

Cave Surveying for Management (Case Study The Jenolan Show Caves)

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Abstract

In 1987 a re-survey of the Jenolan Show Cave system commenced aimed at producing a survey that could be used for interpretation, research and management. The project was encouraged by management and supported with limited funds and facilities. Surveying methods, computing and drafting of maps were based on methods of surveying in wild caves. However, in caves containing infrastructure, like the Jenolan Show Caves, a total station (theodolite with laser distance measurement) traverse of the main passages is necessary. Cave infrastructure changes over time and the survey has had to be continuously updated. However, there are limitations in using traditional cave plans for management. Presently, Jenolan Caves Reserve Trust (JCRT) is in the process of adopting the NSW National Parks and Wildlife Service's Asset Management System (AMS). Traditional wild cave surveys do not give adequate results for an AMS compilation; for example, it is not possible from a plan to calculate the amount of concrete in paths. Traverse lines, passage cross sections and path outlines computed as map grid coordinates are imported into AutoCad as dxf files to allow 3D visualisation and facilitate additional measurement. On implementation of the recent and ongoing survey work, maintenance staff will be provided AMS on mobile devices which will further display images from both surface and improved cave surveys, allowing easy identification and location of assets requiring maintenance. Cave surveying continues to evolve and advancements in technology such as 3D LIDAR and techniques like photogrammetry and the development of virtual reality will continue to improve the cave experience and knowledge for tourists, researchers and cave management.

Introduction

The Jenolan Cave system was originally mapped by Trickett and published in its final form in 1922

(Middleton, 1991). A re-survey of the caves was commenced in 1987 by the Jenolan Survey Project. The Executive of the Jenolan Survey Project comprised four speleologists, Julia James, David Martin, Greg Tunnock and Alan Warild, all with extensive experience in surveying wild caves in order to record their cave explorations. The surveys produced at this time were plans for recording cave length and developed long sections for cave depth. The aim of the Jenolan Survey Project was to produce a cave survey that could be used for research and cave management (Bonwick et al., 1988, James et al., 1988 and James et al., 2009).

Surveying Jenolan Show Caves

The Jenolan Show Caves presented a number of surveying and presentation challenges. The Jenolan Caves system is a long, complex 3D maze containing large chambers, small passages and magnetic infrastructure, hence a number of different surveying techniques were trialled and utilised. With the advent and evolution of computing and the availability of commercial programs, the surveying, drafting and storage of data also changed.

The presence of magnetic infrastructure required, at least initially, the use of non-magnetic surveying methods. Theodolite and total station (theodolite with laser distance measurement and data logger) surveys of the tourist sections were carried out by Chris Dunne and Russell Bridge. These non-magnetic surveys have subsequently formed the mainstay (the base survey) of all ensuing surveying efforts (Figure 1). Separately, spatial dimensions at each survey point (i.e. left, right up and down or LRUD) were measured. Later changes in infrastructure, particularly the replacement of wrought iron with stainless steel, allowed the careful use of magnetic surveying technology like the Disto-X.

Jenolan Show Caves

Survey Standards

- Theodolite - Total station
- Tripod mounted forestry compass
- Wild cave surveying equipment
- Underwater surveying equipment

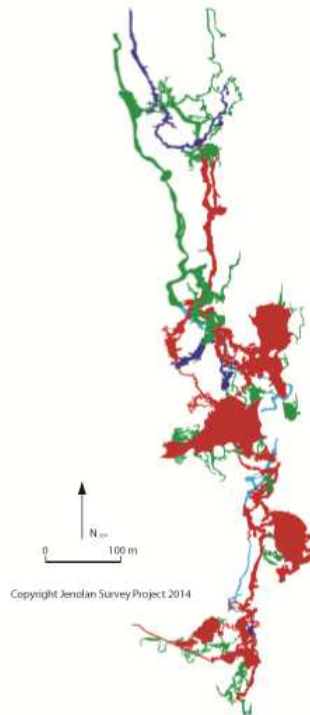


Figure 1: Survey Equipment

Survey locations were marked and photographed, with major passage junctions marked with stainless steel (permanent) disks. Plans and sections were drawn in-situ (Figure 2). Where possible, international

symbols were used or modified in the drafting, but special symbols were required for Jenolan-specific speleothems. Original survey data has been archived, together with photos and initial sketches.

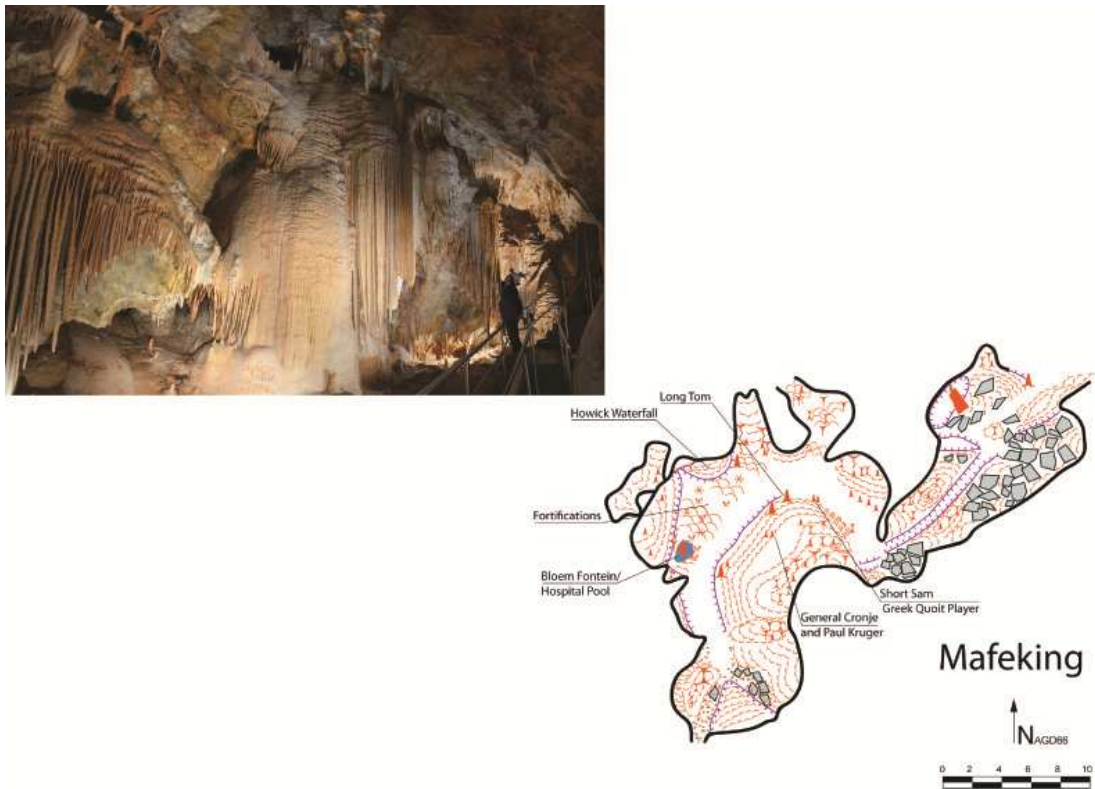


Figure 2: Photograph and Plan of Mafeking

Computer drafting

Plans and sections were computer drafted using Adobe Illustrator which had the following advantages: scalable vector graphic (SVG) input and output, and round tripping; separate layers for different aspects (walls, paths, text, speleothems, infrastructure etc); and, Adobe portable document format (PDF) input and output. Cave Management requested developed long sections (Figure 3) for aiding the description of

show caves to tourists. Contouring of large chambers produced a facsimile of the 3D nature of floor and walls, but not the roof (Figure 4). The combination of the traverse with LRUD data allowed computer generation of 3D representations of the cave system. The accuracy of the 3D depiction of the chambers and passages was improved by increasing the number of the survey points along the traverse and number of cross section data points recorded at each (Figure 5).



Figure 3: Developed Long Section - Pool of Cerberus (Kennedy et al., 2009)



Figure 4: Plan of the Grand Arch

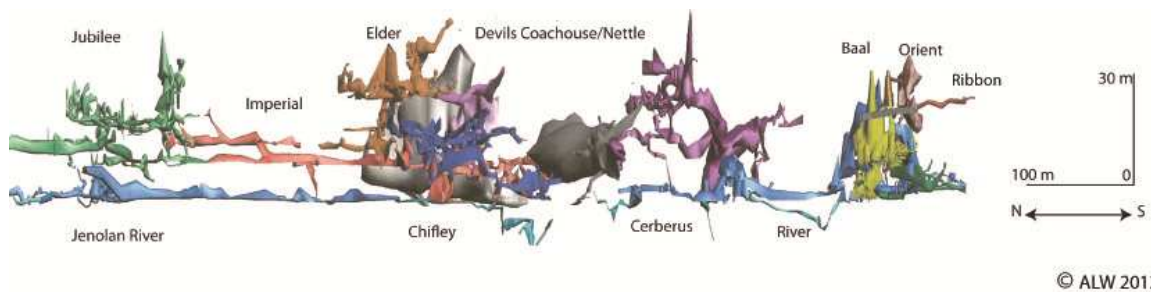


Figure 5: 3D View of Jenolan Show Caves

Connecting the plan to the surface

An aerial survey was commissioned by Jenolan management and connected to State survey markers and permanent surface survey stations. The underground traverse, which was connected to the permanent stations, could then be shown in relation

to the surface. Topographical imagery could then be superimposed on the cave maps to present a “complete picture” of the Jenolan Show Caves and the associated wild caves (Figure 6).

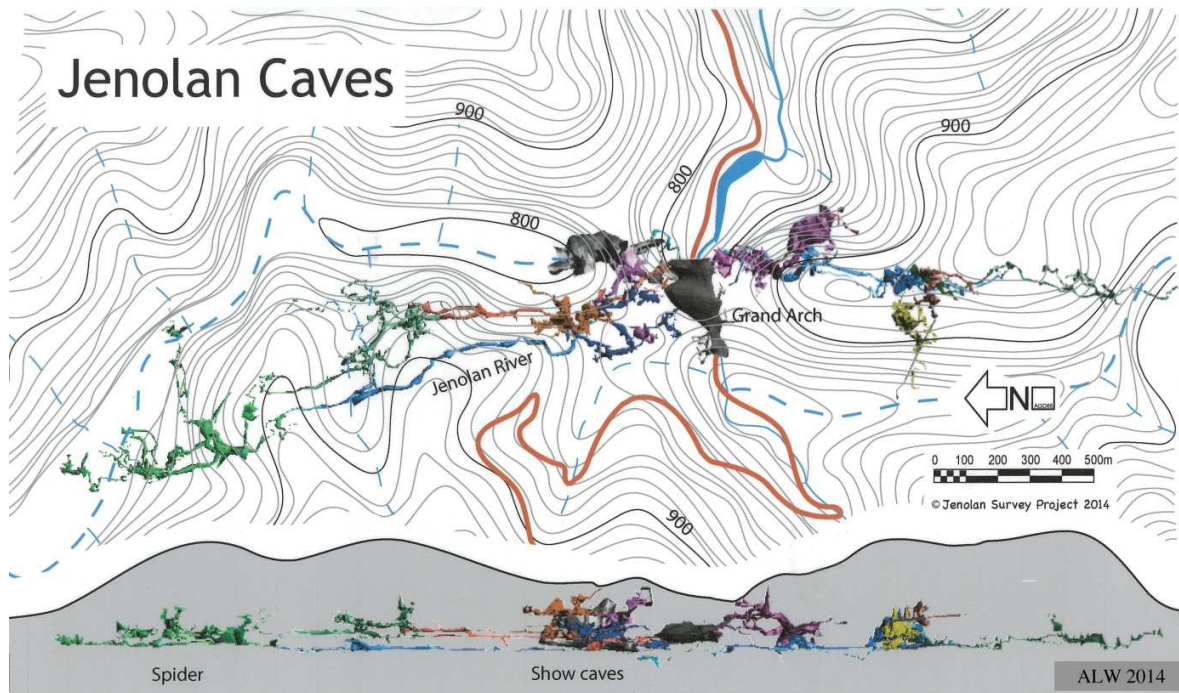


Figure 6: Plan of Jenolan Caves with Superimposed Surface Contours

Management Uses of the Cave Plans and 3D Imagery

In past years, the outputs of the Jenolan Survey Project as described above have been used in numerous ways to improve the cave experience and knowledge for tourists, researchers and cave management. In 2017 Jenolan Caves Reserve Trust (JCRT) decided to adopt the NSW National Parks and Wildlife Service's Asset Management System

(AMS). A drone survey was conducted in 2017. This provided a projected orthomosaic image and a Digital Surface Model and allowed desktop capture of surface asset locations and calculation of dimensions using ESRI's ArcGIS. Utilizing the current survey together with the drone survey a more detailed and spatially accurate digital representation of the Jenolan Caves area above Chifley Cave and the Grand Arch has been made possible (Figure 7).

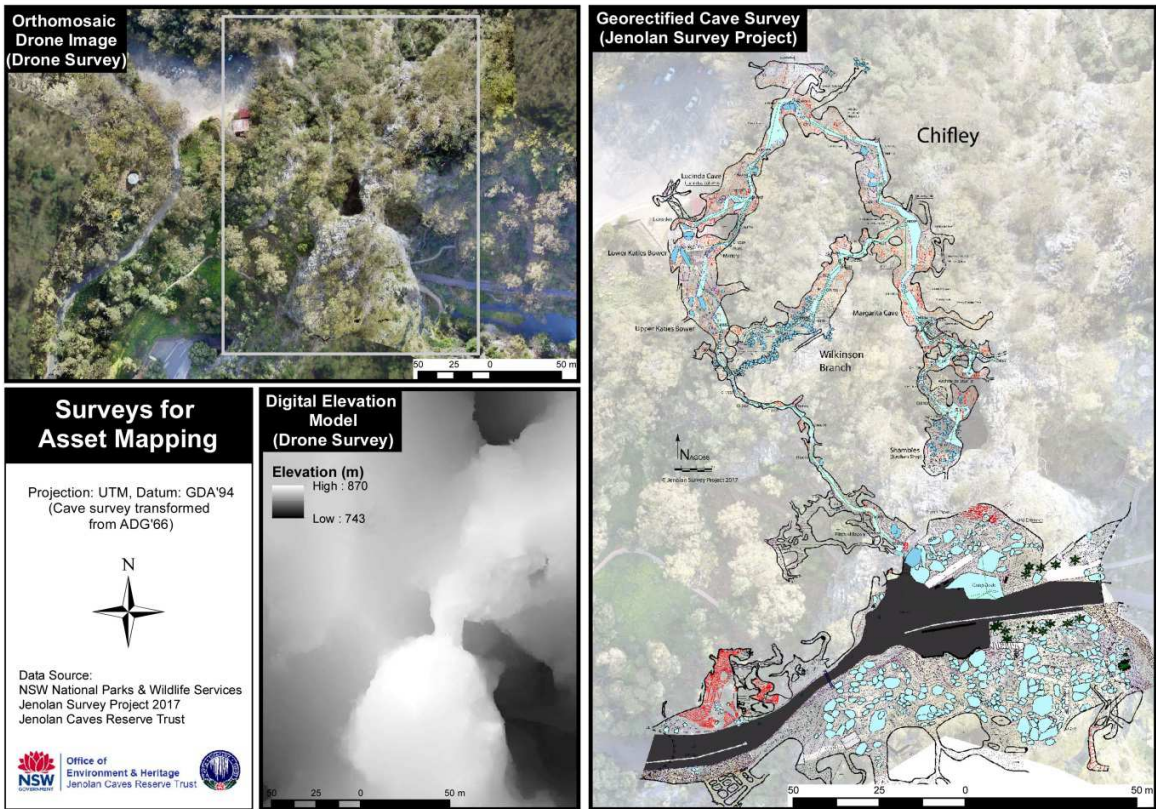


Figure 7: Interrelation of the current plan and drone survey

The cave surveys described above did not give adequate results for an AMS compilation; for example, the use of generic symbols on plans and sections to represent assets, such as different types and composition of protective infrastructure. In order

to capture specific cave infrastructure, additional measurements in the caves were required and subsequent recording onto the current cave plans (Figure 8).

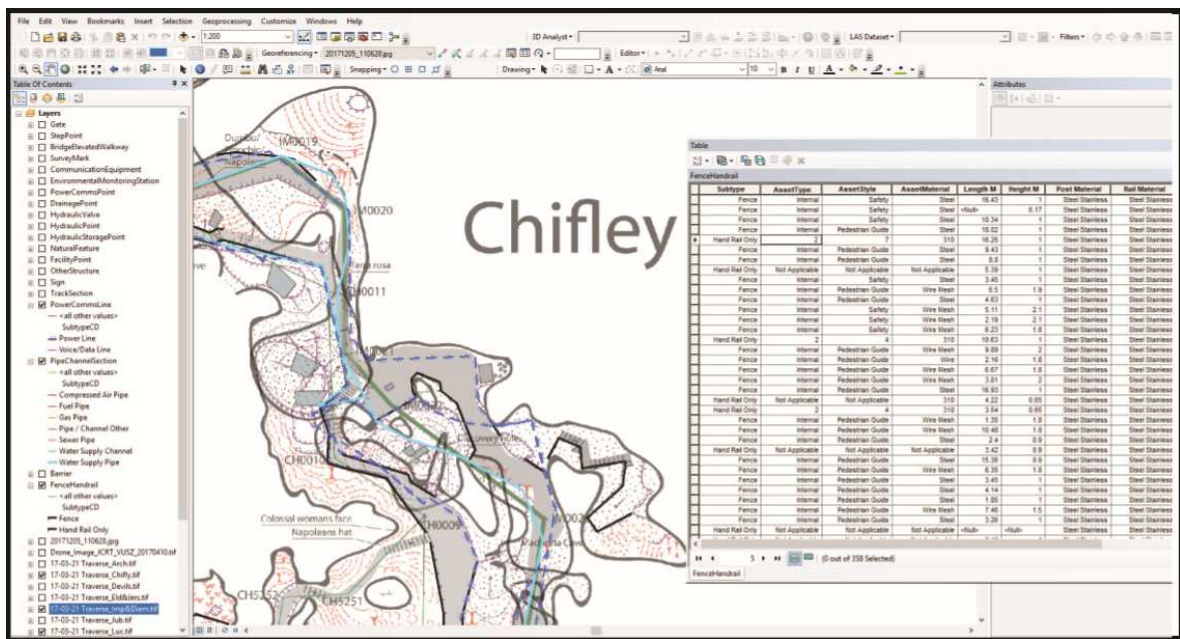


Figure 8: Utility and Fences Mapping

Difficulties were encountered in calculating the amount of concrete in paths and stairs from the plans in part due to legacy of file structure issues. Map grid coordinates have been calculated for path outlines and cross sections in a customised cave survey program using data exported from Adobe Illustrator and supplemented with vertical data. Additional measurements of cross sections at supplementary infill survey stations and infrastructure including path outlines, stairs and handrails both improves accuracy and provides more detail in the resultant 3D image. A

3D dxf file produced by the cave survey program contains map grid coordinates for traverse lines, station labels, left right up and down axes, cross sections, paths and stairs and where measurements are available hand rails. The 3D dxf files can be viewed in engineering computer aided drafting drawing packages or freely available drawing viewers (Figures 9 and 10). The survey elements are placed on different layers to aid visualisation. The revised 3D survey of the cave system will be imported into ArcGIS and geo-rectified to capture the cave assets.

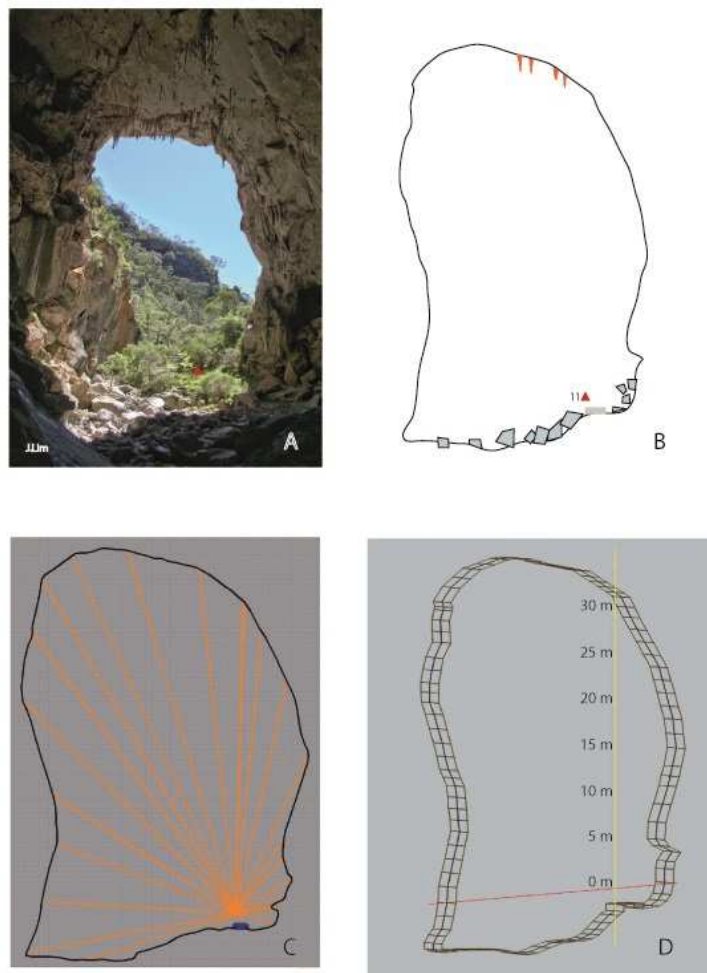


Figure 9A: Photograph of the Devils Coach House looking towards its northern entrance with location of station used for cross section 11.
 Figure 9B: Devils Coach House Cross Section 11 taken orthogonal to a map grid bearing of 340 degrees
 Figure 9C: Disto-X radiations at Devils Coach House Cross Section 11 used to develop the cross section.
 Figure 9D: Oblique view of Devil's Coach House cross section 11 with interpolated additional points for use in 3D representation.

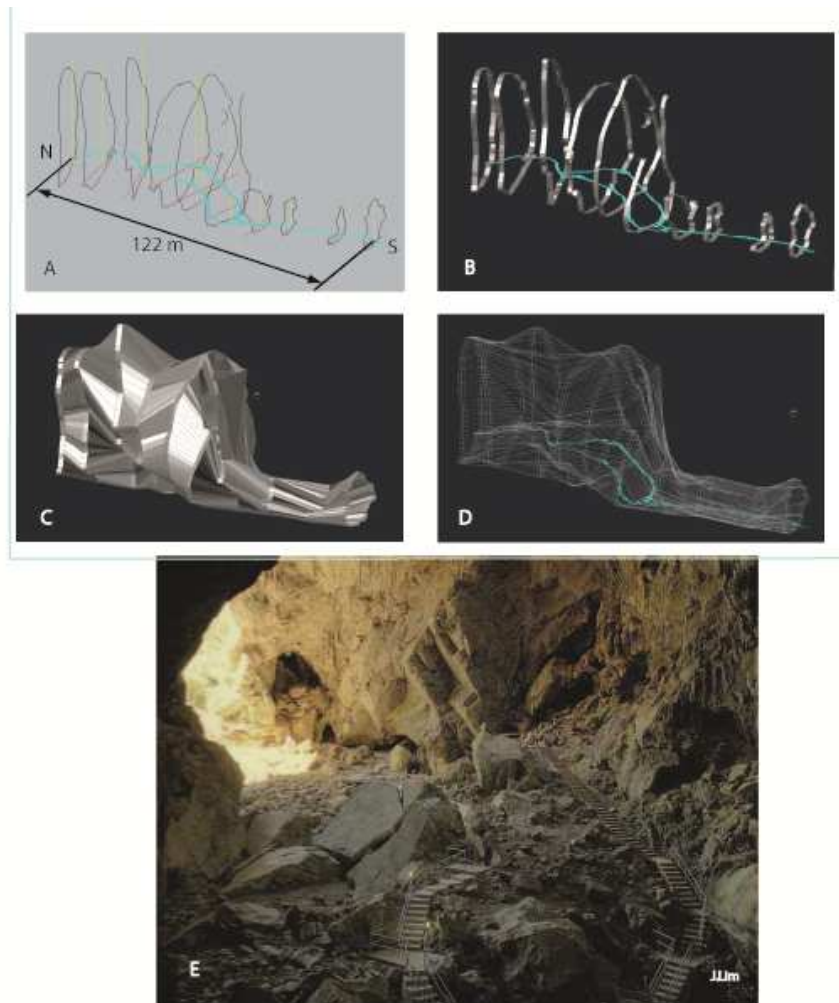


Figure 10: 3D model views and photograph of the Devils Coach House viewed from the Nettle Cave gate
 Figures 10A and 10B: Oblique view of Cross Sections 2 to 11 with tourist path
 Figure 10C: 3D model view developed by connecting adjacent cross section elements
 Figure 10D: Wireframe or X Ray view with tourist path
 Figure 10E: Photograph of the Devils Coach House viewed from the Nettle Cave gate

Next steps

Survey technologies and associated techniques will continue to improve. LIDAR can be used to “map” the surface of cave passages and chambers and infrastructure, but in itself LIDAR does not provide information about orientation. “Structure in Motion” uses photogrammetric principles to produce a mesh of the cave wall from closely spaced pictures. Both these techniques can be useful in improving the visualisation of the cave and hence the tourist experience. While improvements in visualisation are always desirable for management and research in complex 3D systems such as the Jenolan Show Caves they need to be connected to and located within their environment. Consequently the theodolite and total

station traverse produced in the existing survey remains an invaluable tool.

On implementation of the recent and ongoing survey work, maintenance staff will be provided the AMS on mobile devices which will further display images from both surface and improved cave surveys allowing easy identification and location of assets requiring maintenance.

Acknowledgements

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