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AN ASSESSMENT OF GREENHOUSE GAS EMISSIONS FROM THE PROPOSED TILLEGRA DAM

THE WILDERNESS SOCIETY

Institute for Sustainable Futures

UNIVERSITY OF TECHNOLOGY SYDNEY

AN ASSESSMENT OF GREENHOUSE GAS EMISSIONS FROM THE PROPOSED TILLEGRA DAM

September 2009

For The Wilderness Society Newcastle

Institute for Sustainable Futures, University of Technology Sydney

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Please cite this report as: Institute for Sustainable Futures, 2009, AN ASSESSMENT OF GREENHOUSE GAS EMISSIONS FROM THE PROPOSED TILLEGRA DAM Prepared for The Wilderness Society Newcastle Inc. by the Institute for Sustainable Futures, University of Technology, Sydney.

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Executive Summary

The proposed Tillegra Dam would be a significant source of greenhouse gas (GHG). The claims that the dam would be carbon neutral cannot be sustained and the environmental assessment report (EAR) for the Tillegra project needs to be amended.

Even if the GHG emissions from the dam's construction are ignored, it is estimated that a total of at least 327,400 t CO_2-eq (tonnes of carbon dioxide equivalent) of GHG emissions would result from the Tillegra Dam in its first 20 years. However there are large uncertainties associated with surface emissions from water storage dams and these alone could easily contribute 1.0 million t CO_2-eq.

Excluding its construction, the Tillegra Dam will increase the operational GHG intensity of water supply in the Lower Hunter by at least 46%. The potential surface emissions alone from the proposed Tillegra Dam could be equivalent to adding an extra 27,000[1] cars to the Hunter's roads.

The bulk of the GHG emissions from the Tillegra Dam will be surface emissions generated as flooded organic material decomposes. Decomposition produces carbon dioxide and methane. Methane gas surface emissions will be of particular concern because methane has a global warming potential 72 times that of carbon dioxide over a 20-year timeframe, and 25 times that of carbon dioxide over a 100-year timeframe (IPCC 2007).

Once the dam was constructed, the increased emissions would be unavoidable because unlike the GHG emissions associated with new supplies such as recycled or desalinated water, the emissions from large dams occur regardless of whether their water is used.

The GHG assessment in the Tillegra EAR ignores methane generation and release from the storage. This would be the largest source of GHG, and this major flaw means that the EAR needs to be amended.

The carbon offset claims in the EAR are also unsound. The EAR claims that there would be a significant offset for renewable energy generated by a mini hydroelectric plant but no such plant is included in the project. Also of concern is the simplistic inclusion of tree planting as an offset with no consideration of important factors such as the loss of soil carbon in the establishment of plantations on agricultural land.

In stark contrast to the GHG emissions from the Tillegra Dam proposal, a sustainable water strategy for the Lower Hunter, based on improved water efficiency and water conservation measures, could <u>reduce</u> GHG emissions by an estimated 1.5 million tonnes of t CO_2-eq over a 20-year period.

[1] Based on an average car producing approximately 4 t CO_2-eq per year

This report makes seven recommendations as follows:

Recommendation 1 – The Tillegra Dam EAR should be amended to include methane emission from the water storage.

Recommendation 2 – The Tillegra Dam EAR should be amended by removing the offset claimed for renewable energy generated by the mini hydroelectric plant

Recommendation 3 – The Tillegra Dam EAR should be amended to account for current understandings of the soil carbon dynamics associated with tree plantings.

Recommendation 4 – The Tillegra Dam EAR should be amended to include the GHG emissions from the manufacture of materials used in the construction of the Tillegra Dam, particularly steel and cement.

Recommendation 5 – All actions towards building the Tillegra Dam should be halted until a carbon neutral strategy that accounts for Recommendations 1, 2, 3 and 4 can be defined.

Recommendation 6 – The full GHG impacts of dam proposals including surface emissions should be included in future planning for urban water supply across Australia.

Recommendation 7 – the Australian Government should include surface reservoir emissions, particularly those from storages built after 2010, under the CPRS cap.

1. Introduction

This report was produced by the Institute for Sustainable Futures (ISF) at the University of Technology, Sydney. It is an assessment of the greenhouse gas (GHG) impact of the proposed Tillegra Dam. The outline of the report is as follows:

- Chapter 2 provides a background information on GHG emissions from water supply dams and explains why water storages are significant sources of emissions. It also examines the sources of GHG emissions from the Tillegra Dam proposal specifically.
- Chapter 3 reviews the GHG assessment contained in the Tillegra Dam environmental assessment report (EAR) and highlights critical deficiencies.
- Chapter 4 provides an estimate of the GHG emissions that will be generated if the Tillegra Dam is built. The estimate uses the factors set out in Intergovernmental Panel on Climate Change (IPCC, 2007).
- Chapter 5 compares these emission estimates to the current GHG impact of water supply in the Lower Hunter and to GHG emissions (reduction) which could result from a more sustainable water supply strategy.
- Conclusions from this research and resulting recommendations are drawn in Chapter 6.

2. Background

Greenhouse gas emissions from water supply dams

GHG emissions are generated from multiple sources associated with the construction, filling and operation of large water supply dams. These sources include potentially significant emissions released from the dam itself. These emissions, termed surface emissions in this paper, are not currently well understood. However an emerging body of research indicates that surface emissions may be significant from an urban water planning perspective when compared to the impact of alternative water supply strategies, and even when compared to energy intensive new supplies such as seawater desalination.

Importantly, unlike the GHG emissions associated with new supplies such as recycled or desalinated water, the surface emissions from dams occur whether or not water is drawn from them. Moreover, the Australian Government's proposed Carbon Pollution Reduction Scheme (CPRS) does not take the impact of surface emissions into consideration and will do nothing to discourage them. In other words surface emissions will be additional to the emissions 'cap' set by the CPRS.

Emissions from the surfaces of reservoirs are generated beneath the water surface as a result of the decomposition of flooded organic material, which releases carbon dioxide and methane to the atmosphere. Currently these emissions are largely unaccounted for in decision-making regarding new dams. However, from a global perspective they may account for up to 7% of all global warming from documented anthropogenic (man-made) emissions worldwide (St Louis et al. 2000).

In Australia only a small amount of research has been conducted on the greenhouse emissions from water storages and there has been very limited monitoring of these emissions. However, estimates for the proposed Traveston Crossing Dam have shown that its GHG impact would be higher than the alternative desalinated supply (Turner et al. 2007).

With the prospect of new dams such as the Tillegra Dam in the Lower Hunter and the Traveston Crossing Dam in South East Queensland, there is a concern that a potentially major source of new greenhouse emissions from urban water systems is being overlooked.

Reservoir surface emissions

Reservoir surface emissions are generated by the decomposition of organic material beneath the water surface when land is flooded to form a reservoir. There are multiple sources of organic material in the reservoir. In the short term, the main source is biomass present in the region prior to inundation. This is because although when a dam is built the vegetation is typically cleared, there will still be remaining debris such as leaf matter as well as significant carbon in the soil that is submerged under the reservoir waters. In the Upper Williams River Valley the land which would be inundated by the Tillegra Dam is currently used for dairy farming, so rich soils can be expected.

Over time, ongoing inputs will include organic matter that washes in from upstream, plants that might grow on the surface of the reservoir, and any other organic matter from the shores and soils of the reservoir that may settle to the bottom of the lake bed. Organic material is decomposed by microbiological processes mostly at the base of the water column in the bed sediments, which produces carbon dioxide and methane as a result. These gases move upwards through the water column and are released as surface emissions. Methane is produced predominantly through the decomposition of organic matter by bacteria such as methanogens, which operate within anaerobic conditions in soils and water. If the methane percolates up the water column through more aerated regions, another group of bacteria, methanotrophs, will partially oxidise the methane (CH_4) into carbon dioxide (CO_2). Finally, a combination of carbon dioxide and methane gas will be emitted from the surface of the reservoir (Abril et al. 2005).

There are three main mechanisms by which carbon dioxide and methane are transported from their source of generation to the water surface (IPCC 2006a):

1. Diffusive emissions, which occur due to molecular diffusion through the water column and across the water-air interface. This is the major pathway for carbon dioxide, but is a relatively minor pathway for methane (St Louis et al. 2000)
2. Bubble emissions, which are gas emissions generated in sediments that move through the water column as bubbles. This is a minor pathway for carbon dioxide but possibly the major pathway for methane (St Louis et al. 2000)
3. Degassing emissions, which result from a sudden change in hydrostatic pressure, such as the change caused by the passage of water through a turbine when hydoelectic power is generated or turbulence is caused by a spillway.

All three mechanisms have the potential to operate in the case of the proposed Tillegra Dam. Figure 1 gives a diagrammatic representation of the generation and release of surface emissions.

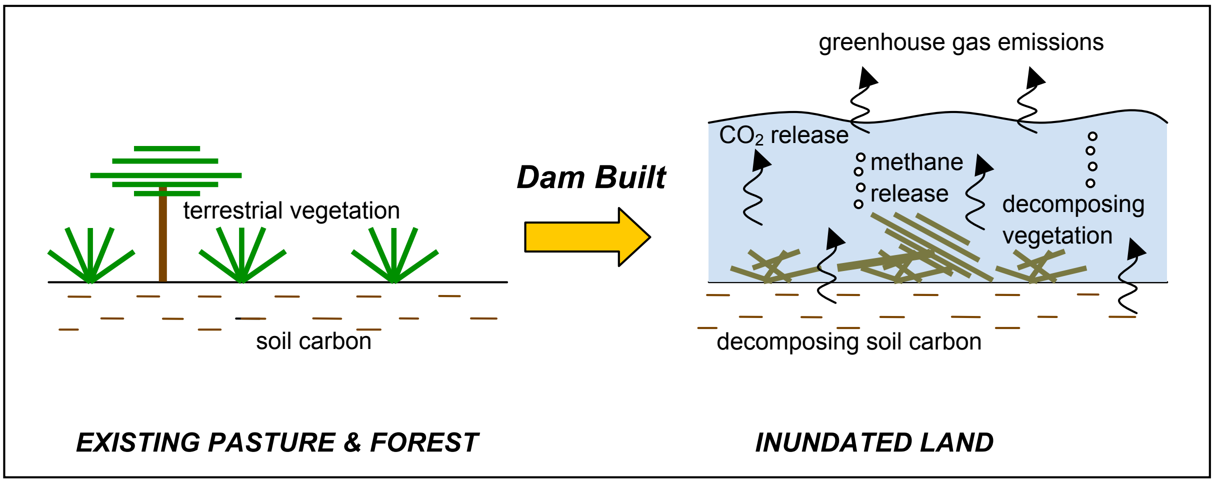

Figure 1: The generation and release of surface emissions

The amount of carbon dioxide and methane released from given water storages will depend on a number of factors (Kelly 1997; St Louis et al. 2000) including:

- The amount of readily decomposable organic carbon that is flooded when the reservoir is created (such as grass, leaves and soil carbon, but not tree trunks which do not decompose easily in fresh water).
- The age of the reservoir, as the profile of surface emissions will most likely be greatest in the years immediately following inundation (initial decade or so) and probably decrease over the following decades (IPCC 2006a). However in a review study covering a significant number of temperate and tropical dams it was noted by St Louis et al. (2000) that all of the reservoirs studied continued to generate surface emissions regardless of age, and did not seem to become similar to natural lakes even after many decades.
- Water temperature, which affects the rate of microbiological activity decomposing organic matter.
- The amount of ongoing carbon inputs deposited into the reservoir.

In assessing the GHG impact of water storages, methane gas surface emissions from the reservoir behind the proposed dam will be of particular concern because methane has a global warming potential 72 times that of carbon dioxide over a 20-year timeframe, and 25 times that of carbon dioxide over a 100-year timeframe (IPCC 2007).

Sources of greenhouse gas emissions from the proposed Tillegra Dam

If built, the Tillegra Dam will be the size of Sydney Harbour and the first large on-river dam built in NSW since the 1980s. It will flood 21 square kilometres of fertile farmland and the ecologically intact Upper Williams River. There will be a range of sources of GHG emissions from the proposal. Some, such as emissions from land clearing, from the manufacture of construction materials and from construction activities, will be associated with the initial stages of the project while others, such as the reservoir surface emissions, will be ongoing.

Table 1 gives a breakdown of the main greenhouse emission sources that can be expected as a result of the Tillegra Dam proposal and shows whether these emissions are covered under the Australian Government's proposed CPRS and in the Tillegra EAR.

Table 1: Major sources of greenhouse gas emissions from Tillegra Dam proposal

Source of emissions	Covered under proposed CPRS	Accounted for Tillegra EAR
Emissions from making the construction materials	Yes	Not included
Electricity and fuel used in construction activities	Yes	Yes
Electricity used in 20 years of operations at the dam site.	Yes	Yes
Reservoir surface emissions of carbon dioxide	Not included	Yes
Reservoir surface emissions of methane	Not included	Not included

While emissions associated with the making of the materials used in the proposed dam's construction would not be insignificant, it is methane gas surface emissions from the reservoir behind the proposed dam that are of particular concern because of the global warming potential of methane.

3. Review of the greenhouse gas assessment in the Tillegra Dam EAR

Overview

The EAR (Aurecon 2009a) concludes that there would be a significant contribution to GHG emissions from the proposed Tillegra Dam. In particular it highlights **CO_2** emissions from the decay of vegetation in the inundation area as a 'major risk' **but fails to acknowledge methane will also be emitted** (see Table 9.3 in EAR). The EAR then outlines what is termed a 'carbon neutral strategy' which it claims will offset the emissions from the dam after 25 years of operation. This 'carbon neutral strategy' is based on claiming significant emission offsets from a mini hydro plant and from tree plantings in vegetated corridors around the dam site.

However, as demonstrated by this report the GHG assessment in the EAR is seriously flawed and needs to be amended. Major sources of GHG emissions appear to have been excluded from the EAR. The most significant of these are surface emissions of methane.

The EAR also fails to include emissions associated with the making of materials used in the proposed dam's construction. While it can be claimed that these emissions are 'indirect', the volume of concrete which would be used does create an issue because of the fuel required and direct carbon dioxide emissions associated with the manufacture of cement and steel.

The offset claims in the EAR are also unsound. A significant offset is claimed for renewable energy generated by a mini hydroelectric plant. There is, however, no plant included in the project and the offsets claimed rest on the unlikely scenario that a third party would be willing to build a plant without having control of the timing of water releases from the dam and then hand over the renewable energy certificates (RECs) to Hunter Water at no cost.

Also of concern is the simplistic inclusion of plantation establishment as an offset. The tree planting offset claims do not account for important factors including the potential loss of soil carbon, a phenomenon that has been shown to occur when plantations are established on rich agricultural land.

Calculated greenhouse gas emissions in the EAR

The Tillegra EAR estimates the total GHG emissions from the project at 210,456 (tonnes of carbon dioxide equivalent.This estimate is made up of:

1) 36,581 t CO_2-eq for electricity and fuel used in construction of the dam and associated roads and works.
2) 1,050 t CO_2-eq for electricity used in 25 years of operations at the dam site.
3) 172,825 t CO_2-eq for decomposition of the vegetation in the inundation area (Aurecon 2009a).

From the calculation presented in Table 3 of the 'Tillegra Dam Planning and Environmental Assessment, working paper F, Sustainable resource use' (Aurecon 2009b) it is clear that that the 172,825 tonnes of CO_2 estimated for decomposition of the vegetation is based on the assumption that all vegetation in the inundation area will be converted to carbon dioxide. The total carbon stock in the inundation area is estimated at 47,092 tonnes based on the Australian Greenhouse Office's National Carbon Accounting Toolbox and Data Viewer (Aurecon 2009b) and a note under Table 3 states that '[the decomposition] emissions were determined as a direct mass-balance conversion to carbon dioxide ($C:CO_2$ ratio of 1:3.67 based on molecular weight)'.

This means that what is potentially the largest source of GHG emissions from the Tillegra Dam project has been excluded from the EAR. This major source is the methane generation and release from the proposed Tillegra storage. As discussed above in Chapter 2, methane gas surface emissions from the reservoirs are potentially one of the largest sources of greenhouse emissions from urban water systems.

The EAR also fails to include emissions associated with making materials used in the proposed dam's construction. These emissions are not included in the assessment as they are not associated with the Tillegra Dam site. However, the emissions associated with making the10,800 tonnes of cement and 3,630 tonnes of steel which would be used for the construction of the dam and related works can be directly attributable to the Tillegra Dam proposal.

Abatement and off-set claims

The EAR outlines a strategy to offset the estimated GHG emissions in order to claim 'carbon neutrality' for the project within 25 years (Aurecon 2009a). The two key elements of the offset strategy are the construction of a mini hydroelectric plant and the sequestration of carbon through forest plantings associated with the dam. Both elements are however highly questionable.

<u>The problem with carbon offsets claimed for the hydroelectric plant</u>

A significant offset of 72,750 t CO_2-eq is claimed for renewable energy generated by a mini hydroelectric plant that the EAR indicates could be built at the Tillegra Dam. The EAR claims credit for producing 3000 MWh/annum of renewable energy. However no hydroelectric plant is included in the project proposal. Further, neither Hunter Water nor the NSW state government have plans to build a hydroelectric plant associated with the Tillegra Dam and the EAR makes clear that a third party would be required to build and operate any such hydroelectric plant.

This offset claim has several key flaws. Firstly, there are the key problems with plant operation mentioned but not resolved in the EAR. These include the relatively small capacity of the plant and the fact that the plant would have to rely on irregular flow releases from the dam over which it would have no control. Because hydroelectric plants generally base their viability on power sales at peak time, this would be a critical problem for the financial viability of the plant.

Secondly, there is the obvious question about financial viability. If a hydroelectric plant is financially viable and therefore attractive to a third party why isn't Hunter Water and the NSW state government proposing to build it?

Finally, there is the issue of the RECs. If Hunter Water were to legitimately claim the renewable energy generated as an offset for the Tillegra project then this would further erode the financial viability of the hydroelectric plant. The third party building and operating the plant would own the renewable energy certificates. Unless the third party was willing to hand over these RECs to Hunter Water, no offset from renewable energy could be legitimately claimed. Claiming an offset from renewable energy generation and then on-selling the RECs is in effect double counting that offset. This problem has already been encountered with other water utilities in Australia (most notably WA Water Corporation) where an offset has been claimed for renewable energy but the RECs are sold. In these cases the carbon-neutral offset claims have been withdrawn by the water utilities after the supply projects were built. A scenario where the RECs are handed over to Hunter Water at no cost is highly unlikely, because the value of the RECs would be one of the attractions for any third party investor in hydroelectricity.

These issues cast significant doubt over whether a mini hydroelectric plant is ever likely to be built on the Tillegra site and if it was, whether the renewable energy could legitimately be claimed as an offset by the Tillegra Dam project.

<u>Issues with carbon sequestration offsets claimed through tree planting</u>

The EAR presents a tree planting initiative for carbon sequestration of residual emissions from the dam. Section 4.4.1 of working paper F of the EAR mentions that there is 'public debate on the viability of this approach' (Aurecon 2009a) and lists some of the shortcomings, but does not address them. Key issues raised in the EAR, but not addressed, include:

- the generation of methane by Australian trees which then actually contributes to GHG emissions
- the potential lack of permanence with tree plantings, particularly due to the threat of fire in the Australian landscape.

Another key issue which brings into question the viability of offset claims made for forest carbon sequestration in the Tillegra Dam project is the loss of soil carbon when plantations are established. This issue is not mentioned in the EAR.

Scientists at CSIRO and elsewhere have conducted research and modelling into the amount of carbon in soils before and after afforestation in Australia. Their research shows that while carbon will be taken up by planted forests as they grow, it can be depleted from the soil for about first 10 to 12 years (Turner & Lambert 2000; Paul et al. 2002). Agriculture soils took about 30 years to return to their original levels of carbon content (Paul et al. 2002). It can then be years before an actual accumulation of carbon occurs in a planted forest if both stand carbon (trees) and soil carbon is accounted for. As Miko (2000) states, '[soil carbon is an] issue because the amounts of carbon could be potentially large and because carbon contained in the soil is potentially less likely to be released either intentionally upon tree harvest or unintentionally upon natural disturbance such as fire.' This point about soil carbon is an important one because it shows that in the short term at least, afforestation is unlikely to result in the offsets claimed in the Tillegra EAR.

The EAR calculates tree planting sequestration based on assuming 50% of an estimated maximum 249 t CO_2 per hectare in a mature forest will occur in the first 25 years. This approach accounts for increased rates of growth in newly planted trees but not the initial loss of soil carbon that is likely to occur in first couple of decades. Because of the simplistic approach taken to tree planting sequestration together with the highly doubtful hydroelectric plant offsets, it is questionable whether any significant greenhouse offset can be claimed for the Tillegra Dam project within the 25-year assessment period set in the EAR.

4. A re-estimation of greenhouse gas emissions from the Tillegra Dam

Overview

An estimation of the GHG emissions that will be generated by the Tillegra Dam can be made drawing on the estimates in the EAR and standard methods from the IPCC (2006). The IPCC (2006) have provided guidance for how to estimate the GHG emissions from water storages in the document, *Guidelines for National Greenhouse Gas Inventories* and this provides an alternative approach to EAR assessment that includes both the carbon dioxide and the methane emissions generated and released from water storages.

Despite their GHG intensity, the GHG emissions from the manufacture of the steel and cement to be used in the construction of the dam are not included in this report's re-estimation of emissions. This is in order to keep the re-estimation in line with the Department of the Environment and Heritage, Australian Greenhouse Office (2007) 'Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at Facility Level – Energy, Industrial Process and Waste Sectors in Australia'. These guidelines do not require emissions from the manufacture of construction materials to be accounted for. However, a life-cycle analysis would attribute these GHG emissions to the Tillegra Dam.

Estimation of reservoir surface emissions from the Tillegra Dam

<u>Methodology</u>

The methodology for calculating the total surface emissions, considering both carbon dioxide and methane, is described the IPCC (2006a and 2006b) in:

- *Appendix 2: Estimating CO_2 emissions from lands converted to permanently flooded lands*
- *Appendix 3: CH_4 Emissions from Flooded Land: Basis for Future Methodological Development*

Carbon dioxide emissions were calculated using Equation 1, where the parameters and the assumed values are given below in Table 2. This approach calculates the carbon dioxide released via a diffusion pathway which is the major pathway for emissions of carbon dioxide.

$$CO_2 \text{ Emissions} = P \times E_{(CO2)} \times A \times f_A \times 10^{-6} \qquad \text{Equation 1}$$

This methodology assumes that initially GHG emissions are primarily due to the decay of flooded organic matter, and therefore that the CO_2 emissions calculated in Equation 1 are valid only for an assessment of the emissions from a newly constructed storage.

Table 2: Parameters and assumed values used in Equation 1

Parameter	Description of parameter	Assumed value	Reasons
CO_2 Emissions	total CO_2 emissions (Gg CO_2 per Year)		
P	number of days in a year	365	
$E_{(CO2)}$	average daily diffusive emissions (kg CO_2 per hectare per day)	8.1	Median value given in IPCC (2006) assuming that the appropriate climate classification is 'warm temperate, moist'
A	total reservoir surface area (hectares)	2,100	Reservoir at full supply level (HWC 2008, p.83)
f_A	fraction of the total reservoir surface area flooded	1	Case for a new reservoir

Methane emissions were calculated using Equation 2, where the parameters and the assumed values are given in **Table 3.**

$$CH_4 \text{ Emissions} = P \times E_{(CH4)} \times A \times 10^{-6} \qquad \text{Equation 2}$$

This approach calculates the CH_4 released via a diffusion pathway. Bubble emissions are usually considered to be a more significant pathway than diffusion for emissions of CH_4. However in order to estimate bubble emissions, site-specific data would need to be gathered to apply a more detailed version of the IPCC (2006) methodology.

Table 3: Parameters and assumed values used in Equation 2

Parameter	Description of parameter	Assumed value	Reasons
CH_4 Emissions	total CH_4 emissions (GgCH_4 per Year)		
P	number of days in a year	365	
$E_{(CH4)}$	average daily diffusive emissions (kg CH_4 per Hectare per Day)	0.150	Median value given in IPCC (2006) assuming that the appropriate climate classification is 'Warm temperate, moist'
A	total reservoir surface area (Hectares)	2,100	Reservoir at Full Supply Level (HWC 2008, p.83)

The methane emissions calculated above were converted into equivalent emissions of carbon dioxide (CO_2-eq) using the relative global warming potential (GWP) ratio for methane of 72 (over a 20-year timeframe). In the past the GWP ratio of methane was calculated for a 100-year timeframe and was taken as approximately 21 (based on the IPCC's 2nd Assessment Report) but this has been revised in the IPCC's 4th Assessment Report (2007) to values of:

- 72 over a 20-year timeframe, and
- 25 over a 100-year timeframe

A 20-year value is given by the IPCC because of the relatively short lifetime of methane in the atmosphere of approximately 8–10 years compared to carbon dioxide which persists over many decades.

Calculated potential surface emissions

Using the equations and data given above, the following greenhouse gas emissions are estimated as given in Table 4 and Table 5 below.

Table 4: Estimated yearly greenhouse gas emissions from reservoirs

Type of emission	**Median estimated emissions ($t\ CO_2$-eq per year)**	**Max ($t\ CO_2$-eq per year)**
Carbon dioxide	6,200	44,000
Methane	8,300	61,000
Total	14,500	105,000

Table 5: Estimated total greenhouse gas emissions from reservoirs over 20 years

Type of emission	**Median estimated emissions ($t\ CO_2$-eq)**	**Max ($t\ CO_2$-eq)**
Carbon dioxide	124,000	-
Methane	166,000	1,220,000
Total	290,000	-

Comparison to the surface emissions estimate in the Tillegra EAR

The EAR estimated the reservoir emissions from the Tillegra Dam at 172,825 tonnes of CO_2 over 25 years and included no methane emissions.

Based on the median IPCC (2006) figures our estimate is 124,000 tonnes of CO_2 over 20 years but with an additional 166,000 tonnes of CO_2-eq due to methane emissions. The calculations show that if only 1.8% of the emissions (by weight) are methane, between 57% and 58% of the total global warming potential from surface emissions for a 'warm temperate' reservoir are likely to come from methane.

The comparison also shows that the median IPCC (2006) figures produce a relatively conservative total carbon flux estimate of 2300 tonnes of methane and 124,000 tonnes carbon dioxide. This compares to the 172,825 tonnes of carbon dioxide in the EAR. This indicates that when methane emissions are included in a revised EAR, the total surface emissions should be higher than our estimate. If approximately 20% of the carbon stock estimated in the EAR were emitted as methane the surface emissions would be have a global warming potential of approximately 1.0 million tonnes CO_2-eq.

Total greenhouse gas emissions due to the Tillegra Dam proposal
The estimated total GHG emission from the Tillegra Dam proposal is given in Table 6 below.

Table 6: Estimated greenhouse gas emissions over 20 years from the Tillegra dam

Type of emission	Estimated emissions (t CO_2-eq)	Source of estimate
Emissions from making the construction materials	Not included	NA
Electricity and fuel used in construction activities	36,581	Tillegra EAR
Electricity used in 20 years of operations at the dam site.	840	Tillegra EAR
Reservoir surface emissions of carbon dioxide	124,000	Table 5 above
Reservoir surface emissions of methane	166,000	Table 5 above
Total	**327,421**	

A total estimate of 327,421 t CO_2-eq of GHG emissions can be attributed to the Tillegra Dam proposal excluding GHG emissions from creating the materials used in the construction of the dam. This estimate is conservative given the low total carbon flux (carbon dioxide and methane) estimate included in comparisons to the assessment in the EAR.

5. How GHG emissions from the Tillegra Dam compare with emissions from the current supply and from a future sustainable supply without the dam

Comparison to operation of the existing water supply in the Lower Hunter
If we consider only the operational GHG impacts, the current average total GHG emissions from Hunter Water Corporation's water supply operations (averaged over the last three years) are approximately 31,200 t CO_2 per year (calculated from data sourced from National Water Commission (2009)). Taking only the estimate for surface emissions from the proposed Tillegra dam as calculated in Table 4 which are 14,500 t CO_2-eq per year: **Tillegra dam would increase the GHG intensity of water supply in the Lower Hunter by at least 46%.** As discussed above this represents a conservative estimate of operational GHG emissions from the Tillegra proposal.

At the upper end of temperate reservoir emissions, based on the IPCC figures, the potential surface emissions alone from the proposed **Tillegra Dam could be equivalent to adding an extra 27,000[2] cars to the Hunter's roads**.

Comparison to a sustainable water supply strategy for the Lower Hunter

ISF's recent review of water supply–demand planning in the Lower Hunter (ISF 2009) found that with no additional measures, there will be sufficient water supply in the Lower Hunter until 2040. Further, analysis in the report demonstrates that if Hunter Water were to implement similar water conservation measures to those already in place in Sydney, then there would be no need for additional supply before 2050. The report also sets out the key elements needed to establish a sustainable urban water strategy for the Lower Hunter.

The review provides two important points of context for understanding the estimated GHG emissions from the proposed Tillegra Dam presented in this study.

Firstly, the review conclusively demonstrates that the proposed Tillegra Dam will not be needed as a source of ongoing water supply until 2040 at the earliest. This is because even without further water conservation incentives, no new water supply will be needed in the Lower Hunter until then. Therefore, in the next 30 years, substantial GHG emissions can be expected from the Tillegra Dam even though its water will not be needed.

Secondly, the review demonstrates that if Hunter Water were to implement similar water conservation measures to those already in place in Sydney, then there would be no need for an additional supply before 2050 (ISF 2009). Given that the current per capita water consumption in the Lower Hunter is above Sydney's (accounting for residential and business use) the savings figures assumed are not excessive. If water conservation, and in particular improving water use efficiency take a significant role in an alternative sustainable urban water strategy for the Lower Hunter then this would have substantial GHG benefits. This is because water savings would also have associated energy savings due to avoided water supply, avoided wastewater treatment and most significantly, avoided hot water heating.

The review's projected GHG emissions savings are achieved through pursuing a sustainable urban water strategy in which water conservation plays a key role. The savings can be estimated and compared to the increase in emissions resulting from the proposed Tillegra Dam. Based on the calculations presented in ISF (2009) a water conservation strategy similar in scale and scope to the one already in place in Sydney could save 205,400 ML over 20 years from 2015. Average GHG intensities for water saved by conservation measures in Sydney (excluding recycling measures) can be calculated from Appendix B of the 'Review of the Metropolitan Water Plan: Final Report' by ISF, Acil Tasman and SMEC (2006). The average GHG intensity is negative 7.5 T/ CO_2-eq per ML. In other words, saving water saved energy.

[2] Based on an average car producing approximately 4 t CO_2-eq per year

Based on these figures estimates for a sustainable water strategy in the Lower Hunter are shown in Table 7.

Table 7: Estimated greenhouse gas emissions from the proposed Tillegra Dam compared to the expected savings that could be achieved from a sustainable strategy

Alternatives	Median estimated Net emissions over 20 years
Water strategy based on Tillegra Dam[#]	**327,421 (t CO_2-eq) [Additional GHG]**
Sustainable urban water strategy[##]	**-1,539,000 (t CO_2-eq) [GHG Saving]**

[#] Excludes claimed GHG off-sets – see chapter 3 for details on problems identified with off-set strategy

[##] Includes energy savings due to avoided hot water heating as well as energy required for water distribution and treatment.

6. Conclusions and recommendations

The Tillegra Dam would be a significant source of GHG. The total GHG emission estimate for the Tillegra Dam proposal is 327,421 t CO_2-eq over the first 20 years. This excludes GHG emissions from creating the material used in the construction of the dam.

A conservative estimate of the surface emissions from the Tillegra Dam would increase the operational GHG intensity of water supply in the Lower Hunter by at least 46%. There are, however, large uncertainties associated with these surface emissions and they could be over 1 million t CO_2-eq over 20 years.

The 'carbon neutral' claims for the Tillegra Dam in the EAR cannot be sustained. Methane generation and release from the surface of the storage, potentially the major source of GHG has been left out of GHG assessment included in the EAR. The carbon offset claims in the EAR are also unsound. A significant offset is claimed for renewable energy generated by a mini hydroelectric plant. However, no actual plant is included in the project. The tree planting is treated simplistically and does not account important factors including the potential loss of soil carbon in establishing tree plantings on agricultural land.

In contrast to the GHG emission from the Tillegra Dam proposal, a sustainable water strategy for the Lower Hunter based on improved water efficiency and water conservation measures could reduce GHG emissions by an estimated 1.5 million t CO_2-eq over 20 years.

Overall, the key messages that stem from this investigation are:

- The GHG impact from the proposed dam would be significant and substantial uncertainty surrounds the magnitude of these emissions

- The emissions generated from the dam would be irreversible and it would not be possible to intervene to stop or control these emissions
- The GHG assessment in the Tillegra EAR is flawed and needs to be amended.
- The emissions generated from the dam will not be included in the Australian Government's proposed CPRS cap and will therefore be additional (unlike energy-intensive water supply options in other regions)
- The emissions will occur regardless of whether the captured and stored water is actually supplied to customers.

Recommendation 1 – The Tillegra Dam EAR should be amended to include methane emission from the water storage.

Recommendation 2 – The Tillegra Dam EAR should be amended by removing the offset claimed for renewable energy generated by the mini hydroelectric plant

Recommendation 3 – The Tillegra Dam EAR should be amended to account for current understandings of the soil carbon dynamics associated with tree plantings.

Recommendation 4 – The Tillegra Dam EAR should be amended to include the GHG emissions from the manufacture of materials used in the construction of the Tillegra Dam, particularly steel and cement.

Recommendation 5 – All actions towards building the Tillegra Dam should be halted until a carbon neutral strategy that accounts for Recommendations 1, 2, 3 and 4 can be defined.

Recommendation 6 – The full GHG impacts of dam proposals including surface emissions should be included in future planning for urban water supply across Australia.

Recommendation 7 – the Australian Government should include surface reservoir emissions, particularly those from storages built after 2010, under the CPRS cap.

7. References

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