Identifying water sources for aerial firefighting

FrontierSI

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1. FrontierSI

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2.0	Complete draft for PMTAG review	03/05/2023

Australian Government

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We acknowledge the traditional custodians across all the lands on which we live and work, and we pay our respects to Elders both past, present and emerging. We recognise that these lands and waters have always been places of teaching, research and learning.

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Executive summary

During active fire events, aerial firefighting units are dispatched by members of the National Aerial Firefighting Centre (NAFC). NAFC members use a variety of data sources to help identify locations for helicopters and fixed wing aircraft to access water. For effective decision making, current and accurate information is critical. This project identified how existing Geoscience Australia (GA) Digital Earth Australia (DEA) satellite-based data products could be tailored to suit the needs of NAFC.

This project aimed to identify additional attributes that would add value to the existing DEA Waterbodies product for users in the emergency management sector and create the associated framework for implementation by Geoscience Australia. FrontierSI hosted an interactive user needs workshop with emergency management agencies from across Australia. This workshop provided insight into how current waterbody datasets are being used and what additional waterbody attributes are needed by users for pre-planning decisions.

A localised prototype workflow was developed, which implements and updates these new attributes. The prototype was developed with the intention that this workflow is implementable by GA. Through communication with the DEA team responsible for the data production and the Flying Hellfish team responsible for cloud services, the workflow was modified to suit the production environment. In the interim, this workflow can be run by NAFC to extract necessary information from the waterbodies product while GA works through implementing the upgrades. This project was successful in identifying and implementing user-driven improvements to the DEA Waterbodies product, and concluded with a set of recommendations for future development for both NAFC and GA.

End-user statement

Anthony Gallacher, National Aerial Firefighting Centre, VIC

The ongoing development of decision support tools to assist our fire and emergency services agencies across Australia is increasingly focusing on preparedness and planning of aerial firefighting resources in the face of limited resources. Planning decisions cover a range of factors including base location, aircraft capability, response times and water sources for aircraft.

The methodology produced in this research program has developed a way forward for further adaptation of national waterbodies datasets to make water availability information more accessible for a range of uses in the Emergency Management sector and beyond. In particular, the NAFC Aviation Coverage Model 5 utilises a waterbodies layer to run aerial firebombing coverage scenarios for fleet allocation planning. The methodology will enhance the development of the model, shifting from a static waterbody layer, to one that is more dynamic, with suitable date attributes and currency.

The results provide a pathway forward for NAFC to develop a waterbodies solution internally, to suit the needs of NAFC and sector agencies. Additionally, the results equip Geoscience Australia with recommendations and a prototype workflow, for wider application of the DEA waterbodies dataset, which provides exciting opportunities for the sector and beyond to harness this data.

We are grateful to Natural Hazards Research Australia for funding this work in conjunction with research partners FrontierSI, and end-user partner organisations Geoscience Australia and Country Fire Authority Victoria.

Introduction

During active fire events, aerial firefighting units are dispatched by members of the National Aerial Firefighting Centre (NAFC). NAFC members use a variety of data sources to help identify locations for helicopters and fixed wing aircraft to access water. For effective decision making, current and accurate information is critical.

This project identified how existing Geoscience Australia (GA) Digital Earth Australia (DEA) satellite-based data products could be tailored to suit the needs of NAFC. The aim of the project was to augment the polygon-based DEA Waterbodies product with additional attributes that met the needs of users, e.g. identifying when water was last observed (by satellite) for each waterbody. Through cross collaboration NAFC, GA, CFA VIC and FrontierSI worked together with end users to identify attributes which would add value and encourage increased usability of GA's DEA Waterbodies product.

Background

The Digital Earth Australia (DEA) Waterbodies product[1] [2] captures the typical geometries and historical presence of water for over 300,000 waterbodies across the country. The product is derived from surface reflectance measurements from the (American) National Aeronautics and Space Administration (NASA) Landsat satellites, providing historical observations of water back to 1987. The product uses processed Landsat data. The processing time results in a two-week lag between the satellite overpass time and when the DEA Waterbodies product is updated. As such, the most recent observations shown in the product typically show the status of the waterbody two weeks ago. Users can access the waterbody geometries through a Web Feature Service (WFS), and further query the historical information by downloading a comma-separated value (CSV) file containing the historical water observations for a given waterbody.

Up-to-date information on the presence of water in the Australian landscape is valuable for emergency services planning, specifically, positioning of aircraft to be able to quickly access water for firefighting. The content of the DEA Waterbodies product, especially the record of how recently water was observed, is valuable for planning. However, the current product does not allow our users to immediately find the information they are most interested in. Rather than being able to see this information directly through the WFS, the user must download the CSV and open it. This is cumbersome for a single waterbody, let alone hundreds of waterbodies. It also cannot be easily integrated into existing NAFC planning systems, which are designed to consume and display the contents of WFS, but not individual CSVs.

Research aims and rationale

The aims of this project were to;

- Offer critical support to disaster management services about the location and currency of surface water through a prototype improved DEA Waterbodies dataset
- Identify user needs for additional attributes derived from existing data which is currently available through the DEA Waterbodies product
- Increase the usability of the product by disaster management services; create a prototype workflow to update the dataset; create a compatible development framework allowing for implementation by GA
- Identify future development opportunities for the Waterbodies product and service.

[1] Krause, C.E.; Newey, V.; Alger, M.J.; Lymburner, L. Mapping and Monitoring the Multi-Decadal Dynamics of Australia's Open Waterbodies Using Landsat. *Remote Sens.* **2021**, *13*, 1437. https://doi.org/10.3390/rs13081437
[2] https://www.dea.ga.gov.au/products/dea-waterbodies

Research approach

Project methodology

Our methodology had two main components: a user needs workshop, and a series of development sprints. The user needs workshop gave us insight into the potential uses for the DEA Waterbodies product, and allowed users to identify waterbody attributes that they felt would be valuable to their work. After identifying viable attributes for development, we completed three development sprints; each sprint consisted of two weeks of development, with one week for providing feedback. This sprint structure allowed for project stakeholders to see regular progress, provide feedback, and have input into the priorities of the following sprint.

User needs workshop

Background

In February 2023, FrontierSI hosted a user needs workshop designed to gain insight into how users from numerous emergency management agencies currently user waterbody data for firefighting approaches. Individuals from 8 organisations attended: Emergency Management Victoria (EMV), New South Wales Rural Fire Service (NSW RFS), Country Fire Authority Victoria (CFA VIC), Australian Capital Territory Emergency Services Agency (ACT ESA), Tasmania Fire Service (TFS), Australian Fire Danger Rating System (AFDRS), Queensland Fire and Emergency Services (QFES) and the Department of Energy, Environment and Climate Action (DEECA) Victoria. Members from the project team from AFAC and NAFC also participated. Representatives from Geoscience Australia (GA) were present to observe the workshop and provide a product overview for the waterbodies dataset to end users.

The design of this interactive workshop allowed for open discussion between end users through asking a series of questions. These questions were designed to understand current processes that use waterbody data, the associated issues and identify what additional attributes users could benefit from in the future. Questions included:

- When do you use information about waterbodies in your role?
- Why do you need information about waterbodies?
- What information and data do you use to make decisions?
- How do you like to access/work with that information?
- What negative experiences have you had when trying to access that information?
- What information/attributes about waterbodies would help you make decisions in your work?

Outcomes from the workshop

Through asking the pre-designed questions and general discussion the user workshop allowed us to identify a collection of user perspectives related to the current and future use of the waterbodies dataset, as well as identify of a set of additional waterbody attributes that would be valuable to end users. These comments reflect the range of opinions observed during the workshop.

Information requirements

- Knowledge of how much water was taken or used from a specific waterbody; having this information easily available would increase efficiency over the current process.
- Data on the presence of hazards around waterbodies; currently this is at the pilot's discretion of the feasibility of using water from a given waterbody.
- Clear documentation of what is included in the DEA Waterbodies dataset and statement of dataset limitations. Users expressed a desire to understand:
  - Dataset inaccuracies related to waterbodies close to coastlines.
  - Limitations to what is included based on current ruleset.
- A system that would allow users to provide feedback on inaccuracies in the data.
- Increase in the coverage of the waterbodies dataset to include New Zealand.

Software requirements

- The ability to integrate the waterbodies product into existing operational systems.

Suitability

- Some users believe the current waterbodies dataset is not fit for operational (initial attack) purposes but recognise the product as useful for pre-planning (such as allocation of different aircraft to areas with suitable waterbodies).
- Some users believe that the current waterbodies dataset is not fit for initial attack purposes and should not be advertised as tactical in associated documentation/user guides.
- Some users believe that they would not find value in the product as they currently do not use the waterbodies dataset and are hesitant to make changes to their current operational practices.

In this workshop, users collectively identified attributes which would add to the usability of the existing DEA Waterbodies dataset. These attributes clearly reflected the needs of the participants whose main use of a waterbodies dataset reside both within the operations and planning aspects of the emergency response sector.

The attributes fell into the following categories:

- Waterbody features
- Dataset currency
- Surrounding waterbody environment
- Biosecurity risk

See Table 1 for full list of attributes in each category, and their feasibility for development as part of this project. The feasibility of attaining these attributes is discussed in the following section.

TABLE 1: ALL ATTRIBUTES IDENTIFIED DURING THE WORKSHOP, AND THEIR FEASIBILITY FOR DEVELOPMENT AS PART OF THIS PROJECT

Attribute	Description	Possible in project scope (Y/N)	Reasoning for inclusion/exclusion from this project
Waterbody features			
Last valid wet surface area (m^2)	Calculates wet area of a waterbody from last valid observation	Yes	Measurement can be calculated based on existing wet observation percentage
Longest line (m)	Calculates the longest line spanning within a waterbody intercepting two vertices	Yes	Possible to calculate for the static waterbody polygon but not for the latest observed wet area. Having this attribute for the static waterbody does not accurately represent the longest line for the most current waterbody depending on wet area.
Change of polygon size over time	Polygon size changes based on each new valid wet observation	No	Current waterbodies dataset does not track polygonised waterbody change
Volume of water extracted	Tracks the volume of water extracted from a given waterbody	No	Requires datasets external to DEAs current dataset
Dataset currency			
Date of last valid water observation	Identifies the last date where a waterbody was clearly observed	Yes	The date of which water was last observed resides in the CSV file
Date when any attribute was last modified	The date when any waterbody attribute was last modified	Yes	Have the date when the CSV was updated, other attributes may not have changed
Percentage coverage of observation	Identifies whether the last observation was a partial or full coverage of a waterbody	No	Need to clarify if values under the threshold are stored, obtaining this attribute may require a change to the waterbodies workflow
Surrounding waterbody environment			
Vegetation	Description of the vegetation surrounding a waterbody	No	Requires datasets external to DEAs current dataset
Powerlines	Description of the powerlines surrounding a waterbody	No	Requires datasets external to DEAs current dataset
Safety of approach	Evaluation of how safe a waterbody is to access for an aircraft	No	Requires datasets external to DEAs current dataset
Biosecurity risk			
Contamination status	Identifies if the water has been contaminated	No	Requires datasets external to DEAs current dataset
Known pests	Identifies any known pests	No	Requires datasets external to DEAs current dataset
Water source	Identifies where the water primarily comes from	No	Requires datasets external to DEAs current dataset

Attribute development

The existing waterbodies product has two components:

- A shapefile containing the waterbody polygons
- A csv containing the timeseries information from the Landsat data

These two components are outlined in Figure 1, depicting the relationship between a waterbody polygon, the attribute table, and the linked CSV.

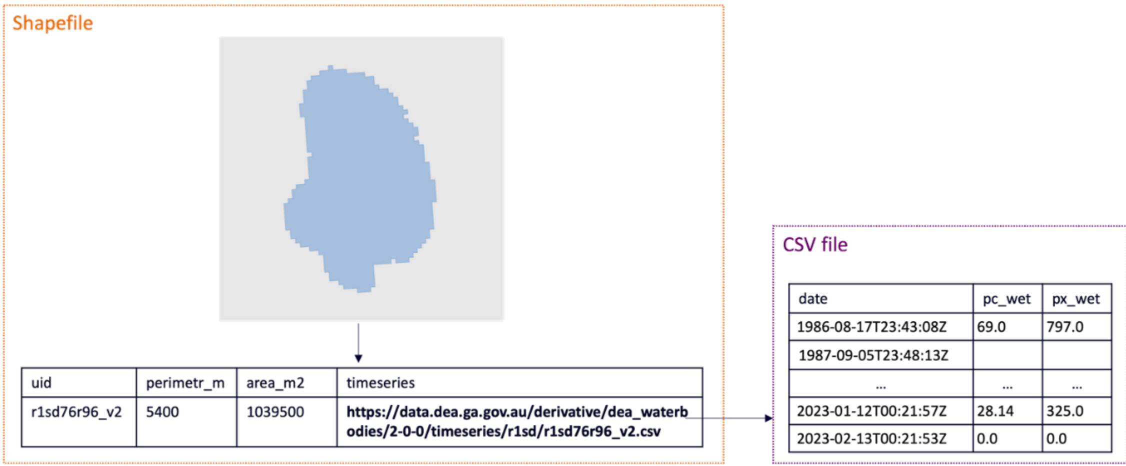


FIGURE 1. OVERVIEW OF THE DIGITAL EARTH AUSTRALIA WATERBODIES DATASET COMPONENTS INCLUDING THE POLYGON AND LINKED CSV FILE, WHICH INCLUDES THE DATE, 'PC_WET' (PERCENTAGE OF WATERBODY OBSERVED AS WET), AND 'PX_WET' (NUMBER OF PIXELS IN WATERBODY OBSERVED IN WET) VALUES.

The goal of this project was to update the attributes in the shapefile, using data contained in the csv. This is because the values in the CSV are not easily accessible through the web feature service that displays the shapefile contents.

Based on findings from the user needs workshop, we used the first two sprints to identify, refine and develop attributes which were feasible within the scope of the project, each of which is described below. All software developed to calculate the attributes has been stored in a public GitHub repository.

Date of last valid water observation

The date of the last valid water observation attribute captures the latest date when water was last observed for each waterbody. For an observation to be valid, at least 80% of the total waterbody was clearly observed and not obscured by cloud, missing data values or satellite data artefacts. This attribute was identified by NAFC in the project scope and by end users in the user needs workshop. As this information is already accessible through each CSV file, having direct visibility of this attribute contributes to time efficiency for emergency agencies in pre-planning practices.

The date of the last valid water observation is stored in the CSV file, visualised in Figure 2. To extract this value, the date column in the CSV file is sorted into ascending order as a precaution. After being sorted, rows which contain NaN values in 'pc_wet' (percentage of waterbody observed as wet) and 'px_wet' (number of pixels in waterbody observed in wet) columns are removed. From here we return the last value which is the most recent valid water observation.

Last valid wet surface area (m^2)

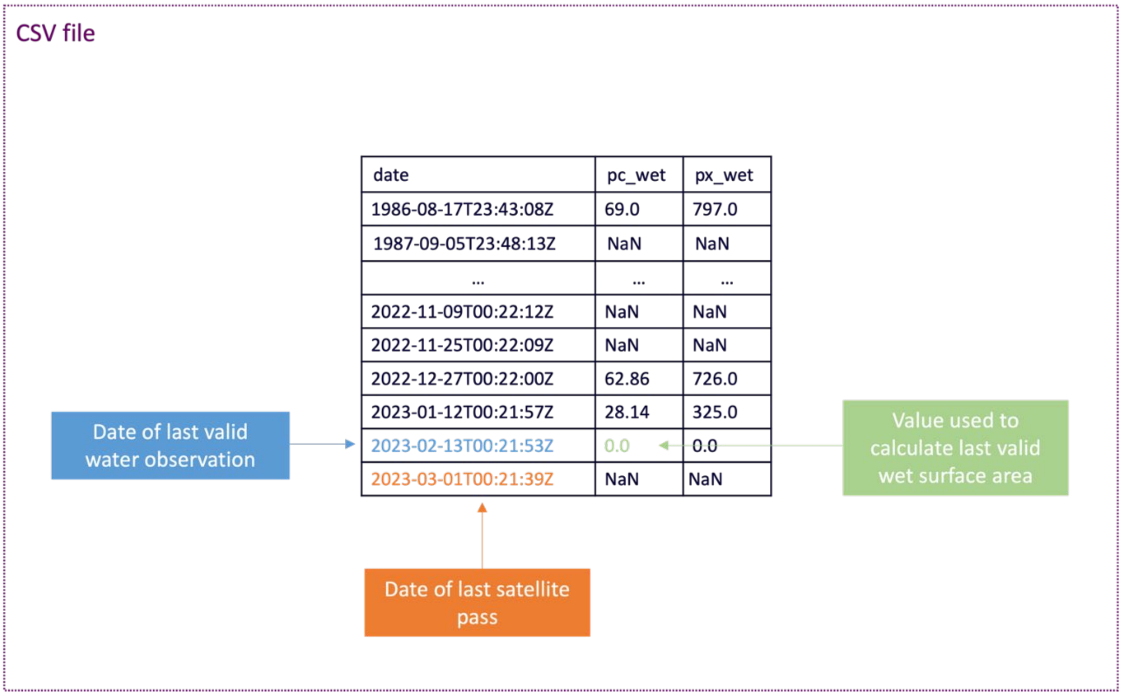
The last valid wet surface area attribute calculated the wet surface area of a waterbody based on the last valid observation. Quantifying an area with a familiar measurable unit, such as meters squared, is more effective and meaningful for users who are not as familiar with quantifying data by pixel size.

The date of the last valid wet observation is stored in the CSV file, which we require for calculating the last valid wet surface area. To extract the last valid wet surface area, we sort the date column into ascending order, remove the NaN values from 'px_wet' and 'pc_wet' columns. The 'pc_wet' value from the last valid wet observation is then taken, shown in Figure 2, and uses the corresponding 'area_m2' static polygon value to calculate and return the wet surface area.

Date of last satellite pass

The date of the last satellite pass captures the most recent date that the satellite passed over a waterbody. This attribute contributes to establishing dataset currency to the user, and allows data to be updated and recorded for each waterbody even if an observation is not valid.

The date of the last satellite pass is derived from the CSV file, visualised in Figure 2. To extract this value, the date column in the CSV file is sorted into ascending order. The last date value is returned as the date of the last satellite pass. If a date row holds NaN values or numerical values, the date still signifies when a satellite last passed over.



date	pc_wet	px_wet
1986-08-17T23:43:08Z	69.0	797.0
1987-09-05T23:48:13Z	NaN	NaN
...	...	...
2022-11-09T00:22:12Z	NaN	NaN
2022-11-25T00:22:09Z	NaN	NaN
2022-12-27T00:22:00Z	62.86	726.0
2023-01-12T00:21:57Z	28.14	325.0
2023-02-13T00:21:53Z	0.0	0.0
2023-03-01T00:21:39Z	NaN	NaN

FIGURE 2. OVERVIEW OF THE VALUES IN A CSV FILE USED FOR CREATING THE NEW ATTRIBUTES INCLUDING THE DATE OF LAST VALID WATER OBSERVATION, DATE OF LAST SATELLITE PASS AND THE VALUE USED TO CALCULATE WET SURFACE AREA.

Date when polygons were created

The date created attribute refers to the date when the polygons were created. This attribute signifies to users that the polygon area is a static feature to which observations are being recorded over. The date when the polygons were created will be the same for the entire dataset as it refers to the last time the polygon dataset was updated.

Date when attributes in database last updated

The date when attributes in the database were last updated signifies when attributes (including the date of last valid water observation, last valid wet surface area and the date of last satellite pass) in the dataset were last updated. This attribute informs users about the currency of the dataset, which was questioned by users in the workshop. This attribute makes the lag in observation to processing much clearer. For example, if a waterbody contained water two weeks ago, but the user can see the data was updated today, they know that they’re looking at the most up-to-date information available.

Metadata URL

The metadata URL attribute provides a link to GA metadata for the DEA waterbodies product. This allows users to access the metadata quickly and easily for this product in case they need to understand how any attributes are calculated or their given units.

TABLE 2: METADATA FOR ALL DEVELOPED AND EXISTING ATTRIBUTES IN THE WATERBODIES PRODUCT

Field	Status	Type	Description	Update Frequency
uid	Existing	String	Unique identifier determined from location of the waterbody	Once per version
perimetr_m	Existing	Real	The perimeter of the waterbody	Once per version
area_m2	Existing	Real	Area of the waterbody, measured in metres squared	Once per version
dt_wetobs	New	DateTime (UTC)	The last date any water was observed. This is subject to the satellite having clear visibility of the waterbody. The satellite must view 80% of a waterbody to have a valid wet observation recorded.	Every two days
wet_sa_m2	New	Real	The total wet surface area recorded by the satellite when it last had clear visibility of the waterbody. Calculated as the wet percentage (pc_wet, see timeseries) multiplied by the waterbody area (area_m2) divided by 100.	Every two days
dt_satpass	New	DateTime (UTC)	The most recent date that the satellite passed over the waterbody.	Every two days
dt_updated	New	DateTime (UTC)	The date that the dt_wetobs, wet_sa_m2 and dt_satpass attributes were last updated.	Every two days
dt_created	New	DateTime (UTC)	The date the polygons were created	Once per version
meta_url	New	String	The metadata url for this dataset	Once per version
timeseries	Existing	String	The Amazon S3 location of the wet percentage time series for this waterbody. The timeseries data is stored in a CSV with the following columns date (DateTime UTC) – date of observation pc_wet (Integer) – percentage of the waterbody recorded as wet (0-100) px_wet (Integer) – number of Landsat pixels recorded as wet	Value is static, but the csv contents is updated every two days

Attributes developed but not included

During the project, users also expressed interest in extracting the longest straight line within a waterbody, with the purpose of identifying waterbodies suitable for access by fixed-wing aircraft. We implemented this attribute by calculating the diameter of the minimum bounding circle for the waterbody. Upon review, the project team decided to not include this attribute for the following reasons:

- Because the polygons are only updated every few years, it is only possible to calculate the typical longest line, rather than the longest line for all water in the waterbody on any given date. The NAFC team specified that this information is only useful if it can be updated regularly, and is based on the distribution of observed water, rather than the typical waterbody polygon.
- The existing algorithm that determines the longest line from the minimum bounding circle is not suitable for complex waterbodies (such as rivers with tributaries), or waterbodies with holes (due to the presence of an island).

Although we did not include this attribute in the final workflow, we have documented the code for calculating it in our GitHub repository.

Attribute integration

A key goal of this project was to build a prototype solution that could be adopted by Geoscience Australia (GA). To achieve this, we met with both the DEA team (responsible for data production) and the Flying Hellfish team (responsible for cloud services). From these meetings, we identified the following key steps in producing and serving the waterbodies product:

- DEA produce the waterbody polygons as a shapefile and provides it to Hellfish.
- DEA run an automated process to update the timeseries information for all waterbodies, storing the timeseries as a CSV in Amazon Web Services' (AWS) S3.
- Hellfish create a Postgres database (with PostGIS) from the shapefile.
- Hellfish serve the database as a Web Feature Service (WFS) through GeoServer.
- Users access the waterbody polygons and their attributes through the WFS.

To ensure our solution could be adopted by GA, we developed a simplified version of the above workflow that could be run in a local environment. We developed the workflow in Python and used GitHub to version control our code. The GitHub repository contains detailed instructions for setting up a local version of our workflow.

Workflow

Once the database and GeoServer are set up, the workflow consists of the following steps, which are run for each waterbody in the database:

- Open the timeseries CSV for the waterbody.
- Identify the most recent date the satellite passed over the waterbody.
- Identify the most recent date that water was observed.
- Calculate the total area of water in square metres for the most recent water observation.
- Commit the dates and area to the database as an update for the waterbody.

A Python script is used to run the update process, calling functions to calculate each attribute value from the timeseries. The local workflow is visualised in Figure 3.

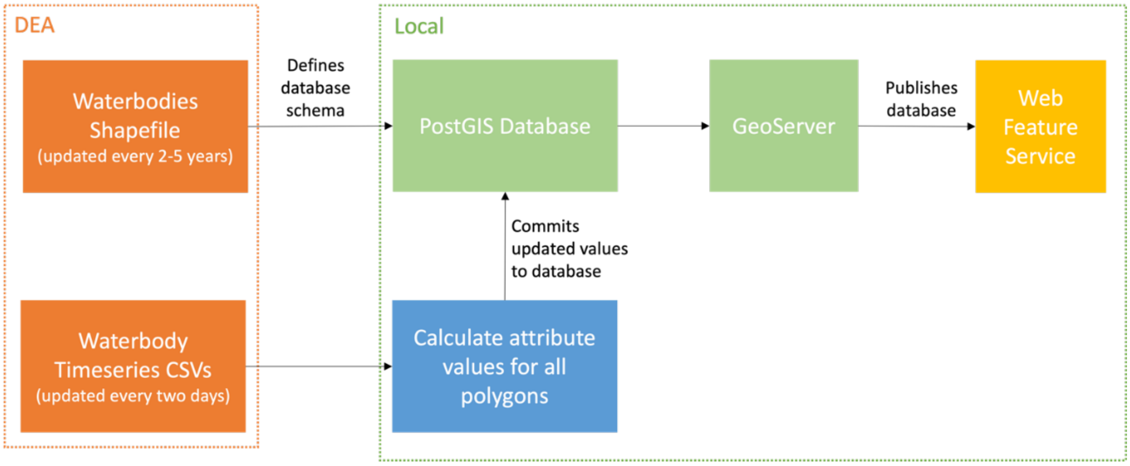


FIGURE 3. OVERVIEW OF THE LOCAL WORKFLOW IMPLEMENTED IN THIS PROJECT.

Handover of workflow

After developing the local version of the workflow, we collaborated with the Hellfish team to identify any modifications that were likely to be required when transitioning the workflow to GA's production systems. We identified the following changes that will need to be made:

- DEA will need to publish a lifecycle hook for the timeseries CSV files. This will allow Hellfish to monitor these files and trigger the update process when they are changed.
- Hellfish will need to write an automated process (using AWS Lambda) that takes in a modified CSV file and updates the database.

The modifications to our workflow to suit GA's production environment are shown in *Figure 4*. The required steps for both teams are discussed in more detail in the Recommendations section.

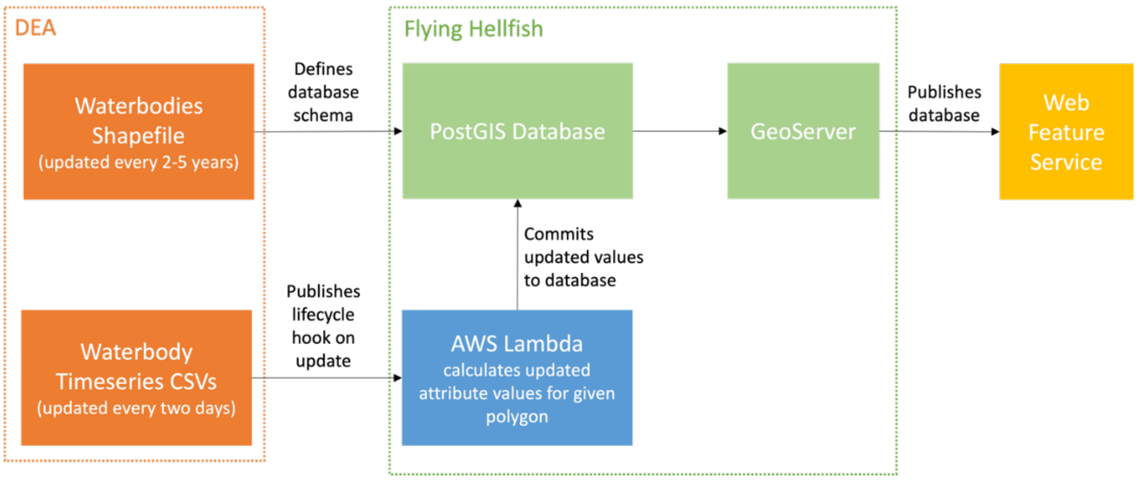


FIGURE 4. OVERVIEW OF THE PROPOSED WORKFLOW TO BE USED IN GA'S PRODUCTION ENVIRONMENT. THE WEB FEATURE SERVICE APPEARS OUTSIDE THE HELLFISH ENVIRONMENT, AS IT CAN BE CONSUMED PUBLICLY, UNLIKE THE LOCAL SOLUTION.

Recommendations for future development

Recommendations for NAFC

Deployment

While GA works on operationalising the new attributes identified in this project, we recommend NAFC implement a local version of the system developed in this project. This has already been proven to work for a small subset of the waterbodies. To make the solution operational for all waterbodies, we recommend the following (Table 3):

TABLE 3: DEPLOYMENT RECOMMENDATIONS FOR NAFC

ID	Recommendation	Reasoning
NAFC.1.1	Investigate methods for parallelising the database operations (to reduce processing time).	We found that the update process is cheap in terms of computer memory and processing. Updating the 300,000+ waterbodies in serial would take 28 hours on an 8-core Apple M1 pro chip with 16 GB of RAM. Parallelising the database operations will allow NAFC to run the process much faster, making it feasible to update the product overnight.
NAFC.1.2	Implement a scheduler to run the process on a regular basis.	This would automate the update process, making sure the WFS was always ready to be used with the most up-to-date information. Currently, the DEA waterbodies product is updated every two days. We recommend NAFC run the process on a similar cadence if they wish to be up to date.
NAFC.1.3	Deploy the workflow in a public-facing GeoServer if other organisations would get value from accessing the WFS.	The workflow developed in this project has been designed to run in a local environment (e.g. a single person's computer) for the purposes of development and testing. To allow external users to access the service prior to GA implementing the service, the WFS will need to be hosted on a server that can be accessed by others.

Additional attributes and layers

During the user needs workshop, many other datasets were identified as valuable for planning, such as the presence of vegetation or powerlines. Given our recommendations for NAFC to implement a functional version of the system while GA operationalises the system, we also recommend the following (Table 4):

TABLE 4: ADDITIONAL ATTRIBUTES AND LAYERS RECOMMENDATIONS TO NAFC

ID	Recommendation	Reasoning
NAFC.2.1	Investigate other data sources that may be of use to end-users and add these to the system.	There are many datasets that may provide value, but are not available Australia-wide, making them unsuitable for the national product produced by GA. However, if NAFC found specialised products that add value, it could be worth investigating how to incorporate these into the system, with the end goal of helping end-users plan the positioning and operations of aircraft.

Recommendations for GA

Operationalising

The next step for GA is to work internally to operationalise the system we have developed during the project. To achieve this, we recommend the following (Table 5):

TABLE 5: OPERATIONALISATION RECOMMENDATIONS FOR GA

ID	Recommendation	Reasoning
GA.1.1	Stand up an internal project to operationalise the system.	Operationalising this system requires participation from DEA and the Flying Hellfish team. An internal project will ensure sufficient resources are allocated to implementing the system developed in this project. The following steps are envisioned for such a project: • DEA to create new version of the waterbodies product (see GA.1.2) and provide to Hellfish to use as the database schema for the WFS. • DEA and Hellfish to discuss optimal running strategy for processing waterbodies and updating timeseries files. • Hellfish to set up an AWS Lambda function to trigger on timeseries updates and run the contents of the updatedb.py script (see GA.1.3). • Hellfish to adapt the updatedb.py script to operate on a per timeseries basis in conjunction with the Lambda function.
GA.1.2	Version the waterbodies product to add new attributes.	When serving this product, the Hellfish team create the database schema from the waterbodies shapefile generated by DEA. This needs to be done any time DEA wish to add product attributes. The new shapefile must include the new attributes identified in Table 2. The shapefile may optionally include attributes that will enhance the product, as suggested in the second collection of recommendations below. When updating the shapefile, DEA and Hellfish must take the following steps: • DEA must upload a copy of the shapefile to their AWS bucket, with any variable attributes set to NULL. This is because the values of these attributes will change as the product is updated, so it is not appropriate to provide these values in the static shapefile. • Hellfish must update the updatedb.py script (and associated Lambda if required, see GA.1.3) to ensure that all attributes are calculated and are updated in the database. • If DEA wishes to calculate new attributes based on the contents of the timeseries csv (see G.2.2), DEA must provide additional functions to return the desired attribute values from the contents of the timeseries csv file. These functions should be included in the attributes_functions.py file and imported and used in the updatebd.py script. We recommend that as part of GA.1.1, the DEA and Hellfish team discuss how to have shared ownership over the code, as both sides will need to update it as part of adding new attributes.
GA.1.3	Publish a lifecycle hook for timeseries csv files.	The Hellfish team will look to automate the process of updating the database whenever new observations are added to the waterbodies timeseries files. Hellfish have identified that the preferred method for this would be for DEA to publish an AWS lifecycle hook for their timeseries files. The Hellfish team can then build an AWS Lambda function that monitors this and triggers the database updates.

Enhancing the product to meet user needs

During the user needs workshop, and in conversation with the project team, we identified two updates that GA could make to the product to add value for end users. To this end, we recommend the following (Table 6):

TABLE 6: RECOMMENDATIONS FOR GA FOR ENHANCING THE PRODUCT TO MEET USER NEEDS

ID	Recommendation	Reasoning
GA.2.1	Include attribute properties as part of metadata.	While reviewing the GA Content Management Interface (CMI) entry for the waterbodies product, our project team found that the entry does not contain a table describing the attributes available for each waterbody, their update frequency, and their type. Such facts are valuable for users who wish to understand the content of the product, even more so with the addition of six new attributes from this project. We recommend that GA add a table like Table 2 to the CMI entry, DOI entry, WFS documentation for DEA Maps, DEA WFS pages, the DEA notebooks and DEA docs.
GA.2.2	Include an appropriate disclaimer in the WFS documentation.	NHRA have requested that GA add an appropriate disclaimer to the updated waterbodies WFS. The disclaimer for this report is included below as a guide. It is expected that GA will adapt this wording to suit the context. "Disclaimer: FrontierSI, Geoscience Australia, National Aerial Firefighting Centre and Natural Hazards Research Australia advise that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable

		to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, FrontierSI, Geoscience Australia, National Aerial Firefighting Centre and Natural Hazards Research Australia (including its employees and consultants) exclude all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.”
GA.2.3	Add counts/percentages of dry and missing pixels to timeseries csv.	When computing the percentage wet area, the DEA process ensures that there are minimal missing pixels, ensuring that the reported presence of water is sufficiently representative of reality. Unfortunately, this results in entries where there is no recorded wet observation, and users are unable to understand why. We recommend updating the timeseries csv to include percent dry and percent missing columns. Coupled with descriptions in the metadata, these values should help users understand the status of the waterbody. GA may still not record percentage wet and percentage dry for observations with too many missing pixels but could still report the percent missing to help users understand why no wet or dry percentage was provided. If pursuing this, DEA and Hellfish will need to: • update the attribute_functions.py file to pull out the appropriate percentages from the csv and convert them to areas • update the shapefile and database schema to include new attributes for storing the wet and missing areas • update the updatedb.py script to commit the new values to the database
GA.2.4	Develop a system for communicating confidence in an observation and add as an attribute.	During discussion with end users, we identified that understanding whether there was any water present, and the level of confidence GA had in this would both be valuable attributes. This is especially relevant for large waterbodies that might only be partially observed due to cloud cover – for an end user, it might still be useful to know that some water was seen, even if a percentage would not accurately represent the truth due to missing data. Another possible usage for this type of system would be if GA were to incorporate a Landsat near-real-time product in – this would reduce the lag in observations, but would need to be accompanied by identifying information to indicate it had not undergone rigorous processing. This type of system may be beyond the scope of the immediate work required for GA to update the waterbodies product for use by NAFC and other agencies, but could be considered for future work.

Lessons learned

During the span of this project, collaboration between the project team was highly effective in creating an environment which produced outcomes that encapsulated the aims of this project. This can be attributed to several factors.

- The sprint format of the project, allowing two weeks for development and one week for review by the project team. This allowed time for constructive review and worked well for members of the team who are spread across multiple projects.
- The user needs workshop provided the project team with a background understanding into the use of waterbody data. This understanding is critical for producing a product fit for purpose, that users want to use.
- The structure of project implementation, having FrontierSI implementing the work allowed for more objective problem solving.
- The project focused on a narrow scope of end-user needs. This may result in some other aspects of the end-user workshop not being explored but allowed the team to focus in detail on the outputs subsequently achieved.
- End-user engagement, participation and frequent feedback throughout a research project are essential to success from a research utilisation perspective.

Conclusion

This project identified and implemented several user-driven improvements to the Digital Earth Australia (DEA) Waterbodies product. From users, we found that information on waterbodies has immediate value during pre-planning stages. We identified several waterbody properties that will help users plan the placement of aircraft for an upcoming season: the surface area of water in the waterbody and the most recent date that water was observed. We developed a local workflow (modelled on Geoscience Australia's existing systems) that proved that the new waterbody properties could be updated on a regular basis and could be accessed by users through the waterbodies product's existing Web Feature Services.

Team members

This project is a collaboration between Natural Hazards Research Australia, NAFC and FrontierSI, advised by GA. A Project Management & Technical Advisory Group (PMTAG), with members from these four agencies and representatives from additional Fire Agencies such as CFA, has overseen delivery of the project against agreed milestones. Roles and responsibilities of key project stakeholders are specified below (Table 7), followed by an RACI framework for key collaborators (Table 8).

TABLE 7: PROJECT TEAM MEMBERS

Roles	People	Contact Details	Responsibility
Natural Hazards Research Australia (NHRA)			
Project Sponsor	Shiva Prasad (Research and Implementation Director)	shiva.prasad@naturalhazards.com.au	Ultimately responsible for what the project is developing and its place or application in the market. Provides timely decisions on project direction in the context of the project's success.
Project Support	Nicklaus Mahony (Research Services Team Leader)	nicklaus.mahony@naturalhazards.com.au	Supports project coordination and ensures project deliveries and activities meet NHRA requirements.
National Aerial Firefighting Centre (NAFC)			
Project Manager	Anthony Gallacher (Manager, NAFC Resource to Risk Project)	anthony.gallacher@nafc.org.au	Responsible for achieving the approved project outcomes by leading the project through initiation, execution, and closure by managing the time, budget and scope to the required quality expectations.
End User	Sandra Whight (Manager Research and Evaluation)	sandra.whight@nafc.org.au	The representative of every person who will use the products of the project. This includes operations and maintenance. The users are all those for whom the project is designed, or who will use the project's products to deliver expected benefits. Users will be involved in the validation of deliverables throughout the project.
Project Support	Céline Vinot (Project Officer, NAFC)	celine.vinot@nafc.org.au	Supports NAFC project activities.
Geoscience Australia (GA)			
Project Advisor	Norman Mueller (Director of Science Engagement)	norman.mueller@ga.gov.au	Responsible for strategic project advice to the project sponsor. Assists PM in identifying issues, reviews deliverables, may be closely involved in one or more technical or business aspects of the project – e.g., architectural design, user requirements analysis, test planning.
Technical Advisor	Bex Dunn (Assistant Director, Engagement & Innovation)	bex.dunn@ga.gov.au	Provides technical advice to support the FrontierSI project team. Identifies issues, supports the review of deliverables, is closely involved in technical aspects of the project.

Roles	People	Contact Details	Responsibility
FrontierSI			
Project Director	Fang Yuan (EO Technical Lead)	fyuan@frontiersi.com.au 0423 001 845	Provides active development, cultivation, and maintenance of associated project relationships. Also, supervises the project, which includes tracking resources and schedule, meeting with stakeholders, reviewing status reports and deliverables and documenting any proposed changes to the project.
Project Manager	Roshni Sharma (Project Manager and Analyst)	rsharma@frontiersi.com.au 0407 757 756	Responsible for achieving the approved project outcomes by leading the project through initiation, execution, and closure by managing the time, budget, and scope to the required quality expectations.
Technical Lead	Dr Caitlin Adams (Senior Data Scientist)	cadams@frontiersi.com.au 0423 681 009	Responsible for the technical direction of the project.
Technical Support	Madeleine Seehaber (Graduate Data Scientist)	mseehaber@frontiersi.com.au	Supports the technical lead in undertaking the technical requirements of the project.
AFAC			
End User	Sam Ferguson (Bushfire Systems Specialist)	sam.ferguson@afac.com.au	The representative of every person who will use the products of the project. This includes operations and maintenance. The users are all those for whom the project is designed, or who will use the project's products to deliver expected benefits. Users will be involved in the validation of deliverables throughout the project.
Country Fire Authority Victoria) CFA			
End User	Danielle Wright (Remote Sensing Analyst)	Danielle.Wright@cfa.vic.gov.au	The representative of every person who will use the products of the project. This includes operations and maintenance. The users are all those for whom the project is designed, or who will use the project's products to deliver expected benefits. Users will be involved in the validation of deliverables throughout the project.

Roles and Responsibilities RACI Matrix

R = Responsible (undertakes the work)

A = Accountable (ultimately answerable for the completion of the deliverable or task)

C = Consulted (those whose opinions are sought)

I = Informed (those who are kept up to date on progress)

TABLE 8: PROJECT RACI MATRIX

TASK	PD - FSI	PM - FSI	Tech - FSI	GA	NAFC	Natural Hazards	PMTAG
Contracts	C	I	I	C	C	R + A	C
Kick-off meeting	C	R	C	C	A	C	I
NHRA Project Plan	I	I	I	I	C	R + A	C
Project Initiation Document	A	R	C	C	C	C	A
Managing Project Scope	A	R	C	C	C	C	C
Tracking schedule and reviewing deliverable	A	R	C	C	C	C	I
Data Sharing	I	C	C	R + A	I	I	C
User Needs Workshop	A	R	C	C	C	C	I
Data Model	A	C	R	C	I	I	I
Status Meetings	A	R	C	C	C	C	I
Data Development	A	C	R	C	I	I	I
Showcase 1	A	C	R	C	C	C	I
Showcase 2	A	C	R	C	C	C	I
Showcase 3	A	C	R	C	C	C	I
Documentation (inc. metadata)	A	C	R	I	I	I	I
Handover Session	A	C	R	C	C	C	I
Short Report	A	R	R	I	I	I	C
Close out meeting	A	R	C	C	C	C	I

Key milestones

This project contains four milestones, which were split into eleven deliverables as agreed by the PMTAG (Table 9, Table 10).

TABLE 9: MILESTONES

Item	Task	Due
Milestone 1 – Fully Executed Agreement	1	8 December 2022
Milestone 2 – Project Summary in NHRA template	2	15 January 2023
Milestone 3 – Final Algorithms & Datasets Showcases	3	6 April 2023
Milestone 4 – Project Close	4	2 May 2023

TABLE 10: DELIVERABLES

Item	Task	Due
Deliverable 1 – Inception meeting	2.1	15 December 2022
Deliverable 2 – Quarterly report	2.2	31 December 2022
Deliverable 3 - Project plan approved by PMC	2.3	15 January 2023
Deliverable 4 - Project summary in NHRA template	2.4	15 January 2023
Deliverable 5 – User needs workshop	3.1	2 February 2023
Deliverable 6 – Data model defining geometry and attribute information	3.2	23 February 2023
Deliverable 7 – Draft algorithms and datasets	3.3	16 March 2023
Deliverable 8 – Final algorithms and datasets	3.4	6 April 2023
Deliverable 9 – Training in tool use	4.1	25 April 2023
Deliverable 10 – Short report	4.2	25 April 2023
Deliverable 11 – Project evaluation	4.3	25 April 2023