# Upper Ovens River low flow planning: Increasing understanding of aquatic habitat under extreme low flows with the use of an interactive river depth map

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**Key Points**

- Technology has allowed the rapid gathering of high precision information about the physical world and has a range of applications for natural resource management
- The North East CMA and Jacobs have developed a GPS based bathymetric survey method and interactive depth map suitable for building knowledge of rivers at the reach or catchment scale
- The product was used to assist in low flow planning for the upper Ovens River in north east Victoria

## Abstract

The upper Ovens River is one of the last major rivers in the Murray-Darling Basin which retains a near natural flow regime. Although largely unregulated, water is harvested by pumping to fill farm dams, to irrigate crops and for domestic, stock and town use. In dry years, consumptive demand has the potential to significantly reduce or stop flow. Low flows and cease-to-flow events can have negative impacts on aquatic fauna by reducing the quality or quantity of aquatic habitat and reducing water quality. One way to assess habitat under low flows is to use hydraulic models, however, this is problematic because the upper Ovens River has a porous riverbed, meaning that a portion of the flow passes through the riverbed, a type of flow not easily accounted for by hydraulic models.

To better understand the upper Ovens River under very low flows, the North East CMA and Jacobs Group Australia completed a bathymetric and aquatic habitat survey. Jacobs developed an innovative kayak mounted survey rig to complete a high accuracy depth and aquatic habitat survey of 40 km of the Ovens River between Bright and Myrtleford under extreme low flows. The output was an interactive, GIS based map of the river, incorporating the depth survey, spatially oriented photography of the river and quantitatively based conceptual models of the main riffles identified in the river. The interactive map and conceptual models provide the CMA with a powerful tool to understand the river and to determine how habitat availability and condition change as flows reduce.

## Keywords

Low flow, bathymetric map, aquatic habitat

## Introduction

Technology is rapidly increasing our ability to gather large amounts of precise, high accuracy information about the physical world. Recent advances in GPS technology has meant that such technology is now sufficiently robust and cost effective to find a range of uses in natural resource management.

This paper describes the development of a GPS based survey method for completing high accuracy, long range depth surveys in rivers. The paper also outlines the production of a GIS based depth map which presents the depth data in a simple and intuitive interactive platform. The interactive map allows the depth data to be visualised in a range of ways and is supported by embedded, geo-located photos.

The bathymetric survey method and interactive map is a powerful and cost effective method for understanding aquatic environments at the reach and river scale and has a range of potential uses. It was developed to support decisions about the management of the upper Ovens River in north-east Victoria under extreme low flows. In this paper, we will describe the development of the bathymetric survey method and interactive map in the context of the management of low flows in the upper Ovens.

## *Understanding low flow in the upper Ovens River*

The upper Ovens River is one of the last major rivers in the Murray-Darling Basin to retain a near natural flow regime. Although largely unregulated, water is harvested from the river to fill farm dams, irrigate crops and for domestic, stock and town use.

The North East Catchment Management Authority (NECMA) is responsible for coordinating integrated catchment management and sustainable land and water use in Victoria's North East. NECMA recognises the need to manage the water resources of the upper Ovens equitably to ensure the long-term sustainability of those resources and protect the environmental, social, and economic benefits the water resources provide.

In 2006, Sinclair Knight Merz (SKM) used the FLOWS method to determine environmental flow requirements for the upper Ovens River and its main tributaries, including the summer low flow recommendations. These environmental flow recommendations are easily met in winter and are usually met in summer during wet years.

In dry years, however, the natural summer low flows are lower than the recommended environmental summer low flow and consumptive demand in those years has the potential to significantly reduce or stop flow in the upper Ovens River and its tributaries. Low flows and cease-to-flow events can have negative impacts on aquatic fauna by two primary mechanisms; i) reductions in water quality, and ii) reductions in quality or quantity of aquatic habitat.

An important component of the sustainable management of the upper Ovens System was the development of a Water Management Plan, which was finalised in February 2012. The key environmental goal of the plan is to reduce the risk to aquatic life during critical low flow periods by restricting surface water and groundwater diversion. While the importance of protecting the ecological values of the upper Ovens River under extreme low flows was recognised in the Water Plan, the nature of the risk to these values from the low flow was still poorly understood.

Much of the riverbed substrate in the upper Ovens River is made of large cobbles. The porous nature of this substrate means that a portion of the flow in the river passes through the riverbed (the hyporheic zone). As a consequence of this hyporheic flow, a gauge may still register flow when water level is very low, but much of the aquatic habitat in the river, particularly at riffles, could be dry.

The hydraulic model used for the environmental FLOWS study does not account for the flow through the hyporheic zone. Although this is not a major issue for estimating the magnitude of normal low flows or high flows, the hydraulic model is unreliable at estimating habitat conditions under very low flows.

## *Physical measurement of aquatic habitat under extreme low flows*

Due to the unreliability of the existing hydraulic model for estimating habitat availability and condition at very low flows, NECMA and Jacobs Group Australia (Jacobs) have developed a method for investigating this using physical monitoring. The ultimate goal of the physical low flow monitoring program is to correlate direct measurements of aquatic habitat availability and condition, particularly at riffles, with flow at nearby gauges. Once this relationship has been established, NECMA will be able to more accurately determine the critical low flow thresholds for the river to protect important riffle habitats, as well as feed back into management rules for consumptive diversions.

The low flow physical habitat monitoring program required the completion of the high resolution bathymetric survey of 40 km of the upper Ovens River between the towns of Bright and Myrtleford to characterise the river and to determine the extent of shallow water habitat. The survey allowed the development of the GIS based interactive depth map of the river.

## Method

### *The upper Ovens River*

The Ovens River runs from the Great Dividing Range in north-eastern Victoria to Lake Mulwala and the River Murray. The upper Ovens River denotes the section of river from the headwaters in the Great Dividing Range to the confluence with the Buffalo River downstream of Myrtleford (Figure 1).

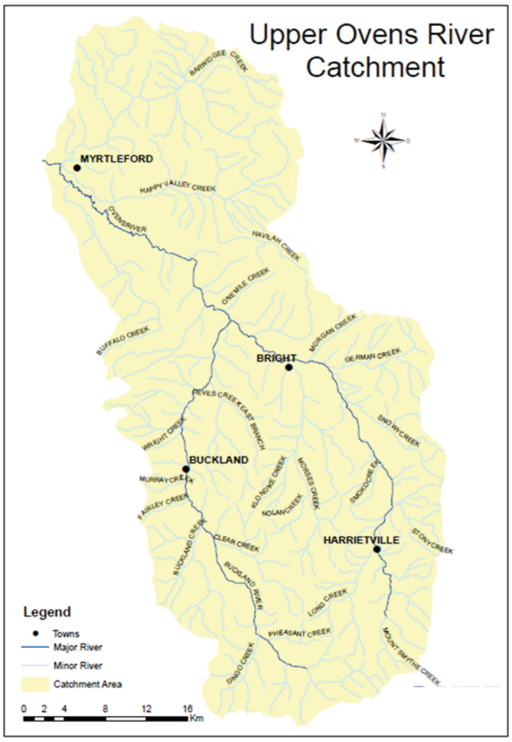


**Figure 1. Upper Ovens River.**

### *Bathymetric survey*

We used a combination of terrestrial and hydrographic techniques to conduct a longitudinal survey of the Ovens River between Bright and Myrtleford. The bathymetric survey was carried out from 16 to 21 of March 2015. Flow, measured at Bright, during the survey ranged between 37 ML/d and 45 ML/day. Flow at Myrtleford over the same period varied between 54 and 78 ML/day.

A bathymetric survey unit (CEESCOPE) was affixed to a kayak that was either paddled or towed down along the thalweg of the river (Figure 2). The boat operator visually selected the thalweg route as they moved downstream. The survey unit continuously recorded the elevation of the bed beneath the kayak as well as Real Time Kinematic (RTK) X and Y GPS co-ordinates along the selected route.

**Figure 2. Kayak mounted bathymetric survey rig.**

Sections of the river system have riparian zones with a substantial tree canopy, which created a challenge for the moving bathymetry system to calculate an accurate Australian Height Datum (AHD) value of the water level. To overcome this issue a second surveyor working in tandem with the bathymetric operator surveyed the change in water levels across each riffle.

This provided a 3 dimensional water level file for the whole 40 km of river surveyed. This data was then correlated with the bathymetry data sets to eliminate any height errors of the bathymetry system caused by the tree canopy interrupting GPS signals to the system.

All site specific and associated topographic data were stored within a Leica Viva GPS Unit. The survey was completed within +/- 0.100 m Horizontal and +/- 0.030 m Vertical relative local uncertainties at 95% confidence and coordinated to GDA94 and AHD datums respectively. Data accuracy was confirmed in the field using manual measurements.

Processing of the raw data sets was undertaken in a Hydrographic software package (Hypack). This enabled all echo-sounding datasets recorded at 10 Hz, to be reviewed, cleaned for outliers and then filtered into a presentable dataset free of errors. Once processed, the survey long-sections were exported, profiling the river depths and water levels at an approximately 0.5 m interval to an AHD accuracy of +/-40 mm.

### *Interactive GIS based depth map*

The output from this project is an interactive, GIS based map of the river, incorporating the depth survey and spatially oriented photography of the river taken with a GPS equipped camera.

## Results

### *Bathymetric survey*

Data collected during the bathymetric survey were post processed to reduce noise related to vegetation, rocks and snags that interfered with the determination of the true bed. The result of the post processing was a set of discrete data points indicating bed depth (and water height) on average every 0.5 m for the approximately 40 km of surveyed river between Bright and Myrtleford.

For the purposes of the spatial output in the interactive map, these discrete data points were organised into different depth classifications. These classifications allow the spatial product to be easily interrogated to understand the depths in the river and allows the generation of simple summary statistics.

To estimate the percentage of the surveyed area between Bright and Myrtleford that was within the different depth classifications we have completed a straight count of the number of discrete data points within each category. The percentages, determined from this count, are shown in Table 1.

This method provides a broad estimate of the river depths, however, the discrete data points are not evenly distributed down the surveyed area of river (slightly more readings are typically returned from shallow areas where progress down the river was slower than in deeper sections). We have also used an estimation method which corrects for uneven sampling. We have completed an interpolation that degrades the data to a 1 m by 1 m pixel value by smoothing the data over gaps larger than 1 m and averaging the data if two or more data points have been collected within the 1 m pixel (Table 1).

The results of both estimation methods were similar. Approximately 12% of the river was below 0.2 m deep at the time of the assessment. Between approximately 35 and 40% of the river was between 0.2 and 0.5 m deep and about 30 % was between 0.5 and 1 m deep. Just over 20% of the river was deeper than 1 m at the time of the assessment (with a maximum depth of about 4.1 m).

**Table 1. Estimates of depth classification percentages in the Ovens River between Bright and Myrtleford**

| Depth range classification | Percentage of recorded data within classification (based on count of data points) | Interpolated percentage of recorded data within classification (based on count of 1 m interpolated pixels) |
|---|---|---|
| **0-0.2 m** | 12 | 11 |
| **0.2 – 0.5 m** | 35 | 41 |
| **0.5 – 1 m** | 30 | 28 |
| **1 – 2 m** | 20 | 18 |
| **2 – 3.5 m** | 3 | 2 |
| **3.5 m – 4.2 m** | 0.1 | 0.1 |

## Discussion

To our knowledge, this is the first time high accuracy GPS survey methods have been used to provide a bathymetric survey of such a long section of a river under low flows. The key to being able to provide a detailed, high accuracy survey over a long distance in a cost effective manner is the innovative kayak mounted bathymetry system.

### *Features of the interactive GIS based interactive depth map*

The interactive map presents the depth data on high quality aerial imagery of the river. The detailed bathymetric survey data was categorised into different depth classes, which have been colour coded to allow rapid visual of different habitats. In addition, a longitudinal cross section of the river is incorporated into the interactive map, allowing both an aerial and cross section view of the river to be visualised together. Both the aerial and longitudinal views are able to be zoomed in and out, allowing the data to be interrogated at the reach scale but also to understand subtle changes in the river depth over the space of metres.

In addition, another valuable feature of the interactive map which can be used for a variety of river management activities is the incorporation of more than 1100 high quality photos. The photos were captured with a GPS equipped camera have been spatially oriented within the aerial view. Clicking on one of the photo icons within the interactive map brings up photos showing important features of the river at that location such as instream and riparian habitat, water extraction points, weirs and areas of erosion. A screenshot of the interactive river depth map is shown in Figure 3.

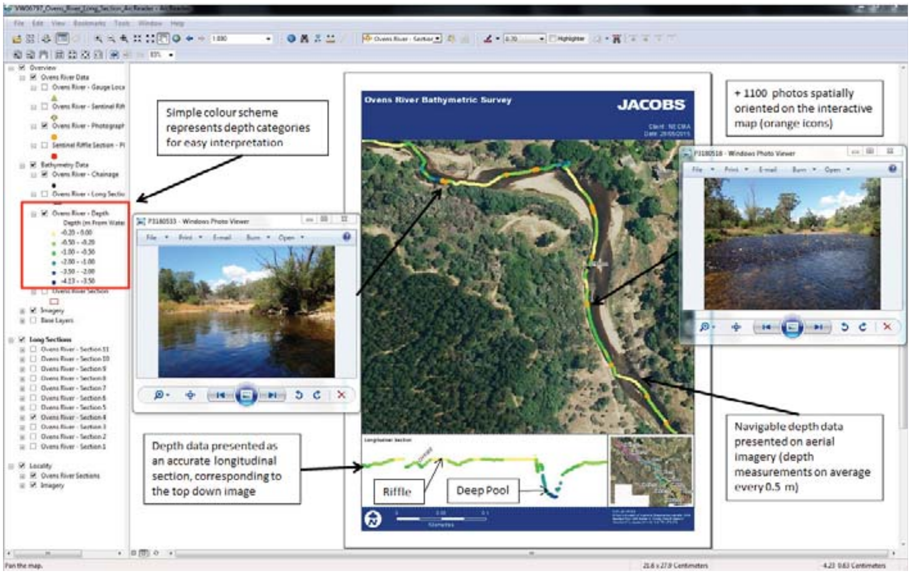


**Figure 3. Example output from the GIS based interactive depth map based spatial product**

## _Use of the interactive depth map in low flow planning for the upper Ovens River_

The interactive depth map was used to select 15 representative 'sentinel' riffles. These sentinel riffles were described and quantitatively based, diagrammatic conceptual models were produced for each one based on the measurements of the wetted width, water depth, algae accumulation and sediment deposition at the riffles. These conceptual models form the basis of the ongoing monitoring program, the aim of which is to correlate direct measurements of aquatic habitat availability and condition at riffles with flow at nearby gauges. Once this relationship has been established, the NECMA will be able to more accurately determine the critical low flow thresholds for the river to protect important aquatic habitats. Figure 4 shows how the interactive map can be linked with conceptual models of riffles to help with low flow planning.

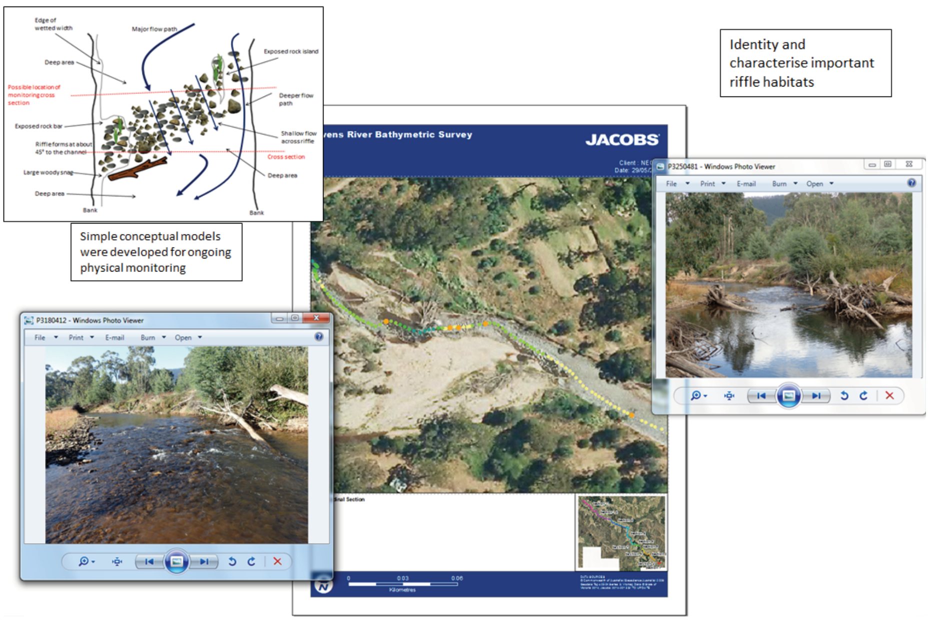


**Figure 4. Interactive river depth map showing conceptual models of riffles.**

### *Other uses of the interactive depth map*

The accurate, bathymetric survey technique, combined with the user friendly GIS based output could be used to answer a range of important questions. The survey method has the ability to identify the location and character of instream habitats, and increasingly importantly - drought refuge habitats, such as deep pools within a system. Such information would be valuable as we go into dry conditions, which is of particular importance as the El Nino strengthens and we face the prospect of dry conditions in the foreseeable future. Knowing where refuge habitats are in a river system may be crucial for ongoing protection of important species, communities and ecological processes.

The kayak based survey rig we developed as part of this study allows long distances of river to be assessed in a cost effective manner. Habitat features and drought refuges are able to be identified where boat access might be difficult, either because of access, shallow water depth or dense vegetation. The survey method could also be easily used to better understand wetlands, providing plentiful and accurate data that could be used to develop hydraulic models, for example.

The development of many hydraulic models currently use LIDAR data. However, LIDAR is not able to penetrate water. In the absence of data below a water line, this survey method can provide bathymetry data which can be tied into the LIDAR data. The additional information on the depth and bed profile of a river or wetland would allow effective environmental water planning.

It is also possible to answer a range of questions through the utilisation of the geo-referenced photos and interactive GIS presentation alone. Following a rapid longitudinal survey an interactive map could be produced which would provide spatially accurate information about the river and could be used to explore such issues as, the location and severity of erosion points, the location and method of water extraction activities, the nature, distribution and extent of fish barriers; and other habitat modifications, such as sand slugs.

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