Australian Government
Department of Agriculture and Water Resources

AUSTRALIAN Pork

# Future proofing PigBal

## Final Report
## APL Project 2025/0044

## June 2025

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## Acknowledgements

This project is supported by funding from Australian Pork Limited and the Department of Agriculture and Water Resources.

The upgrade would also not have been possible without the valuable input from Mr Alan Skerman (formerly of the Department of Agriculture and Fisheries, Queenland).

## Executive Summary

PigBal was first developed nearly three decades ago by researchers including the principal investigator of this project, Eugene McGahan. It has undergone several updates since then, with the most recent being completed in 2018 by Alan Skerman from the Department of Agriculture and Fisheries (DAF), Queensland. Throughout this period, multiple validation exercises have been conducted to ensure that the tool is methodologically sound and the outputs accurate for both producers and regulators.

PigBal is widely used for planning purposes, however, given that the most recent version upgrade was in 2013, its currency has slipped, and an update was required. The 2013 version (PigBal 4) has now been upgraded to a new version of the model (PigBal 5) that includes current feed (usage and ingredient type) and production, along with the additional of Scope 1 and 2 GHG estimations for users.

The upgrade of the model included a number of minor changes to improve explanation and reporting, as well as error fixing from issues reported by users. Some changes and upgrades in the new version of PigBal include:

1. Updated growth curve for current pig genetics in Australia.
2. Updated production numbers for the Farrow to Finish, Breeder and Grower "Standard" inputs.
3. Inclusion of an additional pig class for gestating sows, so users can split the dry sow herd between conventional and deep litter pigs
4. Updates to feed waste inputs.
5. Updated Diet ingredient data with 35 ingredients either added or modified and several outdated (not used) ingredients deleted.
6. Four new "Standard Diet" formulations included.
7. Water intake variables updated based on data from DPI and IA data.
8. GHG emission estimation calculations included with output sheet that also has embedded nitrogen and volatile solids mass flows.
9. Update of the methane abatement calculations to also include methane potential generation.
10. Output sheet added that provides nutrient and solids flow estimations of manure through solids separation, ponds (sludge and supernatant), deep litter storage and application and effluent/sludge storage and application.

It is recommended that PigBal is regularly reviewed and updated (at least every 5 years) due to its use not only as a design tool for new piggeries to assist with planning, but for its usefulness in designing the increasing use of biogas production systems at piggeries. PigBal has and will continue to be utilised to inform industry and government in the update of guidelines, codes of practice and inventory reports.

PigBal has and will likely continue to have issues with the use of Macros that enable it to populate both generic piggery scenarios and diets. It is recommended that future updates to the model include the transformation to a new programming platform. This will enable greater flexibility for users to input data and overcome the issue of Microsoft potentially not supporting the use of Macros in Excel in the future.

## Table of Contents

# 1. Background to Research

PigBal 4 is widely used for planning purposes, however, given that its last update was in 2013, its currency is beginning to slip, and updates are needed. Required updates include the methane global warming potential (currently using the AR4 value), the standard diet formulations, and the growth curve and feed waste calculations which are currently unsuitable for finisher pigs over 100kg liveweight.

In addition to the ongoing regulatory focus on nutrient management for piggeries, Queensland and New South Wales have recently released draft regulations which will see Scope 1 emissions at the farm level fall under remit of the environmental regulators for the first time. At least one other State is in the process of preparing similar regulation.

Futureproofing PigBal is needed to meet the emerging needs of industry, particularly with respect to the quantification of on-farm GHG emissions. To meet this need, disaggregated manure emission factors (for each housing and management system) must be added along with energy emission factors so that, alongside the existing nutrient calculations, producers can determine their total Scope 1 and 2 emissions for each farm with minimal additional data required. This will also ensure that producers can estimate emissions for their operations, proposed development applications or changes of use (and how these might vary under different scenarios). This will equip them to meet the requirements of emerging regulation which include reporting of Scope 1 and 2 emissions, and a plan for emission reduction.

Although PigBal is extensively used by industry for preparing and assessing development applications, as well as sizing biogas facilities, there are a number of errors which are commonly made and at present, there are limited user resources available. To assist with this, a series of short online videos explaining to users in real-time how to populate key parameters correctly and sense check results.

PigBal 4 also contains a number of computational and reporting errors that require correction.

## 2. Objectives of the Research Project

1. Ensure that producers are able to accurately estimate amounts of nutrients produced in effluent (including flows throughout the treatment process), manure, and spent bedding to inform planning.
2. Integrate Scope 1 and 2 emissions factors into PigBal, allowing users to quantify Scope 1 and 2 emissions produced at the piggery.
3. Update the underlying emission factors and formulas, giving regulators confidence that the PigBal tool is an up-to-date and research-backed tool to estimate nutrient impacts for planning.

## 3. Introductory Technical Information

PigBal was first developed nearly three decades ago by researchers including the principal investigator of this project, Eugene McGahan. It has undergone several updates since then, with the most recent being completed in 2018 by Alan Skerman from the Department of Agriculture and Fisheries (DAF), Queensland. Throughout this period, multiple validation exercises have been conducted to ensure that the tool is methodologically sound and the outputs accurate for both producers and regulators.

The project principal investigator has conducted validation exercises on the underlying model, including the Pork RDC project Validation of PigBal for estimating the VS loads from piggeries (c. 2009) and the subsequent APL project No. 2010/1011.34 Validation of the PigBal – Stage 2.

Other resources complementary to PigBal have been developed, including the Piggery Assessment Spreadsheet (DAF). This tool provides a more detailed results, with nutrient volumes at each stage of the housing and manure management process reported. Integrating key components of the Piggery Assessment Spreadsheet into PigBal would improve insights into nutrient flows within a farm.

## 4. Research Methodology

The project was conducted in a number of stages that are detailed below:

**Stage 1 - Project administration (APL)**
Stage 1 of the project required APL to engage with Queensland Department of Primary Industries (DPI) to discuss the copyright of PigBal, and resolve any issues related to the update being performed by a third-party, as APL and DPI are joint owners of the model.

**Stage 2 – Update to growth curve and feed waste prediction and standard diet formulations (DAF)**
Stage 2 of the project involved the update to the existing growth curve and feed waste prediction which are currently not applicable to finisher pigs over 100kg liveweight. For finishers over 100kg (now common in industry), feed waste is substantially over-predicted, over-predicting volatile solids in particular. The underlying formulas required updating to accurately cater to current industry practices. The standard diet formulations were last updated in 2013 and needed updating to reflect current industry formulations and regional variation in formulation (e.g., replacement of mungbeans with lupins for West Australian formulation).

**Stage 3 – Update underlying formulas and expand nutrient flows (IA)**
Stage 3 of the project included the update to existing formulas, factors and references for currency (e.g., methane global warming potential updated from AR4 to AR5 value; methane conversion factor of 0.9 for anaerobic ponds replaced with current location-specific factors).

The Piggery Assessment Spreadsheet is an open-access resource. In order to quantify nutrient flows by housing system, key components of the spreadsheet were integrated into PigBal, improving the disaggregation of results and insights available to the user.

**Stage 4 – Scope 1 and 2 emissions added**
PigBal was expanded to calculate Scope 1 emissions from housing and manure management systems, using methods consistent with the National Inventory Report. Integrated emission factors, thereby ensuring that PigBal returns site-specific emissions calculations and allow users to evaluate the effects of changes in manure management and upstream production (e.g., change in diet characteristics) on their Scope 1 emissions. Scope 1 emissions from energy and Scope 2 emissions from grid electricity consumption were also included.

Scope 1 and 2 emission factors associated with energy use were added and appropriate calculations built into PigBal to report the farm totals. Producers are now able to enter actual data (e.g., for existing facilities) to calculate current farm emissions or select relevant default values for their pig transport emissions if fuel usage is unknown.

**Stage 5 – Development of new user guide and supporting materials (IA)**
Stage 5 involved the development of an updated Technical Manual and a new User Manual and a series of short, pre-recorded videos to be made available to users.

## 5. Results

A new version of the PigBal model has been developed – PigBal 5. The upgrade of the model included a number of minor changes to improve explanation and reporting, as well as error fixing from issues reported by users. Changes in the new version of PigBal include:

1. Updated growth curve for current pig genetics in Australia.
2. Updated production numbers for the Farrow to Finish, Breeder and Grower "Standard" inputs.
3. Inclusion of an additional pig class for gestating sows, so users can split the dry sow herd between conventional and deep litter pigs
4. Updates to feed waste inputs.
5. Updated Diet ingredient data with 35 ingredients either added or modified and several outdated (not used) ingredients deleted.
6. Four new "Standard Diet" formulations included.
7. Water intake variables updated based on data from DPI and IA data.
8. GHG emission estimation calculations included with output sheet that also has embedded nitrogen and volatile solids mass flows.
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Other updates/errors have been added/corrected that were identified by users included:

1. Fixed logic error in equation on Tab 9 - Water (Cell D41).
2. Fixed logic error on Tab 5 - Herd details (Cells G33 to G39).
3. Fixed programming error where the user enters the pig numbers in each class and the mortalities and pigs sold does not update. This was due to these two outputs being calculated from separate user inputs.
4. Resolving programming error that stopped Macros running successfully.
5. Added additional sites to pond design "k" values.
6. Modified standard weight ranges in Example grower pig diets to ensure correct diets are assigned to each class of pig.
7. Updated reference list.

The Technical manual has also been updated to include all modified and updated equations and changes to typical input parameters, as well as additional chapters and appendices relating to nutrient mass flow calculations and greenhouse gas emissions. A simpler User Manual has also been developed for that includes the important details on entering data and interpreting results.

A series of short videos have been prepared to assist users with running PigBal. These videos cover:

1. real-time population of the updated version of PigBal covering the key parameters,
2. how to check nutrient and solids production results,
3. how to check/interpret Scope 1 and 2 GHG emissions, and
4. outline of the scope of the updates and how to use the updated version of PigBal.

## 6. Implications & Recommendations

PigBal 4 has now been upgraded to a new version of the model (PigBal 5) that includes current feed (usage and ingredient type) and production, along with the additional of Scope 1 and 2 GHG estimations for users.

It is recommended that the model is regularly reviewed and updated (at least every 5 years) due to its use not only as a design tool for new piggeries to assist with planning, but for its usefulness in designing the increasing use of biogas production systems at piggeries. PigBal has and will continue to be utilised to inform industry and government in the update of guidelines, codes of practice and inventory reports.

PigBal has and will likely continue to have issues with the use of Macros that enable it to populate both generic piggery scenarios and diets. It is recommended that the model be updated to run on a different programming platform. This will enable greater flexibility for users to input data and overcome the issue of Microsoft potentially not supporting the use of Macros in Excel in the future.

## 7. Intellectual Property

PigBal 4 was the joint property of DPI Queensland and APL. This remains the case for the updated PigBal 5 model.

## 8. Technical Summary

An update of PigBal 4 to Pigbal 5 has been completed. The updated model now includes:

- Additional flexibility when entering herd numbers
- Updated growth curves and feed intake estimates to match modern pig genotypes
- Inclusion of input pages and calculations to enable users to calculate Scope 1 and 2 greenhouse gas emissions for a piggery.
- User inputs and calculations to enable users details on nutrient and solids mass flow through various treatment and storage processes commonly used at Australian piggeries.
- Removal of some Macros within the model that were causing programming errors.
- Corrected computational errors identified by users in PigBal 4.

## 9. Literature cited

References used in the PigBal model, and the updated Technical Manual have been cited in both the model and the manual.

## 10. Publications Arising

Publications developed during the project included the updated Technical Manual and a new User Manual. This have both been provided to APL to provide on their website, with the new PigBal 5 model.