road at the same point as High Road Option A and B
Option B	▪ 18.2 km ▪ This option takes the same route to Salisbury Road as High Road Option C
Option C[1]	▪ 17.5 km ▪ This option takes a route to Salisbury Road closer to the Williams River embankment. It connects to Salisbury Road at the same point as High Road Option C

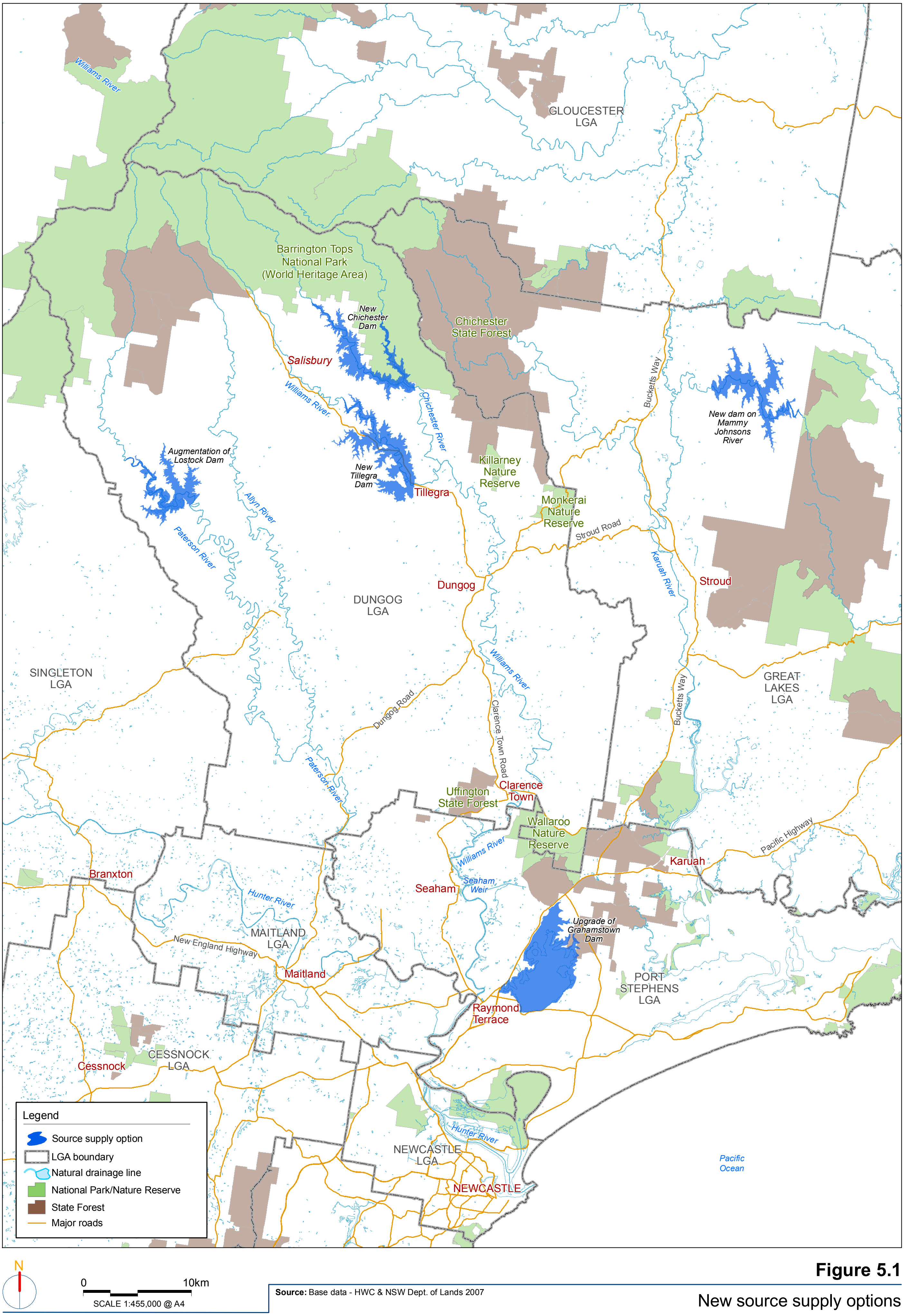
[1] Subsequent to public exhibition, a variation of Option C has been developed in consultation with affected landholders to reduce potential impacts on agricultural land.

5.3.2 Preferred option for relocation of Salisbury Road

Through the consultation process together with consideration of preliminary ecological constraints mapping, the low road option was identified as the preferred route for the relocation of Salisbury Road. The final alignments of northern and southern connections back to the existing sections of Salisbury Road have yet to be decided and would be subject to the outcomes of further consultation with affected property owners.

5.3.3 Relocation of other minor connecting roads

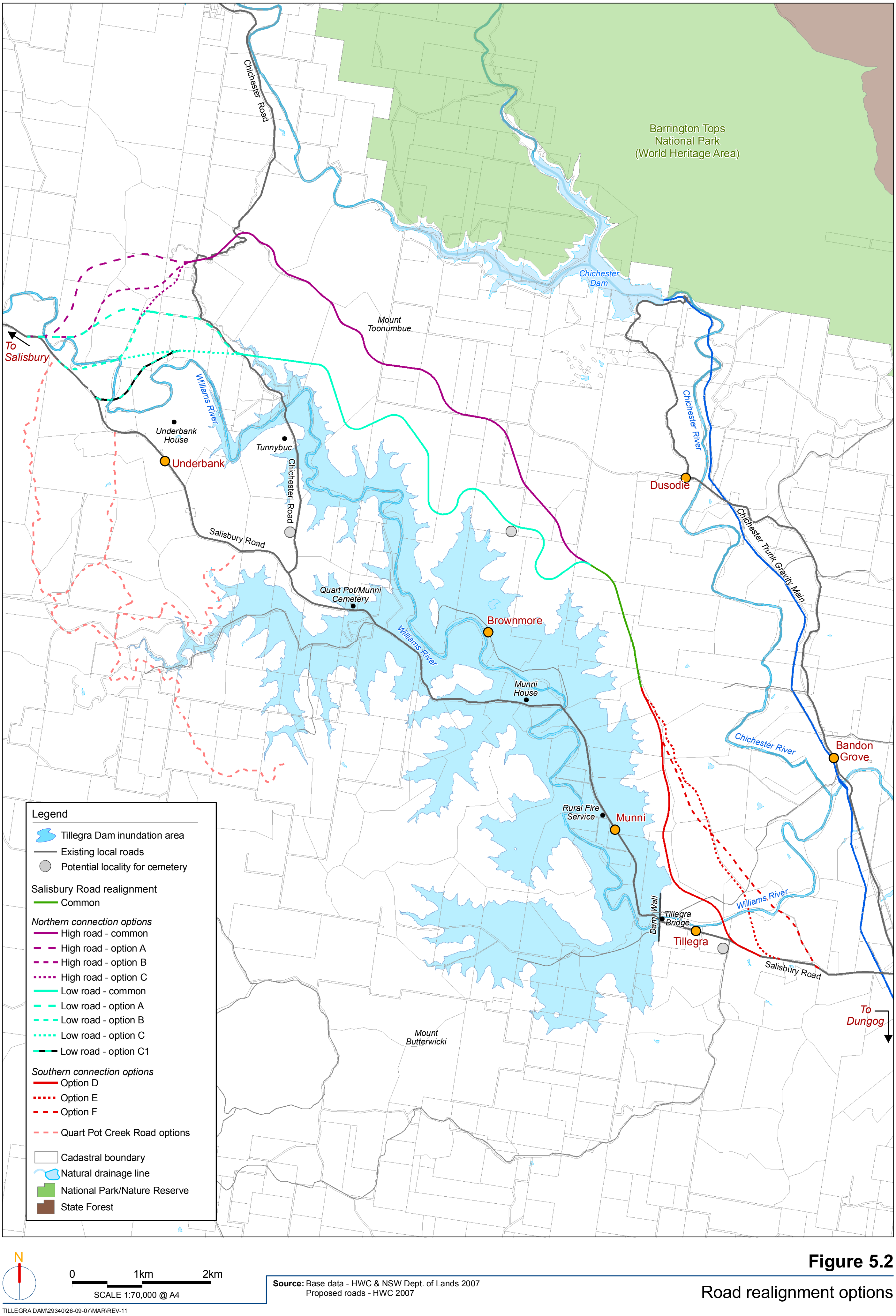
Several options for a new road connecting Salisbury Road to properties to the west of Salisbury Road have been investigated. These roads would be required to maintain access to properties currently serviced by Quart Pot Creek Road. The preferred route in this area would be determined in consultation with affected landowners and relevant public authorities, and with consideration of potential environmental impacts associated with the various options. The outcome of this process would be assessed in the EA report.



Source: Base data - HWC & NSW Dept. of Lands 2007

Figure 5.1

New source supply options



Source: Base data - HWC & NSW Dept. of Lands 2007
Proposed roads - HWC 2007

Figure 5.2

Road realignment options

TILLEGRA DAM\29340\26-09-07\MAR\REV-11

6 Existing Environment

6.1 Climate and meteorology

The two closest Bureau of Meteorology stations to the project area are Chichester Dam (194 mAHD) and Lostock Dam (200 mAHD). Summary details for monthly rainfall and temperature meteorological parameters for these two stations are presented in Table 6.1.

Table 6.1 Monthly rainfall and temperature summary statistics[3]

	Mean rainfall (mm)		Mean number of rain days ≥ 1 mm		Mean maximum temperature (ºC)		Mean minimum temperature (ºC)	
	CD	LD	CD	LD	CD	LD	CD	LD
Jan	169.8	131.3	10.8	10.0	26.2	29.2	16.7	17.2
Feb	177.2	122.9	11.4	9.6	24.9	28.3	16.7	17.2
Mar	173.9	126.3	11.2	9.5	23.3	26.5	16.2	15.4
Apr	94.4	64.6	8.2	7.1	20.2	23.6	12.7	12.7
May	97.9	76.1	8.6	7.8	17.4	19.9	9.7	10.2
Jun	103.6	60.3	8.9	7.3	14.2	16.9	7.0	7.7
Jul	53.0	38.4	7.4	6.1	13.7	16.4	6.2	6.5
Aug	60.0	35.3	6.9	5.5	15.5	18.3	6.9	6.9
Sep	61.9	50.1	7.1	6.7	19.1	21.4	9.8	9.3
Oct	93.1	67.0	8.8	8.0	21.4	24.5	12.1	11.9
Nov	101.4	84.3	9.4	9.6	24.1	26.3	14.9	13.9
Dec	124.7	90.8	10.1	8.5	26.6	28.9	17.2	16.1
Annual	1,311.5	947.7	108.8	95.7	20.6	23.4	12.2	12.1

CD = Chichester Dam, LD = Lostock Dam

Distinct seasonal patterns in rainfall are apparent with the wetter months occurring from December through to March for both sites. This is reflected in both average monthly rainfall totals and the mean number of rain days. The difference between maximum and minimum temperatures does not vary overly from month to month but is greatest in summer months.

The Project is located within a rural environment where there is an absence of heavy industry so the air quality is expected to be high. The major influence on air quality results from rural burning, particularly in the spring and summer months (Dungog Shire Council 2006). Bushfires also contribute to reduced air quality from time to time. Some agricultural activities have been identified as causing nuisance odours such as from fertiliser application. Natural short term or seasonal variations in air quality may occur and would be influenced by the variable topography and seasonal climatic conditions.

6.2 Landforms and topography

The project area is located in the North Coast Bioregion which occupies 7.11 per cent of NSW landforms (DEC 2004). This bioregion covers northern NSW from the shoreline

3 Sourced from Bureau of Meteorology website (www.bom.gov.au)

to the Great Escarpment. Typically, there is a sequence from coastal sand barrier, through low foothills and ranges, to the steep slopes and gorges of the escarpment itself.

The Dungog region is divided into a number of physiographic regions (Henderson 2000). The project area falls within the Dungog Hills region which exhibits rolling to steep hills formed on Carboniferous sediments with the alluvial plains of the Williams and Chichester Rivers and their tributaries. The Williams Range region is located to the immediate west of the project area, occupying steep mountains and rolling foothills on Carboniferous sediments forming the Williams Range and parts of the Wallarobba Range. The Barrington-Chichester Mountains region is located to the immediate north of the project area and occupies highly dissected, steep to precipitous terrain on Carboniferous sediments including Chichester State Forest, Barrington Tops National Park and the Chichester Dam catchment.

Catchment runoff and flow of the various tributary streams into the Williams River have been an important factor in shaping natural drainage channels. Major subcatchments of the Williams River are shown in Figure 6.1. This highlights the contribution of a number of streams that enter the river downstream of the proposed dam site. The Tillegra Dam catchment occupies about 15 per cent of the total Williams River catchment down to the Hunter River confluence.

6.3 Geology

The project area is situated at the southern end of the New England Fold Belt geological province of NSW (Henderson 2000). The geology of the overall Dungog region is extremely complex, mainly due to the structural complexity of the area. According to Henderson (2000), a major east-west compressive event formed the Stroud-Gloucester Syncline in the early Permian. This was followed in the latter part of the early Permian by north-west/south-east normal faulting, tantamount to uplift of the Gloucester Tops and intrusion of the Barrington Tops Granodiorite. Subsequently, a major compression event produced most of the major folds in the region. East-west tension during the late Permian led to high angle faulting which created horsts, grabens and step-faults. These faults are often parallel to the axes of folds. North to south compression followed this causing compression of the Stroud-Gloucester Syncline.

Structural controls existed at the time of deposition in the Permian and Carboniferous which created two distinguishable structural blocks within the Dungog area – the Gresford Block to the west and the Myall Block to the east (Henderson 2000). The project area is located within the Gresford Block. Within this block, the Williams River and the Camyr Allen Faults, to the east and west of the project area respectively, are the dominant structural features that played an active part during deposition in the Carboniferous (Roberts et al. 1991). According to the Dungog 1:100,000 Geological Sheet Series (Dept of Mineral Resources 1991), a number of fault lines running north to south, including the Brownmore Fault, are located within the project area.

A number of geotechnical-related investigations have been undertaken within the project area, namely:

- Hunter District Water Board (1952); investigations included geological mapping and percussion boreholes, some extended with diamond coring.
- L.R. Hall (1952); regional survey of the area was undertaken by the Geological Survey of New South Wales.
- Snowy Mountains Engineering Corporation (1970); investigations included

additional mapping, a seismic traverse in the riverbed and inclined, diamond cored boreholes across the valley floor.

- Water Resources Commission of New South Wales (1985); engineering and cost studies for the development of a proposed dam.
- Douglas Partners Pty Ltd (2007); aerial photograph interpretation of the proposed site and surrounding area together with a follow-up geotechnical inspection.

These investigations were confined predominantly to the valley floor area with an initial appraisal of material sources.

These investigations identified bedding strikes approximately north/south (155°M to 175°M), across the river, and dips moderately upstream at 40° to 50°. The ridge system forming the dam abutments is controlled by strike. According to Hall (1952), a major north/south lineation (parallel to bedding) known as the Tillegra Fault is understood to occur immediately downstream of the site. A number of other lineations have also been identified within the project area.

Two major joint sets have been identified within the project area:

- A set striking 175°M, parallel to bedding, dipping 35° east, downstream across bedding.
- A set striking 085°, normal to bedding, dipping at 60° to 90° north, into the left abutment.

The combination of bedding partings and joints has resulted in a predominantly fractured rock mass.

A shear zone 2.1 metres wide has been identified in the valley floor (SMEC 1970). A shear zone is an area of disturbed rock. They are quite common and can range in size from several centimetres to several kilometres wide. The identified shear zone comprises altered tuffaceous material with an extremely close/very close defect spacing. Water losses in the order of 60 UL[4] were experienced across the shear zone. It is assumed that the zone is controlling the orientation of the river at the site. As a result of regional folding, shear zones are also expected to occur in finer-grained rock types, parallel to bedding.

Further geotechnical investigations will be undertaken for the dam design. Relevant information from these investigations will be used in the environmental assessment.

6.4 Soils

There is a variety of soil landscape types present including alluvial, colluvial, erosional, and stagnant alluvial (Henderson 2000). The following soil types, based on the Australian Soil Classification (Isbell 1996), are located within the proposed inundation area of the project:

- Deep, well-drained Brown Kandosols on floodplains.
- Deep, well-drained Orthic Tenosols on low level terraces.
- Deep, moderately well to imperfectly drained Brown Chromosols on elevated terraces and alluvial fans.
- Shallow to deep, well to imperfectly drained Brown Sodosols on rolling hills

[4] UL = Lugeon units, a measure of transmissivity through rocks determined by pressurised injection of water through a borehole driven through the rock. One Lugeon is equal to one litre of water per minute injected into one metre of borehole at an injection pressure of 10 atmospheres.

predominantly overlying sandstone.

- Moderately deep, moderately well-drained Brown Kurosols on rolling hills overlying sandstone.
- Shallow to moderately deep, well to rapidly drained Leptic Tenosols on rolling hills to steep hills predominantly overlying siltstone.
- Moderately deep to deep, well drained Red Kurosols on shoulders of crests.
- Shallow to moderately deep, well to rapidly drained Orthic Tenosols on steep hills overlying sandstone.
- Deep, imperfectly drained Brown Kurosols on stagnant alluvial plains, located to the south of Quart Pot/Munni Cemetery.

The proposed road options predominantly traverse the following soil types:

- Moderately deep to deep, well to imperfectly drained Brown Sodosols on rolling hills, predominantly overlying sandstone.
- Moderately deep, moderately well drained Brown Kurosols on rolling hills overlying sandstone.
- Shallow to moderately deep, well to rapidly drained Leptic Tenosols on rolling hills to steep hills predominantly overlying siltstone.
- Moderately deep to deep, well drained Red Kurosols on shoulders of crests.
- Shallow to moderately deep, well to rapidly drained Orthic Tenosols on steep hills overlying sandstone.

Overall, soils in the project area are generally susceptible to localised occurrences of:

- Sheet and gully erosion.
- Acidity (and associated aluminium toxicity).
- High run-on.
- Sodicity.
- Mass movement.

Erosion hazard is generally moderate to very high across the project area. Gully erosion is evident along drainage lines, exacerbated by grazing of livestock, and sheet erosion is common on cleared slopes. Due to the seasonality of erosive rainfall in the Dungog area, adequate ground cover is essential (particularly on steeper slopes) to avoid high rates of soil erosion during high intensity summer storms (Henderson 2000).

A review of the DECC's[5] acid sulphate soil risk maps indicated no known occurrence of acid sulphate materials in the project area (DNR 2006). The risk of acid sulphate occurrence in the project area is considered to be low. It is therefore unlikely that this would present itself as an issue in the environmental assessment for the Project.

6.5 Fluvial geomorphology

The Williams River is a relatively steep, large-capacity, gravel bed channel with in-channel benches and various types of gravel and bedrock bars (Erskine 1986; Erskine 1998; Erskine and Livingstone 1999; Erskine 2001). Brooks et al. (2004) classify the river near Munni as 'discontinuous floodplain river style' which is typical of

[5] formerly the NSW Department of Natural Resources (DNR)

many coastal gravel-bed rivers in eastern Australia. As such, it exhibits alternating reaches of close bedrock confinement and unconfined floodplains (Erskine 2001). Significant lateral migration is restricted to unconfined bends (Erskine 1998). The resistance of the channel boundary is also enhanced by dense bankside vegetation, coarse bed material and bedrock bars in the bed (Erskine 2001).

River training works were undertaken on the Williams River and Chichester River discontinuously between 1954 and 1991 for one or more of the following reasons:

- To stop bank erosion.
- To remove obstructions that partially blocked the channel and concentrated flows against the banks causing erosion.
- To provide a stable channel pattern.
- To protect specific structures such as bridges.
- To stop a potential change of river course by alluvial stripping.

There were, however, negative consequences of these river training works (Erskine 1998, 2001; Brooks 2004). These included:

- Extensive removal of natural gravel armour layers, and natural boulder and log steps resulting in the loss of natural energy dissipation and consequent initiation of bed erosion.
- Loss of pools either by infilling with sediment or by bed erosion of the downstream riffle.
- Excessive removal of large woody debris and trees from the channel.
- Planting of large numbers of exotic trees in the riparian zone.
- Extensive bulldozing of the channel to remove bars, particularly mid-channel bars, to artificially create a single thread channel and thereby reduce morphological channel complexity.

For the purpose of the Project, the Williams River has been subdivided into the following four reaches based on geomorphological and hydrological divisions:

- Williams River from Salisbury to the Chichester River confluence.
- Williams River from Chichester River confluence to Mill Dam Falls.
- Seaham Weir pool (Mill Dam Falls to Seaham Weir).
- Seaham Weir to Hunter River confluence.

Key features associated with each of these reaches are summarised as follows.

Williams River from Salisbury to the Chichester River confluence

- Brooks et al. (2006) estimate that the Williams River at Munni expanded in cross-sectional area by 50 per cent after the 1940s. This was attributed to channel and riparian zone disturbance since European settlement, particularly desnagging.
- Channel expansion accelerated with the onset of river training works (which included desnagging) in the 1960s coincident with a series of large floods (Brooks et al. 2004, 2006).
- The entire upper Williams River (from Salisbury to the Chichester River confluence) has been the subject of river training schemes and a Rivercare Plan (Erskine 2001).
- Bed erosion followed the undertaking of works in the Munni and Salisbury

scheme areas. The lips of pools were lowered by both excavation and subsequent bed degradation, and downstream pools were infilled with the mobilised sediment. The relaxation time (the time required for pools to reform) was 15–20 years (Erskine 2001).

- Brooks et al. (2006) suggest that the capacity of the current channel configuration at Munni to transport sediment is currently well in excess of that which can be sustained by the long-term sediment yield from the catchment (ie it is supply limited) so further expansion of the channel cross section would be expected.

Williams River from Chichester River confluence to Mill Dam Falls

- The reach of river from the Chichester River downstream to Mill Dam Falls receives inflows from the regulated Chichester River plus other smaller unregulated tributaries.
- Extensive river training schemes were undertaken in this reach from the 1950s with periodic maintenance continuing up until the early 1980s.
- The Healthy Rivers Commission (HRC) of NSW (1996) and Erskine (1998) briefly reported anecdotal claims that the river training works increased the velocity of flood flows as well as negatively impacting the pool-riffle structure of the river (presumably degrading riffles and infilling pools).
- The Williams River downstream to Mills Dam Falls is of reasonably high gradient, and the bed material remains dominantly coarse grained (gravel to cobble).
- Mill Dam Falls represents a hydraulic and bed control with a rapid forming in this location at high flows. Coarse gravel benches and bars are present at Mill Dam Falls.

Seaham Weir pool (Mill Dam Falls to Seaham Weir)

- Seaham Weir was constructed in 1968 and later sealed in 1978. The initial construction altered the reach of the river between Mill Dam Falls and the weir from that of a free flowing tidal estuary to a freshwater pool.
- Bars and benches of coarse-grained sediment (sand to cobble size) are present in the channel at Mill Dam Falls. This is a natural geomorphic break in the system below which the bed gradient decreases sharply.
- Mill Dam Falls would have been the natural tidal barrier. This was naturally (and is currently) a deposition area.
- The HRC (1996, p. 31) reports anecdotal evidence that construction of the weir caused die-back of phragmites beds lining the lower parts of the banks and that allowing stock to drink directly from the now freshwater pool resulted in decline of bank vegetation, erosion and degradation of water quality. It has also been reported that ongoing variations in water levels within the weir pool associated with the operation of the weir gates, cattle access, and the impact of waves generated by some power boats along the river inhibit reestablishment of riparian and aquatic vegetation.
- The HRC (1996, p. 32) notes the existence of differing views on the efficiency of Seaham Weir pool as a sediment trap. At Seaham, the sediment load of the river would be principally fine-grained. During flood events most of this material would be suspended in the water column and thus would be transported over the weir.

Seaham Weir to Hunter River confluence

- GHD (2006) conclude that a number of processes contribute to erosion of the banks in this reach: recreational boat wake; land and river management practices, and the construction of the Seaham Weir (which would have reduced the volume of sediment transported into the tidal reach of the Williams River).

- While river flow is an important component of the erosion processes downstream of Seaham Weir, it is a secondary role in the sense that flows occasionally (during high flow events) provide the energy to remove material eroded or 'prepared' for removal by other processes.
- Large floods pass Seaham Weir through open gates so the major periods of sediment transport are relatively unaffected by the weir.

6.6 Water resources

Water is supplied to the lower Hunter region from a number of sources. As noted in Section 2.2, the main water supply sources are Grahamstown Dam (supplied by the Williams River) and the groundwater sources of the Tomago sandbeds and Tomaree.

The Grahamstown scheme supplies approximately 40 per cent of the total long-term regional needs (HWC 2006). The scheme comprises Seaham Weir pool, Balickera Canal and the pumping station. Approximately half the stored water for Grahamstown Dam is drawn from the Williams River. Grahamstown Dam has a catchment area of 100 km^2 and a capacity of 190,000 ML.

Chichester Dam has a catchment area of about 200 km^2 and an available storage capacity of 21,500 ML. Water from the dam is dosed with chlorine at the dam before being transported to Dungog water treatment plant via the CTGM (HWC 2003). The majority of treated water is provided to Maitland and Cessnock.

The volumes supplied by the different sources to meet demand in 2005-06 are shown in the following table. Over the past 25 years, annual demand has varied depending on both residential and industrial needs, the introduction of pay-for-use pricing and general climatic conditions. Annual demand is currently 72.8 GL.

Table 6.2 Water sources at 2005-06

Source	Volume (GL)
Chichester Dam	29.4
Grahamstown Dam	31.5
Tomago Sandbeds	9.8
Anna Bay Sandbeds	2.1
Total	72.8

Source: (HWC 2007b)

The water supply of the lower Hunter region is susceptible to long droughts during which storage volumes can plummet dramatically. The North Stockton sandbeds are a contingency water supply source to assist in the event of drought. During the last significant drought period in the early 1980s, storage volumes dropped to critical levels and water restrictions were applied. Drought issues are amplified by increased future demand of which population growth is a significant contributor (HWC 2007b).

The Tillegra Dam project lies within the Williams River catchment which is approximately 1,300 km^2 in area at the Hunter River confluence (Wooldridge et al. 2001). The catchment rises to approximately 1,500 metres above sea level in the northern elevated region which includes Barrington Tops National Park. The average recorded streamflow at the lower end of the Williams River is about 360,000 ML per year (HWC 2003).

The Department of Water and Energy (DWE) is responsible for managing water access and trading in NSW. While rural land holders have access to water for basic purposes such as for stock and domestic uses, licences and/or approvals are required for extracting water from rivers or aquifers for commercial purposes. The Hunter catchment represents 80 per cent of the irrigated area in the NSW mid-coast region (Water Use Efficiency Advisory Unit, 2002). The majority of irrigation industries in this region are wine grapes and dairy cow pastures.

Irrigation licenses are administered by the DWE. Along the Williams River, management of licences is facilitated using the Glen Martin gauging station. Currently, there are 177 licences which can take up to 8,300 ML/d. Irrigation demand is highest in summer when it can reach 62 ML/d (DNR 2007). The difference between the total licence allocation and observed peak irrigation demand reflects that not all licences issued have been acted on (these are referred to as 'sleeper' licences). Additional demands are placed on the water resource by HWC (approximately 60,000 ML/y or 164 ML/d) and stock and domestic uses.

River flows

The flow regime in the area of the proposed Tillegra Dam site is influenced by the steep upper catchment and rolling hills around the dam site including rainfall variations across the catchment. Construction and operation of Tillegra Dam would also affect future river flows past the dam.

Other than the steep slopes of the upper areas, most of the catchment has been cleared of vegetation over the past 200 years (HRC 1996). Land clearing typically changes the hydrology by increasing runoff characteristics, particularly during storm events with increased baseflows. Dry weather low flow periods are evident in the Williams River flow records (1931 to 2007) at Glen Martin for the periods 1964/65, 1979/81 and 1990/91. The recent dry weather from 1997 to early 2007 that affected most of the south-eastern coast of NSW was not evident in the flow records until 2005. As a result, the duration of the longest drought on record is 18 months.

River flows at Tillegra vary from nil to a flood peak of 41,159 ML/d. The average flow is 258 ML/d with a median inflow of 46 ML/d.

Chichester Dam has a maximum environmental flow release of 14 ML/d, this being the nominal 95th percentile of Chichester River inflows to the storage. By comparison, the 95th percentile for the Williams River at Tillegra is 1.8 ML/d as the Williams River has a naturally drier catchment than that of the Chichester River.

Flows in the Williams River downstream of the proposed dam site increase as the tributary inflows contribute to the main channel. Flows at Glen Martin (some 60 kilometres downstream of the Tillegra gauge) range from nil to a flood peak of 103,488 ML/d. The average flow is 718 ML/d and median inflow is 98 ML/d. The catchment area at Tillegra represents approximately 30 per cent of the catchment at Glen Martin and contributes approximately 40 per cent of the flow.

Water quality

Average surface water quality at the proposed Tillegra Dam site for the period September 1987 to May 2007 is shown in Table 6.3.

Table 6.3 Surface water quality at Tillegra Dam site

Parameter	Average	Maximum	Minimum	ANZECC Guideline[A]
Temperature (Celsius)	17.8	29.0	8.5	
NO_3+NO_2 (mg/L)	0.084	0.700	0.003	0.015
TN (mg/L N)	0.66	2.59	0.02	0.25
TP (mg/L P)	0.068	0.566	0.002	0.02
pH	7.7	8.8	7.2	6.5-8.0
EC (µS/cm)	182	407	79	350
Suspended solids (mg/L)	2.0	3.6	2.9	25
Turbidity (NTU)	28.6	222	0.6	2-25
Chlorophyll α (µg/L)	1.1	9.3	<0.01	5[B]

[A] SE Australia Upland River

[B] Lowland criterion has been applied for chlorophyll α (Upland criterion does not exist as periphyton considered more appropriate to consider)

The influence of agricultural activities in the catchment on river water quality is reflected in elevated concentrations of nutrients with the exception of chlorophyll α which exceeded the guidelines only once out of the 42 measurements made during the monitoring period. The low chlorophyll α indicates low phytoplankton abundance in the flowing waters of the river.

While suspended solids exceeded the guideline only once, the effects of land clearing on siltation of the river are reflected by turbidity measurements which exceeded the guideline 40 per cent of the time.

In 2006, HWC conducted a trend analysis of water quality records for the Williams River at Tillegra for the period 1987–2005 and found the following statistically significant trends:

- An increase in colour (Hazen units) and silica.
- A decrease in conductivity.

No long term trend was discerned for pH, turbidity, NO_2, NO_3, total Kjeldhal nitrogen, total phosphorus, total nitrogen, iron, manganese, copper, chlorophyll α or faecal coliforms.

Blue-green algae

Under the guidelines for managing risks in recreational waters (NHMRC 2006), blue-green algae should not exceed 50,000 cells/mL or a biovolume of 4 mm^3/L for the combined total of all blue-green algae where a known toxin producer is dominant in the total biovolume. The biovolume guideline is 10 mm^3/L if no toxic blue-green algae are present.

The available HWC blue-green algae database for the Chichester storage, the Seaham Weir pool (measured from 1992 to 2007 at Boags Hill), and Clarence Town was examined. For all three sites, The data showed only a low frequency of exceedence (less than one per cent of the time) of the total cell count guidelines. Cell densities above the guideline tended to occur in the downstream ponds during periods of low river inflows when longer residence times and stratification provided stable conditions within the ponds for blue-green algae to grow.

Elevated levels of potential toxic species of cyanobacteria (blue-green algae) were recorded in the Seaham Weir pool four times from 1991 to 2006 when the total cell count exceeded the recreational guidelines of 50,000 cells/mL. Examination of the more recent data showed elevated cell counts occurred twice in January 2007. Elevated levels occurred during only five of the 16 years of measurement.

In warmer months, the Seaham Weir pool is prone to regular blooms of cyanobacteria comprising a mix of toxigenic and non-toxigenic varieties. Since 2000, non-toxigenic varieties have dominated with infrequent occurrence of toxigenic species.

6.7 Aquatic ecology

There are hundreds of kilometres of freshwater habitat within the Williams River catchment. While there have been considerable impacts on these reaches they continue to provide important habitat for aquatic flora and fauna.

The headwaters of the Williams, Chichester and Wangat Rivers are located in the Barrington Tops National Park to the north west of Dungog. The montane reaches flow through the *Nothofagus* (beech) dominated temperate rainforests. The slope reaches of the Chichester and Wangat Rivers are impounded by Chichester Dam (completed in 1927) creating an artificial lacustrine environment. Regulated releases (and spills) from Chichester Dam join the Williams River just upstream of Bandon Grove bridge.

The Williams River contains a variety of aquatic habitats. The upper reaches through the proposed inundation area contain riffle and pool sequences, gravel bars, bed rock and pools (DPI 2006). Riparian vegetation in this area is confined to the main channel and absent along most tributaries. Instream large woody debris is present in places. Further downstream in the lowland reaches, the channel gradually widens forming an unbroken watercourse with deep pools, rock platforms and snags. Macrophyte species such as spike rush (*Eleocharis acuta*), *Vallisneria* sp. *Phragmites* sp. are common (DPI 2006; Dungog Shire Council 2004).

The aquatic habitat within the catchment has experienced significant impacts since European settlement. Forest clearing for agriculture during the nineteenth century increased runoff and flood peak discharges. Increased sediment loads smothered habitats such as gravel beds and shallow holes. Flood mitigation measures were implemented in the 1950s that involved extensive ‘desnagging’ (ie removal of in-stream woody debris) and the clearance of in-channel vegetation from bars and banks (Brooks et al. 2004). Engineering works included channel realignment and the removal of gravel and boulders from riffles. The changes to channel morphology created bed instability resulting in the erosion of riffle habitat and infilling of low pools. Increased erosion, sedimentation and bank undercutting contributed to channel widening downstream (Brooks et al. 2004; Dungog Shire Council 2004).

Present day algal assemblages in the upper reaches are indicative of those found in more natural environments but the presence of taxa such as *Melosira* sp., *Cladophora* sp. and *Compsopogon* sp. further downstream are associated with nutrient enrichment (Dungog Shire Council 2004). The Category 1 noxious weed Alligator Weed (*Alternanthera philoxeroides*) was found in the Williams River in 1993 and is moving upstream at a rate of one kilometre per year[6]. Other common aquatic weeds include Water Hyacinth (*Eichhornia crassipes*) and Salvinia (*Salvinia molesta*) (Dungog Shire Council 2004).

[6] NSW Department of Primary Industries web site (http://www.dpi.nsw.gov.au/agriculture/farm/pest-weeds-management/weeds/profiles/alligator/agfact), Accessed 23 August 2007.

Surveys of freshwater fish in the Williams River catchment have identified 18 species, two of which are introduced pest species: the mosquito fish, *Gambusia holbrooki*, and the common carp (*Cyprinus carpio*)[7]. Published fish distributions (McDowall 1996) suggest a further 14 fish species may be present. There appear to be relatively few differences in species recorded in the reaches above Dungog to those downstream at Clarence Town. However, the bullrout (*Notesthes robusta*) has only been found in lower reaches and the climbing galaxias (*Galaxias brevipinnis*) was only recorded in a high altitude montane tributary. The Australian bass (*Macquaria novemaculeata*), important to recreational fishers, appears abundant throughout much of the Williams River.

No fish recorded above Seaham Weir are listed as threatened under the *Fisheries Management Act 1994* or the EPBC Act. The freshwater catfish has been afforded protection from commercial fishing in NSW due to its reduced numbers, particularly in main channel habitats, and the uncertain taxonomy in some eastern populations (NSW Fisheries 1999). The freshwater catfish is required to be given consideration during planning decisions although McDowall (1996) contends that the Hunter Region catfish have been translocated from western populations, similar to those in the Shoalhaven and Hawkesbury-Nepean systems, and as such are not native to the area.

Many of these fish species move considerable distances within the Willams River. At least eight species (Australian bass, longfinned eel (*Anguilla reinhardtii*), shortfinned eel (*Anguilla australis*), freshwater mullet (*Myxus petardi*), freshwater herring (*Potamalosa richmondia*), striped gudgeon (*Gobiomorphus australis*), bullrout and common jollytail (*Galaxias maculatus*)) move between freshwater and estuarine/marine habitats for various stages of their life cycles (DPI 2006, McDowall 2006). Seaham Weir, located approximately 10 kilometres upstream of the confluence with the Hunter River, is a tidal barrier that separates freshwater from estuarine habitat. The weir allows downstream fish movement but upstream fish passage is only possible when medium to high flows coincide with high tides and active fish migration (DPI 2006). Seaham Weir has been identified as high remediation priority by the DPI due to its restriction of fish passage to up to 250 kilometres of upstream habitat (including tributaries). The DPI has suggested that the existing ineffective submerged orifice fishway be replaced by a vertical slot fishway.

The anticipated principal influences on aquatic ecosystem processes within the project area are summarised in Figure 6.2.

6.8 Terrestrial ecology

The project area is located within the Hunter-Central Rivers Catchment Management Authority (HCRCMA) region. The two main catchments in the vicinity of the project area are the Williams River catchment containing the Williams River and the Paterson-Allyn catchment containing the Paterson and Allyn rivers. The region is characterised by a mosaic of rugged and hilly country with valleys that have been extensively cleared for dairy and beef production. The project area is located in the NSW North Coast Bioregion, one of the most diverse in NSW.

Although much of the native vegetation within the project area has been removed or disturbed to varying degrees through past development, agriculture or poor land management practices, fragmented habitat remnants are apparent in the area (Dungog Shire Council 2004). Despite the fragmented nature of the landscape, discontinuous

[7] BioNet database (http://www.bionet.nsw.gov.au), Accessed 23 August 2007

corridors and habitats can often provide important stepping stone links between other areas of more contiguous vegetation. Mapping of key habitats and corridors across the north east of NSW undertaken by Scotts (2003) shows several remnants identified as key habitats within subcatchments in close proximity to the project area.

An initial review of the available literature shows that there has been no comprehensive documentation or mapping of biodiversity within the project area despite some studies undertaken in associated National Parks and State Forest areas, and on private lands. This suggests the possibility of knowledge gaps in the understanding of the biodiversity in the project area.

Based on air photo interpretation and vegetation mapping undertaken for the Comprehensive Regional Assessments (CRAFTI), four broad vegetation communities were identified as occurring in the project area:

- Dry Sclerophyll Shrub/Grass Forests.
- Swamp Sclerophyll Forests.
- Wet Sclerophyll Forests.
- Rainforests.

The northern areas, Barrington and Gloucester Tops National Parks support cool temperate rainforests dominated by Antarctic Beech (*Nothofagus moorei*) which occur on soils derived from basalts. Eucalyptus communities are common in areas of granite derived soils. The dominant species in these areas include Blackbutt (*Eucalyptus pilularis*), Sydney Blue Gum (*E. saligna*), Spotted Gum (*Corymbia maculata*), Grey Gum (*E. punctata*), Forest Red Gum (*E. tereticornis*), Red Bloodwood (*C. gummifera*), Brush Box (*Lophostemon confertus*) and White Mahogany (*E. acmenoides*)[8].

Preliminary desktop investigations shows that the endangered ecological community (EEC) White Box-Yellow Box-Blakely's Red Gum Woodland and Derived Native Grassland has the potential to exist in the project area. This EEC is listed as critically endangered under the EPBC Act and endangered under the *Threatened Species Act 1995* (TSC Act). The following EECs listed under the TSC Act may also occur in the area:

- Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions.
- Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion.
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions.
- Lowland Rainforest in NSW North Coast and Sydney Basin Bioregions.

The region supports a wide range of habitats including rainforests, moist forests, woodlands, riparian vegetation and aquatic ecosystems (Dungog Shire Council 2006). These habitats in turn are likely to support a wide range of flora and fauna including threatened species. Such a wide range of habitats indicates a wide range of biodiversity within the existing environment. Pressures on biodiversity within the Dungog area include habitat fragmentation and vegetation clearing, introduced species and fire.

The diversity of habitat in the project area provides suitable habitat for a number of threatened bird species such as the Glossy Black-cockatoo (*Calyptorhynchus lathami*),

[8] NSW Dept of Environment and Climate Change website (www.nationalparks.nsw.gov.au/npws.nsf/ Content/North+Coast+-+biodiversity), Accessed 21 June 2007

Swift Parrot (*Lathamus discolour*), Regent Honeyeater (*Xanthomyza phrygia*), Brown Treecreeper (*Climacteris picumnus*), Speckled Warbler (*Pyrrholaemus sagittatus*), and Diamond Firetail (*Stagonopleura guttata*) (Satler and Creighton 2002). A number of other threatened fauna species such as the Large-footed Myotis (*Myotis adversus*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Spotted-tail Quoll (*Dasyurus maculatus*) may also be found in the project area[9].

A search of the DEW protected matters database identified a total of 25 threatened species, 13 listed marine species (all birds), one threatened ecological community and 15 migratory species listed under the EPBC Act likely to occur in the project area.

Riparian vegetation currently exists along parts of the Williams River within the project area. The riparian lands and vegetation provide important habitat for land-based plants and animals, and may contain a high diversity of species. Information on the condition of the riparian zone in the Dungog LGA is available from a number of sources. Riparian vegetation in the area has been mapped and classified as good (6,724 km^2), sparse (2,107 km^2) and missing (4,334 km^2) (Dungog Shire Council 2004).

A number of wetland areas have been identified within the Williams River floodplain downstream of Fosterton. These occur in relic river channels and oxbow lakes that have formed as the river meandered its way through the floodplain over the millennia. Presently, most of these wetlands are within private landholdings adjacent to the river. These have been, and continue to be, altered significantly by agricultural activities.

6.9 Socioeconomic issues

The Dungog Shire covers an area of 2,248 km^2 and had a population of 8,432 persons at June 2006. Dungog Shire's population has been increasing steadily over the past 15 years resulting from its quality rural environment and lifestyle and its accessibility to Newcastle. The Shire's population increased from 7,360 in 1991 to 8,033 in 2001 and more recently to 8,432 persons in 2006. Total population growth has been 15 per cent over this period. The population density is 3.8 persons/km^2.

The economy of the Shire is based on agricultural production, grazing, timber, services industries and tourism. In particular, Chichester Dam, the Williams and Paterson Rivers and the surrounding Barrington Tops National Park are catalysts for attracting visitors to the Shire. Land use in the immediate project area is shown in Figure 6.3.

The dam and associated infrastructure (including relocation of Salisbury Road) would affect approximately one per cent of the total area of the Shire. HWC has been progressively acquiring properties in the Tillegra locality. At the Project's inception in November 2006, there were approximately 38 landowners with rural properties in the inundation area. Currently (October 2007), 17 properties remain to be purchased.

6.10 Visual amenity

The landscape in the project area is dominated by cleared rural land with dispersed residences and various other cultural elements such as sheds, roads, fences, transmission lines and the CTGM. Small church buildings also occur within the area. The density of development varies throughout the project area with closer spaced but still low density settlement along the Chichester Dam and Salisbury Roads. Away from

9 NSW Dept of Environment and Climate Change website (www.nationalparks.nsw.gov.au/npws.nsf/Content/North+Coast+-+biodiversity), Accessed 21 June 2007.

these roads, settlement is more sparsely distributed particularly on the steeper slopes of the Williams and Chichester River catchments.

Most of the land has been cleared for grazing purposes and remnant woodland is comparatively rare in the immediate project area. Some views to more distant elevated upland areas reveal areas of extensive woodlands.

The project area is mostly free of commercial or industrial development and presents a pleasant rural setting that no doubt has intrinsic value for tourism in the form of country drives, rural cycling and potentially rural home-stay holidays. The town of Salisbury in the upper part of the Williams River catchment provides an example of a small village within a rural setting that includes cabin style holiday accommodation. Most traffic on Salisbury Road is likely associated with local residents with visitors to the area forming an intermittent presence.

The scale of the topography in terms of height is not such as to be spectacular for its peaks but the relief does present dimension and variety to the local rural landscapes. Views of the local landscape are considered pleasant and interesting to the casual observer in the variety of examples of steep ridges, streams over gravel-lined river beds and intermittent remnant woodlands and grasslands.

The CTGM is a prominent element alongside Chichester Road being very exposed and clearly visible due to it being above ground and painted silver within a grassland landscape. Power lines are generally for local supplies and being of low voltage with simple pole structures and lightweight conductors, are not a significant element in the landscape.

Views of the landscape are obtained from residences in the area, the roads passing through the area and aircraft flying over the area, the latter forming a comparatively minor portion of the observers of the local landscape. Public views of the local landscape from vehicles passing through the area are generally a series of fleeting glimpses of various landscape elements and result in a general perception of the rural character with more prominent features often influencing the experience of the landscape.

6.11 Contemporary heritage

Seventy-three historical heritage items were identified within the proposed Tillegra Dam development area following consultation with the Dungog Historical Society and historical research. These items include numerous mid-to-late nineteenth and early twentieth century houses and homestead complexes, extant and former bridges, a former school site, a former church site, Quart Pot/Munni Cemetery, a family burial ground, two possible burial grounds, a cricket ground and the possible site of c1829 Mann’s hut and stockyards. Twenty-nine of these items were identified in the field.

Of these 73 items, only four are listed under the Dungog LEP and the Hunter REP. None of the identified heritage items are listed on the State Heritage Register. The extent, nature and significant of these and other historical heritage items would be considered in the environmental assessment.

6.12 Aboriginal heritage

Relatively few studies of Aboriginal heritage have been undertaken within the project area. The sparsity of sites recorded is not consistent with historic evidence that relatively large numbers of Aboriginal people are likely to have inhabited the area. It has been suggested that a major factor in explaining this is the lack of areas with suitable ground surface exposure where artefacts would be expected to occur (Koettig 1984).

A search of the DECC Aboriginal Heritage Information Management System (AHIMS) database for sites within the Dungog LGA resulted in a list of 33 site features. The features are listed as one art site, 13 artefact sites, three burials, one ceremonial site, two shell deposit features (associated with middens), two 'earth mounds' (sometimes recorded at midden sites or other areas of deposit), three grinding groove sites, seven scarred trees and one area of potential archaeological deposit (PAD). This list is a testament to the variety of types of occupation evidence that may occur in the region.

None of the site features or Aboriginal objects on the AHIMS have been recorded within the current project area boundaries.

6.13 Noise and vibration

Due to the predominately rural nature and associated lack of development in the project area there are generally low levels of noise emissions. This has been confirmed by information obtained from a noise survey carried out over a period of seven days, with Rating Background Levels typically less than 40 dB(A).

Existing vibration levels within the project area are negligible as there are no major sources of vibration within and surrounding the project area. Similarly, there are no sensitive receivers with the exception of residences sited alongside roads within the area. A vibration survey at a number of these residences identified levels less than 0.2 mm/s due principally to infrequent traffic.

6.14 Contaminated land

A search of the DECC's online Contaminated Site Register was undertaken on 26 July 2007. This register provides a record of written notices issued by the DECC under the *Contaminated Land Management Act 1997* in relation to the investigation or remediation of site contamination that presents a significant risk of harm to human health or the environment. The search revealed that there were no contaminated sites recorded within the Dungog LGA.

A search of the DECC's online POEO Act public register was undertaken on 26 July 2007. This revealed that there have been eight licences and notices issued to premises located within the Dungog LGA. The only licence within the vicinity of the project area is an environment protection licence for Dungog Shire Council for premises entitled *Waterways within the Dungog Shire LGA*.

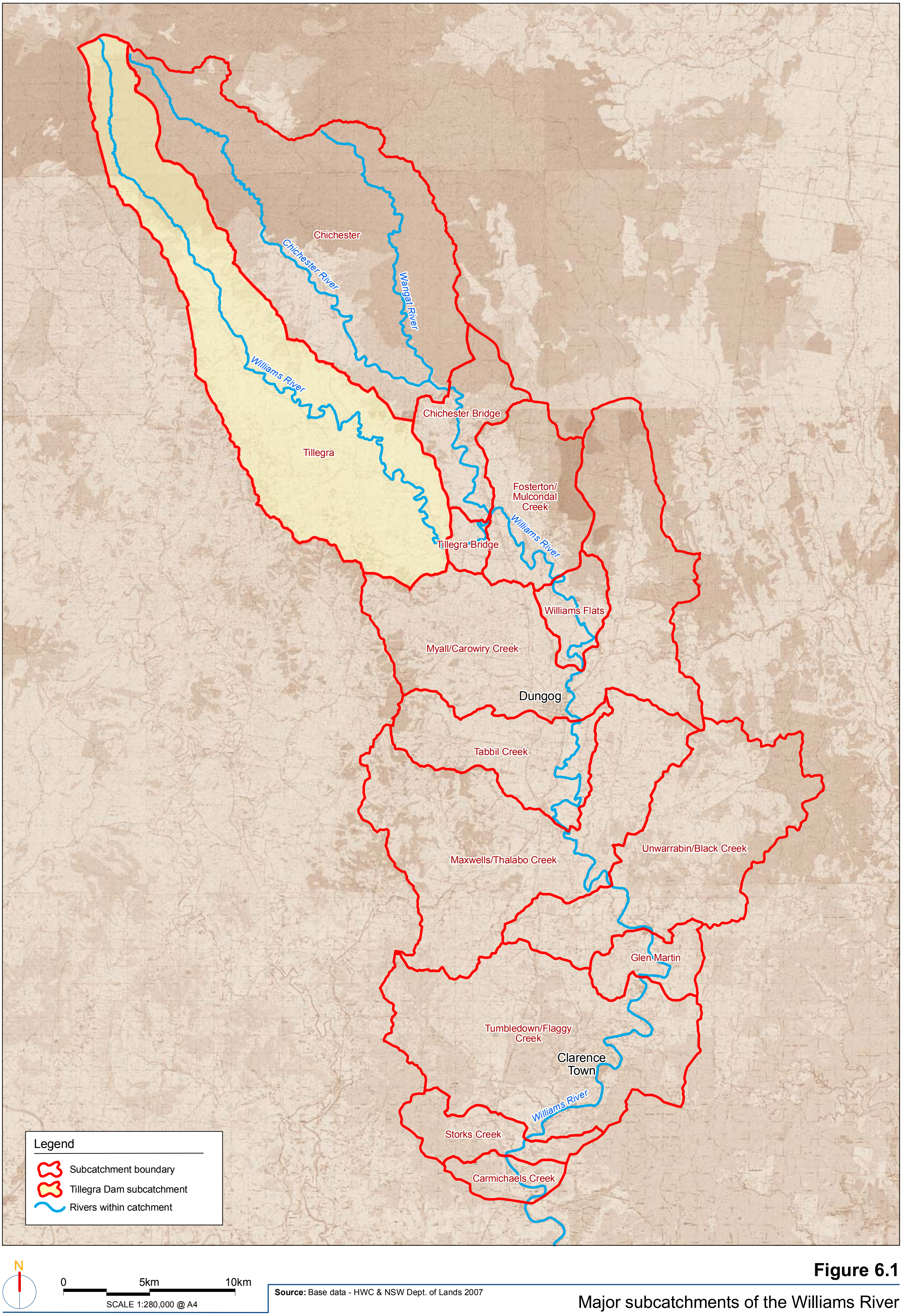
Standard livestock dip treatment (cattle and sheep) historically involved the use of environmentally persistent chemicals such as arsenic and organochlorines (aldrin, dieldrin, DDT and lindane). Consequently many sites are subject to residual soil contamination in the vicinity of the dip. A search of the DPI's online Cattle Dip Site Locator was undertaken on 26 July 2007. The database contains the most current list of cattle dip sites in the Northern Rivers region of NSW. As the project area does not sit within the Northern Rivers region, no information was available. However, past or present livestock dip sites may still occur within the project area.

The aerial photography review indicated that a number of properties (at least 12) contain farm infrastructure (livestock yards, large buildings and sheds) that are indicative of the potential for historic or current livestock dip sites or chemical storage facilities. These sites are all located within the proposed inundation area with none along the current proposed road alignments.

Discussions with Dungog Shire Council (Terry Kavanagh, Manager Environmental Services) and a review of aerial photography yielded the following information:

- The predominant current and historic land use is agriculture comprising mainly grazing and dairy operations, as well as some intensive agricultural practices.
- There are no sites within the project area that are listed on Council's potentially contaminated land register.
- Council is not aware of any livestock dip site register for the LGA.

Contaminated soils, in particular those associated with livestock dip sites, are potential areas of concern as pollutants could affect water quality following inundation of contaminated land. Additionally, disturbance and handling of contaminated land during construction activities could present a risk to both the environment and human health.



Source: Base data - HWC & NSW Dept. of Lands 2007

Figure 6.1

Major subcatchments of the Williams River

TILLEGRA\29340\26-09-07\MAR\REV-6

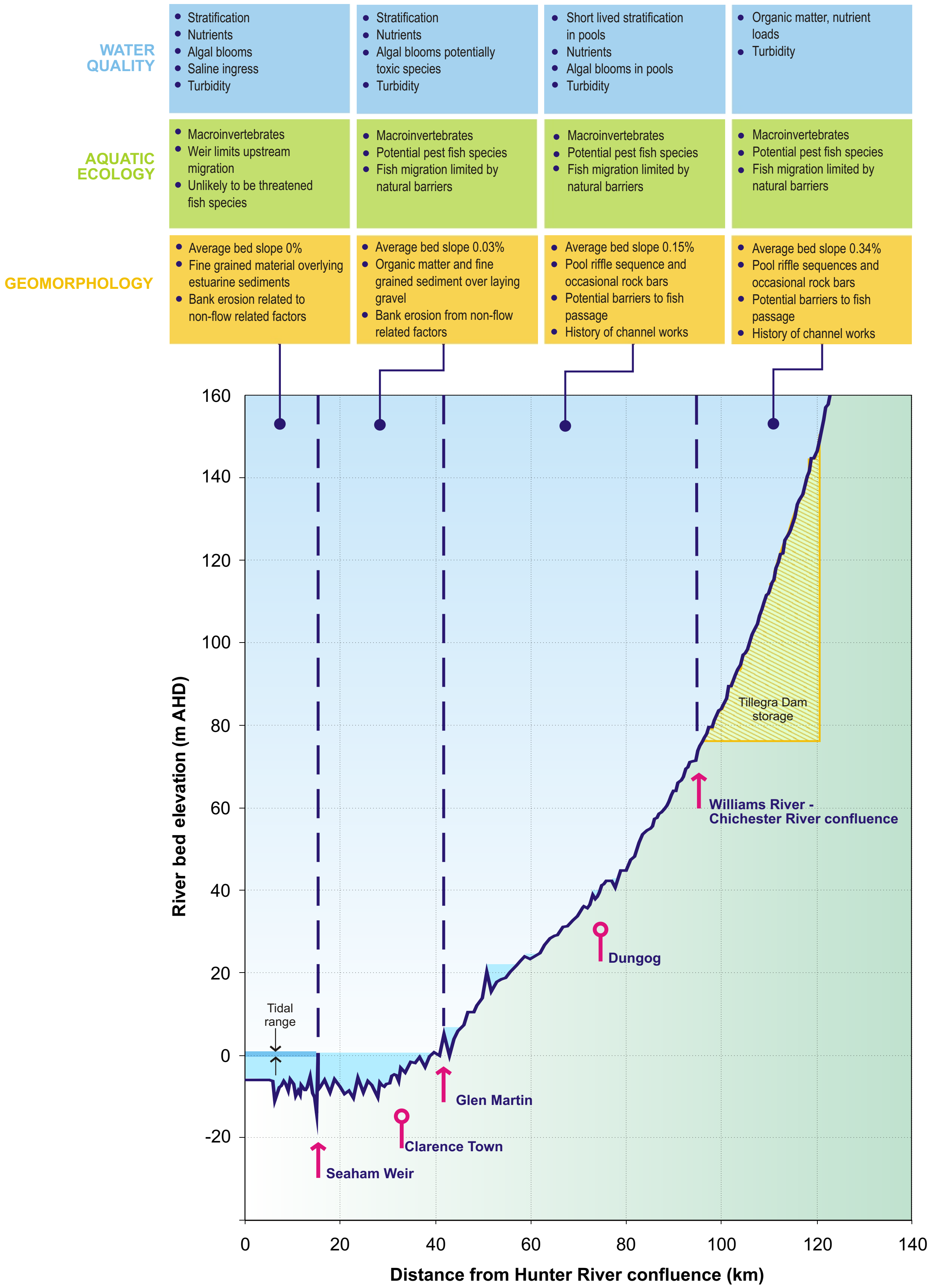


Figure 6.2
Existing aquatic ecosystem components of the Williams River

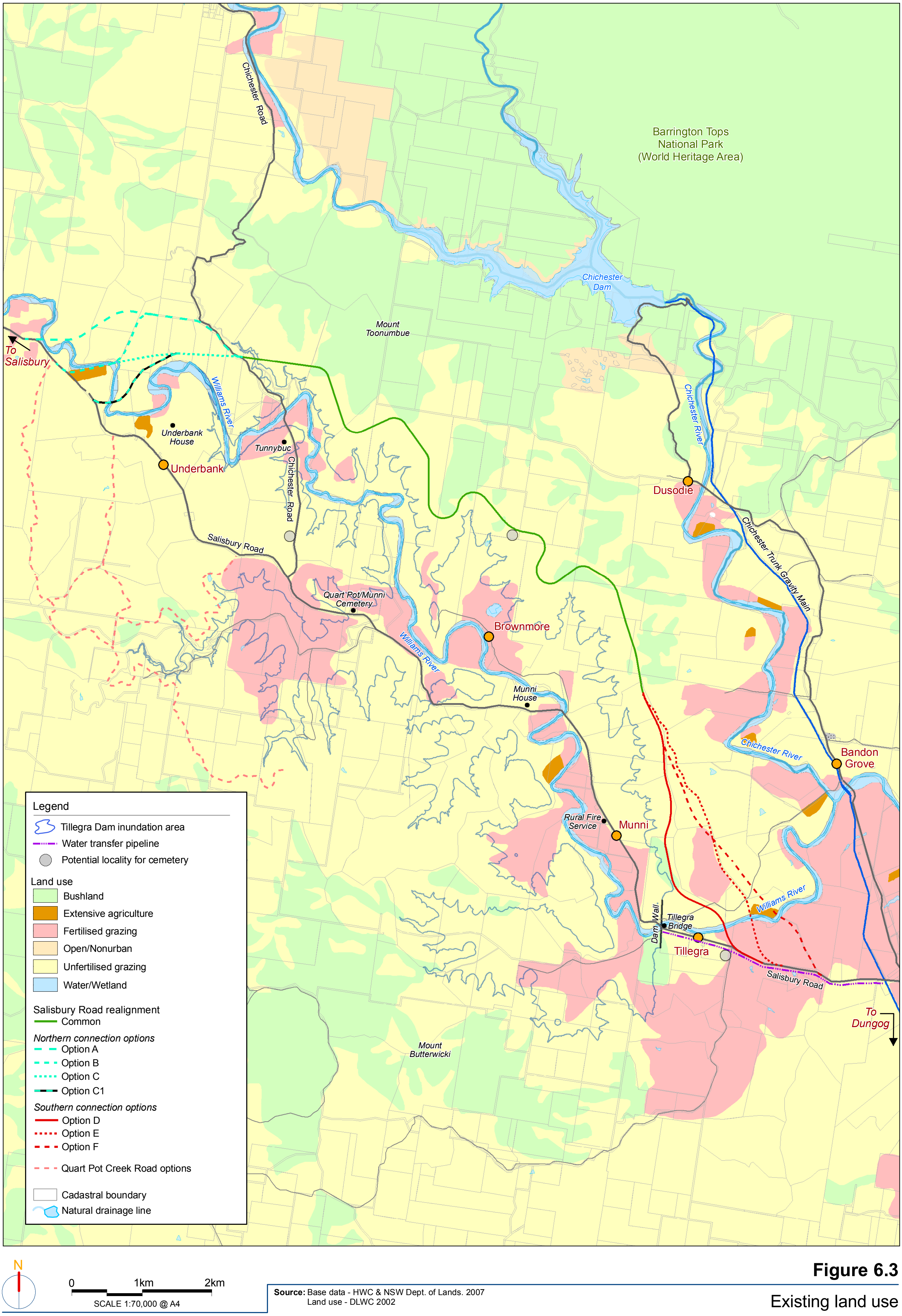


Figure 6.3

Existing land use

Source: Base data - HWC & NSW Dept. of Lands. 2007
Land use - DLWC 2002

TILLEGRA DAM\29340\26-09-07\MAR\REV-14

7 Preliminary Environmental Assessment

7.1 Overview

As noted in Section 4.1, HWC intends to lodge an application under Section 75E of the EP&A Act for approval to carry out the Project. Subsequent to this, the Director-General of the DoP will issue requirements for the environmental assessment. In preparing these requirements, Section 75F requires the Director-General to consult with relevant public authorities in relation to key issues for consideration in the environmental assessment.

In preparing documentation to support the project application, HWC has conducted a screening of likely environmental issues of relevance to the Project and, through a qualitative risk assessment, categorised these as either key or non-key issues.

The following have been identified as key environmental issues associated with the proposed Project:

- Fluvial geomorphology.
- Water quality and environmental flows.
- Aquatic ecology.
- Terrestrial ecology.
- Sustainable resource use.
- Socioeconomic issues.
- Landscape and visual amenity.
- Contemporary heritage.
- Aboriginal heritage.

These issues would require further detailed assessment and are likely to require project specific impact mitigation measures.

A number of other environmental issues have also been identified in the preliminary environmental assessment. These issues are outlined in Section 7.11 and are generally considered to be common issues frequently encountered in construction projects. The potential impact of these additional environmental issues would be mitigated during construction and/or operation, largely through the application of best practice impact mitigation and management measures. They are unlikely to require unique or project specific impact mitigation measures.

It should be noted that some public authorities may identify other matters as key issues. Additionally, as the environmental assessment progresses, information may come to light which provides a greater understanding of issues such that they change in importance to the environmental assessment.

7.2 Fluvial geomorphology

7.2.1 Summary of potential issues

The following potential geomorphologic issues have been identified for the Williams River system downstream of the proposed dam wall at Tillegra:

- Altered frequency, duration and timing of channel maintenance flow events potentially leading to changes in the physical channel structure that could impact ecological processes.

- Reduced sediment transport due to trapping by the proposed dam, potentially leading to changes in the physical channel structure that could impact on ecological processes.
- Altered hydrology leading to altered channel and overbank hydraulics, meaning that some physical features such as bars and benches, floodplain surfaces and wetlands, may experience an altered pattern of inundation and exposure, in terms of frequency, duration and timing.
- The above issues require consideration for the dam filling phase, normal operation mode and drought operation mode as the pattern of outflows from the dam will be different in each case.

The following potential geomorphologic issues have been identified for the proposed inundation area upstream of the dam wall at Tillegra:

- Erosion of the reservoir shoreline, largely due to the combined effects of bank saturation, relatively stable water level, and wind waves.
- Deposition of sediment within the storage, potentially decreasing its capacity over time.

Mitigation measures could include:

- Operating the dam to ensure that channel maintenance flows still occur, even if at reduced frequency.
- Manual transfer (bypassing) of coarse bed material from upstream of the dam to downstream of the dam.
- Management of flow transfers so that important geomorphic features that can be identified as having ecological functions are inundated with a frequency, duration and timing that facilitates, as far as practicable, maintenance of natural ecological processes.

7.2.2 Further assessment

The following activities would be undertaken to assess the potential impacts of the Project on fluvial geomorphology and to identify appropriate impact minimisation and mitigation measures:

- Establish geomorphological flow objectives (covering the full range of geomorphologically active flows).
- More detailed assessment of sediment budgets (incorporating the entire river downstream of the proposed dam).
- Assessment of shoreline erosion processes.
- Sampling of bed and bank material, particle size analysis, and characterisation of geomorphic features.
- Determine the flows required to perform the identified geomorphological processes (all of which would be linked quantitatively to the important ecological processes identified by the ecological analysis).
- Assess the effectiveness of any proposed flow regime in achieving the geomorphological flow objectives and compare this with the effectiveness of the current flow regime.
- Identify alternative environmental flow options to meet the geomorphological flow

objectives (coordinated with the requirements of the ecological objectives).

- Assess the effectiveness of alternative environmental flow options in achieving geomorphological flow objectives.

7.3 Water quality and environmental flows

7.3.1 Summary of potential issues

The proposed Tillegra Dam is similar in size, volume and depth to Glennies Creek Dam (Lake St Clair) some 30 kilometres to the west. Monitoring and specialist studies in Glennies Creek Dam form a good indication of the likely behaviour of water quality in the proposed Tillegra Dam storage. The Glennies Creek Dam information indicates that Tillegra Dam would likely be strongly stratified in summer with adequate levels of dissolved oxygen in the surface waters (epilimnion). Deeper waters are likely to become depleted of dissolved oxygen leading to release of metals (manganese and iron) from sediments. As part of the environmental assessment, the Glennies Creek Dam data would be examined to see if vertical mixing could lead to water quality issues for short periods in autumn.

Releases from Tillegra Dam would be made via the multi-level offtake structure. This would facilitate matching (as far as practicable) physico-chemical properties (particularly water temperature, dissolved oxygen and nutrient concentrations) of storage water with the existing downstream river situation.

Blue-green algae blooms are common in the Seaham Weir pool and are also of concern for water supply storages. Blue-green algae is most likely due to elevated nutrient inputs from agricultural runoff. This was demonstrated for Glennies Creek Dam by the former Department of Land and Water Conservation (DLWC 2003). Causes, effects and control of blue-green algae blooms would be investigated further as part of the planning process.

Recreational usage, such as the use of motorboats on the storage, may have potential impacts on water quality both within the storage and for downstream users. These and other potential conflicts with maintenance of good water quality would be addressed during the environmental assessment. The possible occurrence of algal blooms could restrict some forms of recreation at certain times.

Downstream of Seaham Weir, reduced flows could lead to an increased number of days of saline ingress from the Hunter River estuary. The preliminary results from the hydrology model indicate there is relatively small change in the flow at Glen Martin. Assuming this low impact on flows also applies downstream then the estuarine salinity regime is expected to remain similar to existing conditions. Previous work in the estuary indicates the estuarine reach is strongly stratified by salt and temperature in the warmer months. An analysis of the relationship between flow past Seaham Weir and the salinity regime in the Williams River estuary below the weir will provide an assessment of the likely impact of the dam on estuarine salinity.

Environmental flow rules would be based upon analysis of future demand scenarios as applied to the long-term hydrographic database and determination of the environmental water requirements of the existing ecosystems.

A drought trigger release is proposed to be used for the filling period to provide a shorter time frame to achieve security of supply and as a contingency for occurrence of droughts in the future.

The minimum environmental flows, including a drought trigger, would be based upon analysis of the long-term hydrographic database and assessment of requirements for aquatic ecology. The Chichester River provides a significant inflow just five kilometres below the dam site. These inflows, in addition to tributary inflows further downstream, would be taken into account in setting the minimum and drought trigger environmental flow regimes.

7.3.2 Further assessment

The following activities would be undertaken to assess the potential impacts of the Project on water quality and to identify appropriate impact minimisation and mitigation measures:

- Analyse existing water quality and flow data to assess the relationship between discharge and water quality in the river reaches and at Seaham Weir pool.
- Assess discharge variability for existing and modelled future systems in terms of seasonality, periods of low flow and drought/wet cycles.
- Conduct aquatic life surveys to determine the density of fish in upstream and downstream reaches of the proposed dam site, including specific water quality and physico-chemical measurements for possible future use in AusRivAS assessments.
- Assess the effect of the Williams River inflows on the estuarine salinity regime.
- Determine river flow requirements for aquatic ecology, geomorphology, water quality and adjacent (riparian/floodplain) wetlands.
- Combine results of hydrology models and water requirements to determine appropriate (sustainable) environmental flow releases from Tillegra Dam.
- Identify appropriate drought trigger releases to provide security of supply and for longer droughts than indicated by the historical record.
- Assess the effects of high flow releases on geomorphology and aquatic life, and identify strategies to minimise changes to the high flow regime.
- Identify possible strategies to assist in maintaining water quality in the storage.
- Identify river management strategies using the results of the above assessments.

7.4 Aquatic ecology

7.4.1 Summary of potential issues

Experience has indicated that there is a range of potential ecological impacts on aquatic flora and fauna caused by dams. The modelled daily flows in the Williams River suggest there would be relatively small effects of the dam on overall river flows. This notwithstanding, the following potential changes and processes resulting from construction and operation of the dam could impact on aquatic assemblages of the Williams River:

- Mobilisation of sediment into waterways during dam construction.
- Loss of riverine habitat.
- Creation of artificial lacustrine (lake) and lentic (still water) environments.
- Changes to natural flow regime.
- Creation of barriers to fish passage.
- Alterations to aquatic habitat that impact on the abundance and/or availability of

invertebrate prey of fish (mainly insects and insect larvae).

The following ecological issues have been identified for specific locations within the region.

Inundation area

- Loss of approximately 20 kilometres of riverine habitat and associated assemblages.
- Creation of approximately 2,100 ha of artificial lacustrine and lentic environments.
- As the dam storage would be kept between 90 per cent and 100 per cent full outside of drought periods, vegetation of the storage perimeter is expected to provide a larger but different type of habitat for fish that prefer to live in a lake environment. There is evidence of introduced species such as Carp and *Gambusia* in the river that may reside in the dam.

Areas upstream of dam storage

- The reservoir and/or dam wall may disrupt or eliminate access to seasonal or ephemeral habitat. In the case of species that require downstream migration to estuarine habitat (and the return of recruits), these barriers may result in local extinction in areas upstream of the dam storage.
- Fragmentation of a continuous population and reduced genetic flow if the species is able to sustain itself above the barrier eg the Climbing Galaxias and Freshwater Catfish.

Dam wall to Chichester River confluence

- A barrier to passage may disrupt or eliminate access to upstream seasonal or ephemeral habitat. Female Australian Bass are known to inhabit upstream freshwater reaches and fish sampling is proposed to determine if they are distributed throughout the river system to determine if the dam would limit available habitat.
- The reduction in low flows (above environmental releases) could also impact on aquatic biota.
- Changes to flow regime may lead to a change in inundation patterns of adjacent wetlands reducing duration of, or timing of, access to these productive areas.
- An increase in the size or frequency flows in the range 500–1,600 ML/d associated with dam releases may have a greater impact on habitat closer to the spillway. This could result in the erosion of banks, riffle and gravel bars, altering or reducing critical habitat for fish and their invertebrate prey.
- Increased sedimentation in near-aquatic environments caused by major earthworks during construction. Increased sediment loads and high turbidity can cause direct mortality to fish and their invertebrate prey by damaging their gills, smother spawning grounds and macrophytes, infill shallow holes and a decrease in primary productivity via increased light attenuation.

Chichester River confluence to Seaham Weir

- Barriers to passage and/or changes to the flow regime can disrupt or eliminate access to upstream seasonal or ephemeral habitat. For example; changes to the timing, magnitude and/or frequency of flow events may affect the capacity of fish to migrate downstream and/or return from estuarine environments downstream of Seaham Weir. Australian Bass are one of several species with this life cycle requirement. Adults, particularly females, follow flood cues and migrate to estuaries downstream from May to August which corresponds with the period of highest flows in the Williams River. Juvenile fish migrate back upstream in spring and early summer. Should the flow regime change following regulation to more frequent higher flows in mid to late summer to support water demand this may have an impact on bass spawning and the return of juveniles.

- Impacts of changed flow regime on habitat structure with flow-on effects to distribution and abundance of invertebrate prey of fish

7.4.2 Further assessment

The following activities would be undertaken to assess the potential impacts of the Project on aquatic ecology and to identify appropriate impact minimisation and mitigation measures:

- Habitat assessment upstream, within the inundation area and downstream to Seaham Weir.
- Detailed fish surveys to determine the distribution and abundance of fish assemblages in the various reaches.
- Targeted surveys of important recreational fishing species (Australian Bass).
- Assess impacts on migratory species considering the modelled operational flow regime, proposed environmental flows regime, water quality, hydrological and geomorphology assessments.
- Assess the impact of the proposed operational water transfer scheme on aquatic habitats and the distribution and abundance of invertebrate fish prey.
- Assess the potential for significant impacts on relevant NES matters or on Commonwealth land and determine the need to make a referral to the Minister for the Environment and Water Resources in accordance with the EPBC Act.
- Explore mitigation and/or compensatory measures such as construction of a fishway at Tillegra Dam or, as an alternate compensatory measure, a fishway at Seaham Weir, and consideration of stocking the dam with fish.

The assessment would also include preliminary identification of areas in the vicinity of the project area which may be suitable for protection, enhancement or revegetation for provision of compensatory habitat to address biodiversity impacts if required.

Proposed fish sampling program

The assessment of the relevant potential issues outlined above is proposed to be undertaken by a sampling program at sites in the Williams River upstream and downstream of the dam site. The proposed sampling sites are:

- Reference reach upstream of Tillegra Dam (TDR1).
- Environmental flow reach 1 km downstream of the dam wall (TDE1).
- Environmental flow reach 1.5 km upstream of the Chichester River confluence (TDE2).
- Environmental flow reach 1.5 km downstream of the Chichester River confluence (TDE3).
- Reference reach 15 km downstream of the Chichester River confluence (TDR2).

Significant effects of dam releases, if any, on aquatic life are expected to be evident in the short distance from the dam site to the junction with Chichester River. These sampling sites are expected to cover these effects and river flows are expected to have recovered to be similar to the dam inflows by the river reach TDR2.

The effects of increased flows by water supply releases are also expected to be most evident in this short distance from the dam with little effect further downstream. However, to confirm this, AusRivAS sampling is proposed to be undertaken at the above sampling sites and at sites further downstream to Seaham Weir. If the sampling shows effects of increased river flows on macroinvertebrates is not significant as catchment size increases, then is it likely further sampling would only be needed in the reaches from TDR1 to TDR2.

The sampling would also confirm the suitability of future comparisons of TDR1 and TDR2 for assessment of the dam effects on river flows in the upper Williams River.

7.5 Terrestrial ecology

7.5.1 Summary of potential issues

The construction of Tillegra Dam and relocation of Salisbury Road would have a range of impacts on terrestrial ecology including potential impacts on species, populations or ecological communities listed as threatened under the EPBC Act and the TSC Act and the presence of other significant environmental features including regionally significant species or habitats of conservation significance.

The following potential issues relating to terrestrial ecology have been identified for the Project:

- Loss of riparian vegetation associated with the inundation area.
- Potential impacts on downstream riparian communities through significant changes to flow regimes.
- Fragmentation of riparian and remnant vegetation, and EECs.
- Loss of habitat for threatened fauna including some remnants within the inundation area.

7.5.2 Further assessment

The following activities would be undertaken to assess the potential impacts of the Project on terrestrial ecology and to identify appropriate impact minimisation and mitigation measures:

- Detailed floristic surveys to determine the presence and distribution of plant species and communities occurring within the project area as well as the suitability of habitat for threatened plant species
- Targeted surveys of potentially occurring threatened species
- Assess the significance of any impact on potentially occurring threatened species or communities as defined by the Part 3A process
- Assess the potential for a significant impact on relevant NES matters or on Commonwealth land and the need to make a referral to the Minister for the Environment and Water Resources in accordance with the EPBC Act
- Assessment of potential impact on vegetation corridors within the locality
- Assessment of potential impact on areas of high biodiversity

Assessments for flora and fauna will be undertaken in accordance with relevant DECC guidelines such as *Draft Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities*.

Assessments would include preliminary identification of areas in the vicinity of the project area which may be suitable for protection, enhancement or revegetation (including recharge and discharge areas to address salinity) for provision of compensatory habitat to address biodiversity impacts if required.

7.6 Sustainable resource use

7.6.1 Summary of potential issues

Modak, Berkel and Chandak (2004) have identified that the goal of sustainable resource use should be

> to use natural resources efficiently and effectively, to produce products and services that meet consumer needs and bring quality of life, while progressively reducing the ecological and social impacts associated with resource extraction, utilisation and recovery, to a level that is compatible with the eco-system's carrying capacity.

For the Tillegra Dam Project, sustainable resource use is a key issue for design, construction and operation of the dam. Strategies for the sustainable use of resources and the minimisation of impacts associated with energy usage and resultant greenhouse gas emissions would need to be developed.

The following potential sustainable resource use issues have been identified for the Project:

- Sourcing and availability of construction materials for the dam – this will be dependent on the type of dam wall to be constructed (concrete faced rockfill dam; earth core rockfill dam; roller compacted concrete dam; or earth fill dam).
- Increased fuel usage and transport costs associated with importation of construction material if required.
- Energy usage and greenhouse gas emissions for the construction of the dam, particularly related to fuel usage of construction plant and equipment.
- Management of construction wastes, including the ability to reduce, reuse or recycle.
- Loss of vegetation within the inundation area which would otherwise act as a potential carbon sink.
- Potential loss or sterilisation of resources within the inundation area.
- Sustainable use of water and potential impacts to environmental flows which could compromise the sustainability of downstream ecosystems.

7.6.2 Further assessment

The following activities would be undertaken to assess the potential impacts of the Project on sustainable resource use and to identify appropriate impact minimisation and mitigation measures:

- Review relevant legislation and policies.
- Assess the carbon and nitrogen cycles in the pre-impoundment watershed. This involves establishing a carbon budget including description of flow rates, concentrations, residence times, etc.
- Assess changes to carbon inputs in the watershed from various construction activities, including deforestation, fuel consumption by construction vehicles and embodied energy of construction materials.

- Assess characteristics of the proposed dam and inundated area that would change the carbon cycle (including size, temperature, bathymetry, etc).
- Assess emissions from associated infrastructure such as pumping stations, substations, etc.
- Examine residual benefits or co-effects of afforestation/reforestation.
- Identify cost effective and practical methods to provide carbon offsets such as separation of methane rich water, hydro-power generation, tree planting (including opportunities for mitigating historical impacts on downstream riparian vegetation), etc.
- Assess construction material requirements and the feasibility of sourcing these from within the inundation area.

7.7 Socioeconomic issues

7.7.1 Summary of potential issues

The proposed dam would affect approximately 2,100 ha of cleared and/or agricultural land through inundation as the storage fills. This would result in the displacement of existing property owners and leaseholders and the loss of productive agricultural land. As noted elsewhere in this report, HWC has progressively been acquiring land within and adjacent to the inundation area. As at September 2007, HWC had acquired approximately 70 per cent of land within the inundation area.

Flow-on effects to sections of the local business community could be expected through a reduced demand for certain services, eg building supplies. There would also be impacts on other items of value to the community such as Quart Pot/Munni Cemetery. Conversely, the dam would also provide opportunities for development of local and regional economic activities such as tourism.

Construction of the dam would necessitate the relocation of local roads (eg Salisbury Road), and community infrastructure and services (eg the RFS depot).

In short, there is a need to consider the financial flow on effects of the Project to the community, as well as the wider social implications of the project. From a technical perspective, some of the matters that have been identified include:

- Identification of augmentation measures that would provide the identified water supply shortfall and meet the water requirement objective to be set by HWC.
- Identification of source supply schedules and timing and sequencing of measures.
- Identification of capital costs, operating costs and supply volumes of potential water supply augmentation measures.
- Identification of any environmental and social impact mitigations that will need to be estimated included in the capital and operating costs for the measures including land acquisition, community displacement, relocation of roads and other services and reafforestation as a carbon offset.
- Opportunities for tourism or other initiatives to support local economic development.
- Compliance of economic assessment work using the cost effectiveness analysis (CEA) with the New South Wales Treasury's *Economic Appraisal Principles and Procedures Simplified* (July 2007).

Earlier preliminary work by the Hunter Valley Research Foundation (HVRF) examined the regional economic impacts from the construction of the Tillegra Dam. It was estimated that the economic benefit to the region would be substantial including generation of a significant number of jobs.

7.7.2 Further assessment

The CEA methodology would be used to assess the water supply options including the Tillegra Dam project. CEA is an analytical technique design to compare the costs and effectiveness of alternative options. The aim of using the method is to choose the least expensive alternative which guarantees that the specified goals/targets are fulfilled.

The advantages of the CEA approach are that the benefits of the water supply options do not have to be measured because the water yield supply targets and level of service would be defined by HWC in the initial stages of the EIA thereby transferring the study emphasis on the identification and measuring of direct and indirect costs that will comprise the options. The CEA approach concentrates on the cost analysis of water supply options to determine the least cost supply planning result The least cost supply planning is undertaken by considering the present value of costs of supplying water under the “with” project case versus the present value of supply costs under the “without” project case. Collective and quasi collective goods (ie benefits) whose values cannot be estimated on the basis of market prices (eg externalities and intangibles) would be qualitatively assessed and reported in the socioeconomic section and in other appropriate sections of the EA report.

Building on the earlier HVRF work, regional economic impact modelling would be undertaken for the EA by the Centre of Policy Studies (CoPS) Monash University. The CoPS will use updated construction costs for the Tillegra Dam for input in the computable general equilibrium (CGE) modelling process. The CGE modelling would determine the total economic impacts of the construction and operational phase of the project and provide results for key economic aggregates including net impact on state and regional output, employment and household consumption.

The views of the community and other stakeholders will be considered as part of the socioeconomic assessment.

7.8 Landscape and visual amenity

The principal components of the Project contributing to its visual impact are:

- The dam wall and spillway on southern abutment.
- The multi-level offtake.
- Associated infrastructure at the dam wall.
- The dam storage (impoundment) and inundation of existing landscape and heritage buildings.
- The relocated section of Salisbury Road.
- Tree planting around the storage.
- Viewing and recreational facilities located adjacent to the storage.

The visual aspects of these project elements are considered as follows.

7.8.1 Summary of potential issues

Dam wall and spillway

The introduction of the dam and spillway into the rural landscape at Tillegra would involve large bulky structures that would be visible from some residences in the area to the east of the dam site and potentially from vehicles travelling along Chichester Road or on the new alignment of Salisbury Road.

The crest of the dam wall would be at an elevation of approximately 153 mAHD which is more than 100 metres below the surrounding ridges. The wall would span about 700 metres between the northern and southern abutments. The finish of the eastern face of the dam wall would affect its appearance from the east. While there may be limited scope to vary the appearance based on the materials to be used, this matter would be reviewed as part of the design. Where practicable, structures on the dam wall would be designed to minimise their prominence and to blend in with the overall form of the dam structure. The visibility of the wall can be partly influenced by the degree that it occurs behind the ridge. If the dam is able to be keyed into the northern and southern abutments there may be scope to reduce the apparent lateral dimension of the completed wall structure.

Three of the four dam types under consideration would require a separate spillway. The spillway for the RCC dam would likely be integrated into the dam wall. For the other dam types, the spillway would be located on the southern abutment and be about 110 metres wide, passing though a channel excavated up to 15-20 metres depth into the top of the ridge line that would form the southern abutment. The spillway would continue downslope in a generally northeast direction to rejoin the Williams River. The current design of this feature means that it would be clearly visible from viewpoints to the east including Bandon Grove.

The spillway would be located in an area of remnant woodland vegetation which would need to be cleared for the spillway construction. Due to the aspect of the spillway it would be difficult to provide screening apart from at the location of viewpoints. A degree of filtering of views to the dam site would be provided by topography and vegetation. Possible alternative locations for the spillway would be considered as part of detail design.

Associated infrastructure at the dam wall

The associated infrastructure at the dam wall would include a hydro-electric power generation facility, water supply pipeline, pumping station and chlorinator, discharge structure and electricity supply works. While such structures are minor features of the overall changes at the dam site, the integration of their form with the overall structure would reduce their prominence and improve the appearance of the final installation. Screening could also be considered for these features. Power supply at the site may well be installed underground or in cable trenches to avoid above ground power lines being visible at the dam site.

Storage water body

A large area of existing farmland and scattered rural residences would be inundated following filling of the dam storage. The storage area would replace an often complex mix of fields, woodlands and cultural features with a large water body. While this would to some extent simplify the landscape, the contrast between the water body and the surrounding lands would increase the diversity of the views for the storage locality. The addition of trees around the storage would also vary the current landscapes. The appearance of the storage would also vary with fluctuations in the storage level. Lower storage levels would expose bare slopes that would be more subject to erosion with sediment potentially increasing turbidity of the storage waters.

Multi-level offtake

A multi-level offtake would be sited behind the dam wall, the final location being subject to detail design. Most of the structure would be usually below the storage level and its location would be mean that there are limited public views to the structure. The main areas where the structure would be visible by the general public will be from vehicles driving along the new Salisbury Road on the Chichester Range. The pipeline to the CTGM would be underground and likely visible only at connection points with the pump station at the dam and at the CTGM.

Realigned Salisbury Road

The proposed new route for Salisbury Road would cross the Williams River below the dam, requiring a new bridge, and then climb up and over the ridgeline eventually connecting with the existing Salisbury Road above the storage. All options for the initial section running up to the ridgeline would increase the visibility of the road in the vicinity of the dam compared to the existing road alignment. The elevated position of the road would provide potential for one or more lookouts where views of the dam, storage and surrounding country could be gained by travellers on the road.

Tree planting around the storage

Tree planting around the storage would be a positive contribution to providing an emissions and biodiversity offset, however, consideration would need to be given to species, distribution and suitability of land for such plantings. While HWC has committed to planting of 1.5 million trees, not all trees would necessarily be planted in the immediate vicinity of Tillegra Dam.

From a visual aspect, it would be beneficial to balance the plantings and to provide some diversity in the viewing experiences.

Recreation facilities

One or more recreation areas could be provided around the storage. These would likely be further removed from the dam wall and steep slopes and potentially in the north western part of the storage. While these would provide a beneficial use of the storage, any development of recreation facilities would need to be sensitively designed to blend in with the landscape.

7.8.2 Further assessment

The following scope of work was identified for the environmental assessment:

- Identification of key visual aspects of the development and impacted elements of the community.
- Identification of appropriate locations in the viewshed for development of photomontages to illustrate the visual effect of significant elements of the Project.
- Provision of description and appropriate supporting graphics to demonstrate the nature of the proposed changes.
- Identification and development of practicable measures to mitigate visual impacts.
- Identification of opportunities to jointly mitigate visual and other impacts where practicable and cost effective (eg reafforestation).

7.9 Contemporary heritage

7.9.1 Summary of potential issues

The following potential issues relating to contemporary heritage have been identified for the Project:

- The loss of locally significant heritage items within the inundation area.
- The loss of an archaeological site that may be of State heritage significance (c1829 Mann's hut and stockyards).
- The preservation of Munni House and relocation of Quart Pot/Munni Cemetery.
- The requirement to mitigate the potential impact of Tillegra Dam on identified heritage items through archival recording, archaeological investigation, heritage interpretation and oral history recording.

7.9.2 Further assessment

The following scope of work was identified for the environmental assessment:

- Identification and recording of heritage items by conducting more comprehensive field survey, broader community consultation and historical research.
- Further assessment of the proposed impact of the proposal on identified heritage items including the preparation of Statements of Heritage Impact (SOHI) for built heritage items and Archaeological Impact Assessments (AIA) for known and potential archaeological sites.
- Preparation of management strategies for Quart Pot/Munni Cemetery and Munni House to inform activities prior to and during construction and filling of Tillegra Dam.
- Further consideration of options to mitigate the impact of Tillegra Dam on identified heritage items. These options include archival recording, archaeological investigation, heritage interpretation and/or oral history recording.

7.10 Aboriginal heritage

7.10.1 Summary of potential issues

As part of the preliminary environmental assessment a total of nine survey units were surveyed on foot totalling approximately 175 ha. No Aboriginal sites were located as part of the field inspections. One small piece (<20 mm) of silcrete was located eroding out of the banks of the upper reaches of a first order creek line. It is likely the silcrete piece is a by-product of artefact flaking. The silcrete piece provides evidence of human activity as it is not stone that is naturally occurring in that location.

- Ground surface visibility is a major issue for the identification of sites within the project area. Visibility was generally less than one per cent across the project area.
- A background analysis of the project area and its environmental and archaeological context revealed that the region is at present poorly understood archaeologically. Very few studies have been undertaken and therefore very few Aboriginal sites have been recorded in the region. Predictive models are currently poorly developed and not easily verifiable due to the ground conditions.
- Aboriginal people clearly inhabited the project area region and it remains in doubt

whether the issue of visibility entirely explains the absence of sites. Geomorphological processes in the Williams River valley clearly also play a part in the likely preservation of sites and need to be further understood.

- There is currently a lack of local Aboriginal community information about cultural sites in the area.
- An understanding of the impacts of inundation on archaeological sites will be important in ongoing assessment of the project.

Appropriate mitigation measures would need to be further developed in conjunction with greater understanding of the indirect impacts and the nature and extent of the archaeological resource of the project area.

7.10.2 Further assessment

The following scope of work was identified for the environmental assessment:

- Undertake further Aboriginal consultation in accordance with the DECC (2005) *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation.*
- Undertake appropriate consultation in the community to identify individuals or organisations with relevant information about past Aboriginal occupation of the project area region.
- Undertake assessment in collaboration with appropriate specialists to understand the extent of potential impacts associated with inundation of sites or PADs.
- Conduct further analysis to improve understanding of the potential for alluvial deposits within the project area to contain archaeological deposit or paeleosurfaces with archaeological potential.
- Undertake further investigation of a landform based model to determine the effectiveness of predictive modelling and the likelihood of intact areas of archaeological deposit occurring across the project area.

7.11 Other environmental issues

In addition to the environmental aspects already discussed, the following issues would also be addressed in the detailed environmental assessment:

- Land use changes.
- Infrastructure, dilapidation and access.
- Geology and soils.
- Contaminated land.
- Air quality, climate and greenhouse gases.
- Waste management.
- Hazards and risks (including dam safety issues).
- Cumulative impacts.

These are considered to be of relatively lesser consequence taking into account the scope of the Project, the existing environment and the implementation of standard and best practice management and mitigation measures.

These issues are summarised in Table 7.1 together with proposed management and mitigation measures. These would be reviewed further during the preparation of the detailed environmental assessment.

Any additional environmental safeguards required to minimise and mitigate impacts would be documented in the Statement of Commitments in accordance with Section 75F(6) of the EP&A Act as part of the environmental assessment.

Table 7.1 Other environmental issues

Issue	Potential impacts	Management and mitigation measures
Land use changes Land currently used for agriculture and other purposes within the inundation area will obviously change. There may be other consequential land use changes in the district associated with the potential use of the storage for recreational activities such as fishing, boating, etc.	Virtually all the land to be inundated is zoned Rural 1(a). Some land zoned Recreation 6(a) in the upper reaches of the storage area near FSL may also be affected. The dam wall and spillway would affect Crown Land zoned Environment 7(a).	Given the nature of the land use change, there would be limited opportunities to specifically mitigate this impact. There may, however, be opportunities to facilitate or support alternative economic activities such as tourism.
Infrastructure, dilapidation and access The Project would impact on infrastructure such as electricity and telecommunication services either directly through construction activities or from rising water levels in the inundation area. Transport of construction materials could contribute to wear and tear on local roads and bridges. The relocation of Salisbury Road and Quart Pot Creek Road would likely affect access for a number of property owners. Construction activities may also temporarily affect access to properties.	The Project could impact on utilities principally through a disruption to service. The likelihood of this is low and would generally be limited to short periods associated with the switch over from existing infrastructure to new replacement infrastructure.	Affected utilities would be relocated in consultation with the respective owners. This would occur prior to the commencement of construction. Opportunities to co-locate services would be investigated during detail design.
	Wear and tear on local roads and bridges could affect level of service and potentially safety for other road users. Similarly, construction activities could impact on other infrastructure such as buildings in close proximity to construction activities.	Pre- and post-construction dilapidation surveys would be undertaken to assess the effects of construction activities on local roads and other potentially affected infrastructure. The need for remedial works (or other measures) to meet necessary level of service and safety standards would be assessed in consultation with Dungog Shire Council prior to construction and implemented as appropriate. Level of service and safety on local roads used by construction traffic would be monitored periodically during construction. Remedial measures would be implemented as appropriate.
	There may be a need to change existing access arrangements to individual properties either temporarily during construction or permanently.	Alternative access arrangements would be provided in negotiation with affected property owners to a standard at least equal to that which previously existed.

Issue	Potential impacts	Management and mitigation measures
Geology and soils		
Geological conditions will have a significant influence on design considerations for the dam. Management of erosion potential would require attention during construction activities and may also be an issue with respect to the new shoreline of the storage.	Seismic activity, faulting movement and differential weathering could affect the integrity of the dam wall and other infrastructure. Erosion of unconsolidated or disturbed material from construction activities could result in sedimentation and impact on water quality and aquatic ecology. Degraded water quality could also affect downstream water users. Erosion could also be a potential operational issue. Inappropriate land management practices upstream of the dam could result in increased rates of sediment generation. Sediment could also be generated through erosion along the new shoreline. Over the long term, sediment build up could reduce the storage volume. Accumulation of sediment in proximity to the offtake could reduce operational flexibility.	A detailed investigation of geotechnical conditions would be undertaken as part of the design process. Erosion control measures for construction activities would be designed in accordance with accepted practices (eg the 'Blue Book') and implemented through a project-specific erosion control and sedimentation plan which would be prepared prior to construction. Areas around the storage shoreline would be assessed for erosion potential and appropriate stabilisation measures (eg rock blankets, gabions, vegetation, etc) implemented. The amount of vegetation to be removed for construction activities would be kept to a minimum.
Contaminated land		
Some farming activities (such as use of cattle dips) can be highly polluting. Runoff of excess nutrients into water bodies may also be an issue.	Pollutants from contaminated sites could enter the water column following inundation and have a detrimental effect on storage water quality. Environmental and health impacts could also arise due to the disturbance of contaminated land during construction. The limited assessment undertaken to date suggests the expected level of impact to be low to moderate.	Further investigation would be undertaken during the design phase to assess the likelihood of contaminants occurring in the inundation area and in areas where construction activities would take place. A risk assessment would be undertaken prior to the commencement of works to determine the likelihood of encountering contaminated land. Should it be required the presence and extent of contamination would be determined at potentially contaminated sites, and where required, remediation would be planned and undertaken in consultation with the DECC. This would be undertaken in accordance with applicable requirements of the *Contaminated Land Management Act 1997* and State Environmental Planning Policy 55 – *Remediation of Land* (SEPP 55). If required, procedures for correct handling of

Issue	Potential impacts	Management and mitigation measures
		contaminated material would be incorporated into the Construction EMP.
Waste management		
The Project would generate a number of waste streams and utilise a variety of materials during the construction phase.	Wastes generated during construction would potentially include excess unsuitable spoil material, material from the removal of sections of existing road, concrete and road base, steel, waste oils and liquids from maintenance of construction plant and equipment, waste water and general garbage and sewage. Green waste (cleared vegetation) would also be generated. During operation, generation of waste products would be minimal and generally be limited to those activities associated with ongoing maintenance.	To minimise impacts associated with waste, the resource management hierarchy principles of the *Waste Avoidance and Resource Recovery Act 2001* would be adopted as follows: 1. Avoid unnecessary resource consumption as a priority; 2. Avoidance is followed by resource recovery (including reuse of materials, reprocessing, recycling, and energy recovery; and 3. Disposal is undertaken as a last resort. These principles would be used in developing strategies to minimise impacts associated with waste generation and disposal. The strategies would be included in the Statement of Commitments and in the waste management plan(s).
Dam safety		
	Failure of the dam wall would result in flooding, property damage, personal injury and potential loss of life.	Tillegra Dam would be prescribed under the NSW *Dams Safety Act 1978*. HWC would comply with safety requirements required under that Act and the requirements of the Dam Safety Committee. Dam design would be subject to expert peer review. Design would allow for emergency de-watering. A Dam Safety Emergency Plan would be prepared and implemented. An asset management plan would be implemented to ensure appropriate maintenance works are routinely carried out.

Issue	Potential impacts	Management and mitigation measures
Hazards and risks		
During construction, the workforce and the general public may be exposed to certain hazards associated with construction activities. The design process would address post-construction, hazards and risk such that residual hazards would be minimal and able to be managed through appropriate operational practices. The issue of dam safety is dealt with separately above.	Potential hazards and risks associated with construction of the Project include hazards of working in close proximity to heavy machinery and construction plant. The likelihood of significant impacts on the general public is consider low as they would be excluded from all construction areas. There may be potential for minor impacts where it would be necessary to undertake construction work in close proximity to areas used by the general public (such as crossing a public road), however, these would be adequately managed through preparation and implementation of appropriate safety plans.	Specific construction hazards would be addressed through best practice industry occupational health and safety measures including training, accreditation, adherence to NSW WorkCover requirements, backed up by inspections, audits and site management planning for occupational health and safety. These measures would be included in the Statement of Commitments and detailed in a hazards and risk management plan. The Plan would be prepared prior to the commencement of works and would include contingency measures to deal with accidents and major incidents resulting from the works. The Plan would cover both construction personnel and the general public.
	Likely hazards associated with operation of the Project can be separated into those faced by HWC personnel in carrying out routine maintenance and related activities and by the wider community. Hazards for HWC personnel may include working at heights, working in confined spaces, working close to water, handling of hazardous materials (such as chemicals) and such like. Hazards for the wider community are expected to be minimal and not necessarily unique to the dam. For example, use of the storage for water-based activities would carry a certain low level of risk but this would generally be no different from the use of any lake or river.	The effective management of operational hazards would be addressed through a combination of design and operational management practices. For HWC personnel, appropriate training would be provided in all facets of maintenance work. This would be undertaken in accordance with a formal occupational health and safety management system. For the general public, management strategies would include exclusion from specific areas (such as through provision of safety fencing), provision of appropriate signage, etc. Specific measures would be developed during the detail design phase. Management of potential hazards associated with possible use of the storage for recreational activities would be addressed separately as part of consideration of any such proposals.

Issue	Potential impacts	Management and mitigation measures
Air quality		
The Project is located within a rural environment and air quality is generally high. Local air quality is influenced by the variable topography throughout the project area and climatic conditions. There is a limited number of sensitive receptors (such as residences) within the project area and in proximity to the major construction areas.	Emissions would be small and generally related to construction only (greenhouse gas emissions during operation considered elsewhere). During construction, activities such as earthworks, stockpiling and vegetation removal would expose soils that have the potential to be eroded by wind, resulting in dust. Emissions from heavy vehicles and construction machinery would also occur. The extent of impacts would vary depending on the type of construction activity being undertaken and prevailing weather conditions. Potential construction air quality effects would be unlikely to result in significant adverse impacts due to their short-term nature and the fact that there are limited sensitive receptors within the project area. There is likely to be negligible impacts on air quality during operation of the storage. The incremental impact on air quality associated with use of new roads is considered negligible.	Construction impacts would be subject to the application of standard mitigation and best practice construction measures for suppression of dust, minimisation of land clearing and management of emissions from construction plants. No burning of cleared vegetation or other materials would be permitted. These and other relevant measures would be identified in the Statement of Commitments and carried through to an air quality management plan which would be prepared prior to the commencement of works.
Noise and vibration		
The existing ambient noise levels for the project area and surrounds are considered low. Sources of noise within and surrounding the project area include infrequent road traffic. There is a low number of noise and vibration sensitive receivers within the project area.	During construction, it is anticipated that noise and vibration levels would be increased in the short-term as a result of construction activities and associated heavy vehicle movements. There is the potential for levels to exceed the relevant NSW Government criteria particularly if blasting is undertaken. The perception of the relative noise level increase may also be an issue as a result of the existing low to moderate ambient noise levels experienced within the project area. Noise emissions from operations would be associated with the pump station and the hydro-electric power station. Noise emissions may also be associated with water discharges through the outlet channel and spillway.	Impacts expected during construction would be managed through the adoption of management practices consistent with the NSW Government's *Environmental Noise Control Manual* (Chapter 171) which sets out noise criteria applicable to construction site noise for the purpose of defining intrusive noise impacts. Such practices include respite periods and scheduling noisy activities to limit their impact. Impact mitigation measures and procedures would be identified in the Statement of Commitments and included in a noise and vibration management plan (NVMP) which would prepared prior to the commencement of works. Should blasting be required, a blast management plan

Issue	Potential impacts	Management and mitigation measures
		would be prepared as part of the NVMP and would be implemented in consultation with the DECC. Impacts associated with construction vibration will also be minimised through the adoption of best management practices and the application of relevant standards such as German Standard DIN 4150 (1999) and British Standard BS6472. Prior to construction, dilapidation surveys would be undertaken on buildings that could be potentially impacted (generally buildings located within 20 m of works). Management strategies to minimise impacts associated with increased vibration levels would be developed and included in the Statement of Commitments for the Project and would be detailed in the NVMP. Control of noise from operational activities would be achieved through design and specification of the required acoustic performance of enclosures, pipework, penetrations and the like.
Cumulative impacts		
Planning and construction of the Project would likely occur in parallel with other local and regional developments and there would be potential for impacts associated with individual projects to collectively affect particular areas or sections of the community.	The specific nature of cumulative impacts would be a challenge to characterise and would likely be dependent on availability of suitable information relating to other developments. Possible impacts could include increased volumes of construction traffic along particular transport routes, demands on specific construction materials, etc. It is currently unclear whether there would be significant cumulative operational impacts.	During the detailed assessment, a desktop review would be undertaken to identify other major developments whose impacts could overlap (in time and or space) with the Project. Subject to the availability of suitable information, the associated impacts would be assessed with respect to the Project. Preparation of environmental management plans for the construction phase would include consideration of other major developments concurrently underway. Opportunities to implement appropriate mitigation measures would be identified and implemented where cost effective and practicable.

8 Proposed Scope of Environmental Assessment

Table 8.1 outlines the proposed scope of the environmental assessment for the Project. This is based on the preliminary assessment of key issues discussed in Chapter 6. All other issues would be able to be managed through detail design and through the application of best practice measures and site-specific safeguards as described in Table 7.1.

Table 8.1 Scope of the environmental assessment

Issue	Scope of studies for EIA
General	▪ Consideration of planning and statutory requirements ▪ Detailed description of the Project ▪ Outline of construction activity including construction timetable, material requirements and sources, likely heavy vehicle movements, construction hours, etc ▪ Consideration of the principles of ecologically sustainable development with regard to the Project ▪ Assess the potential for a significant impact on relevant NES matters or on Commonwealth land and determine the need to make a referral to the Minister for the Environment and Water Resources in accordance with the EPBC Act
Stakeholder consultation	▪ Description of consultation activities conducted to date and issues identified ▪ Outline of proposed stakeholder consultation and communications strategy
Fluvial geomorphology	▪ Establish geomorphological flow objectives (covering the full range of geomorphologically active flows) ▪ More detailed assessment of sediment budgets (incorporating the entire river downstream of the proposed dam) ▪ Assessment of shoreline erosion processes ▪ Sampling of bed and bank material, particle size analysis, and characterisation of geomorphic features ▪ Determine the flows required to perform the identified geomorphological processes ▪ Assess the effectiveness of any proposed flow regime in achieving the geomorphological-flow objectives and comparison with the effectiveness of the current regime ▪ identify alternative environmental flow options to meet the geomorphological flow objectives ▪ Assess the effectiveness of the alternative environmental flow options in achieving the geomorphological flow objectives
Water quality and environmental flows	▪ Analyse existing water quality and flow data to assess the relationship between discharge and water quality in the river reaches and at Seaham Weir pool ▪ Assess discharge variability for existing and modelled future systems in terms of seasonality, periods of low flow and drought/wet cycles ▪ Conduct aquatic life surveys to determine the density of fish in upstream and downstream reaches of the proposed dam site, including specific water quality and physico-chemical measurements for possible future use in AusRivAS assessments

Issue	Scope of studies for EIA
	▪ Assess the effect of the Williams River inflows on the estuarine salinity regime ▪ Determine river flow requirements for aquatic ecology, geomorphology, water quality and adjacent (riparian/floodplain) wetlands ▪ Combine results of hydrology models and water requirements to determine appropriate (sustainable) environmental flow releases from Tillegra Dam ▪ Identify appropriate drought trigger releases to provide security of supply and for longer droughts than indicated by the historical record ▪ Assess the effects of high flow releases on geomorphology and aquatic life and identify strategies to minimise changes to the high flow regime ▪ Identify possible strategies to assist in maintaining water quality in the storage ▪ Identify river management strategies using the results of the above assessments
Aquatic flora and fauna	▪ Habitat assessment upstream, within the inundation area and downstream to Seaham Weir ▪ Detailed fish surveys to determine the distribution and abundance of fish assemblages in the various reaches ▪ Targeted surveys of important recreational fishing species ▪ Assess impacts on migratory species considering the modelled operational flow regime, proposed environmental flows regime, water quality, hydrological and geomorphology assessments ▪ Assess the impact of the proposed operational water transfer scheme on aquatic habitats and the distribution and abundance of invertebrate fish prey ▪ Explore mitigation and/or compensatory measures, eg construction of a fishway at Tillegra Dam or, as an alternate compensatory measure, a fishway at Seaham Weir, and consideration of stocking the dam with fish ▪ Preliminary identification of areas in the vicinity of the project area which may be suitable for protection, enhancement or revegetation (including recharge and discharge areas to address salinity) for provision of compensatory habitat to address biodiversity impacts if required
Terrestrial flora and fauna	▪ Detailed floristic surveys to determine the presence and distribution of plant species and communities occurring within the project area as well as the suitability of habitat for threatened plant species ▪ Targeted surveys of potentially occurring threatened species ▪ Assessment of the significance of any impact on potentially occurring threatened species or communities as defined by the Part 3A process ▪ Assessment of potential impact on vegetation corridors within the locality ▪ Assessment of potential impact on areas of high biodiversity
Sustainable resource use	▪ Review relevant legislation and policies ▪ Assess the carbon and nitrogen cycles in the pre-impoundment watershed ▪ Assess changes to carbon inputs in the watershed from various construction activities including deforestation, fuel consumption by construction vehicles and embodied energy of construction materials ▪ Assess characteristics of the proposed dam and inundated area that would change the carbon cycle ▪ Assess emissions from associated infrastructure such as pumping stations, substations, etc ▪ Examine residual benefits or co-effects of afforestation/reforestation

Issue	Scope of studies for EIA
	▪ Identify cost effective and practical methods to provide carbon offsets ▪ Assess construction material requirements and the feasibility of sourcing these from within the inundation area
Socioeconomic issues	▪ Assessment of preferred water supply option (Tillegra Dam) using CEA methodology in accordance with the NSW Treasury's *Economic Appraisal Principles and Procedures Simplified* ▪ Apply CGE modelling process to assess regional economic impacts of the Project ▪ Consider the views of the community and other stakeholders as part of the socioeconomic assessment
Visual	▪ Identification of key visual aspects of the development and impacted elements of the community ▪ Identification of appropriate locations in the viewshed for development of photomontages to illustrate the visual effect of significant elements of the Project ▪ Provision of description and appropriate supporting graphics to demonstrate the nature of the proposed changes ▪ Identification and development of practicable measures to mitigate visual impacts ▪ Identification of opportunities to jointly mitigate visual and other impacts where practicable and cost effective
Contemporary heritage	▪ Identification and recording of heritage items by conducting more comprehensive field survey, broader community consultation and historical research ▪ Further assessment of the proposed impact of the proposal on identified heritage items, including the preparation of Statements of Heritage Impact (SOHI) for built heritage items and Archaeological Impact Assessments (AIA) for known and potential archaeological sites ▪ Preparation of management strategies for Quart Pot/Munni Cemetery and Munni House to inform activities prior to and during construction and filling of Tillegra Dam ▪ Further consideration of options such as archival recording, archaeological investigation, heritage interpretation and oral history recording to mitigate the impact of Tillegra Dam on identified heritage items
Aboriginal archaeology	▪ Undertake further Aboriginal consultation in accordance with the DECC *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (2005) ▪ Undertake appropriate consultation in the community to identify individuals or organisations with relevant information about past Aboriginal occupation of the project area region ▪ Undertake assessment in collaboration with appropriate specialists to understand the extent of potential impacts associated with inundation of sites or PADs ▪ Conduct further analysis to improve understanding of the potential for alluvial deposits within the project area to contain archaeological deposit or paeleosurfaces with archaeological potential ▪ Undertake further investigation of a landform based model to determine the effectiveness of predictive modelling and the likelihood of intact areas of archaeological deposit occurring across the project area

Issue	Scope of studies for EIA
Cumulative impacts	▪ Detail the Project in its relationship to other developments occurring or proposed ▪ Identify potential cumulative impacts
Statement of Commitments	▪ A full list of environmental mitigation and management measures to be applied to the project works, including identification of procedures, practices and protocols

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