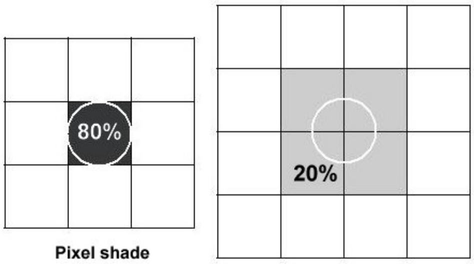
Improving Karst Data Using Google Earth

Graham Pilkington

Google Earth is a free interactive internet software package that supplies images of satellite data in near true-colour with a pixel resolution varying from about 20m down to about 0.2m. The pixel size is variable across Australia but is supplied as strips of pixel data usually north-south or east-west. These strips have been adjusted for image distortion so that a nearly consistent scale is presented. The strips have been merged together where they overlap to present a scaled map image.

In this talk I will use the Nullarbor for examples of how Google Earth can be used.

What has to be remembered at all times is that each pixel is the average colour and intensity over that pixel coverage area (blended across pixels to make the display smoother). This means that the pixel colour depends on where the edges of the pixel fall. For instance, if a horizontal black hole surrounded by white rock is the size of a pixel and the pixel is exactly over the hole, then the pixel will be 80% black and the adjacent pixels white. However, if the pixels bisect the hole, then those pixels will be only 20% black and spread over four times the area.

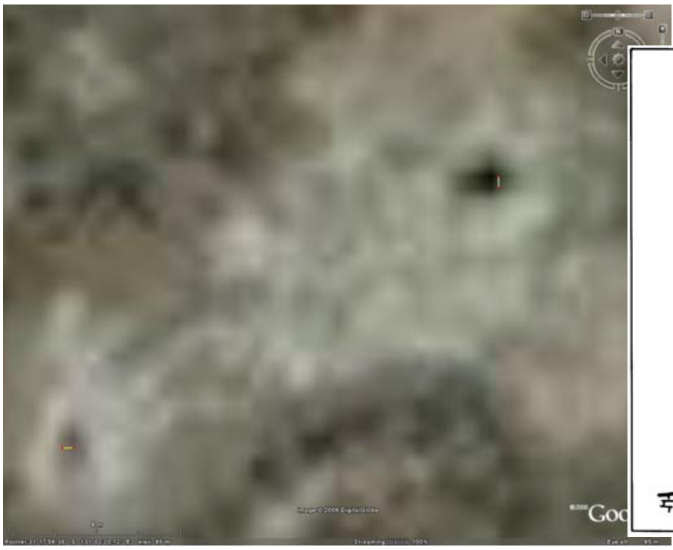


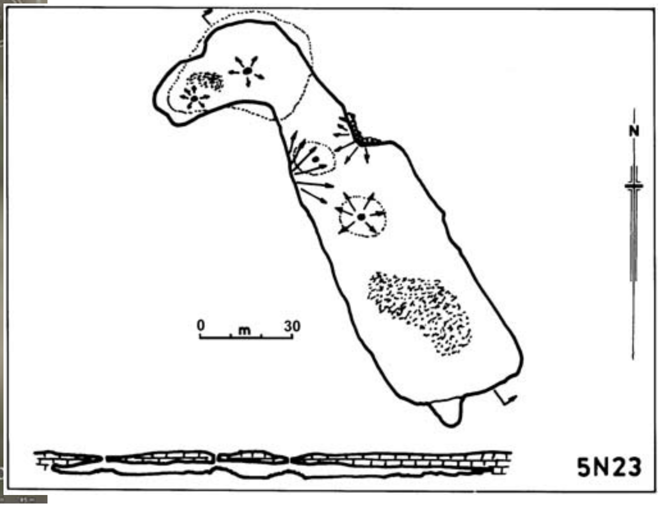
Pixel shade
over a black circle of pixel diameter in a white backgound

If the pixel size is greater than the size of the object being looked for, then it's a waste of time looking at the image because background "noise" will swamp the image. However, such objects as blowholes inside larger dolines can be estimated on the assumption that the doline is the result of the presence of a blowhole. To check the pixel size in an area, zoom in so that individual pixels can be seen, then measure with the Google scale bar. The satellite images are upgraded occasionally, hence large-sized pixel areas need to be checked up on periodically to see if better data are now available.

My first example of how Google Earth can be used is by looking at Jimmies Cave, 5N-23.

According to the Nullarbor Caving Atlas of 1986, its given location was accurate to ±100m and it also has an ASF grade 2 map made by Joe Jennings in 1957.



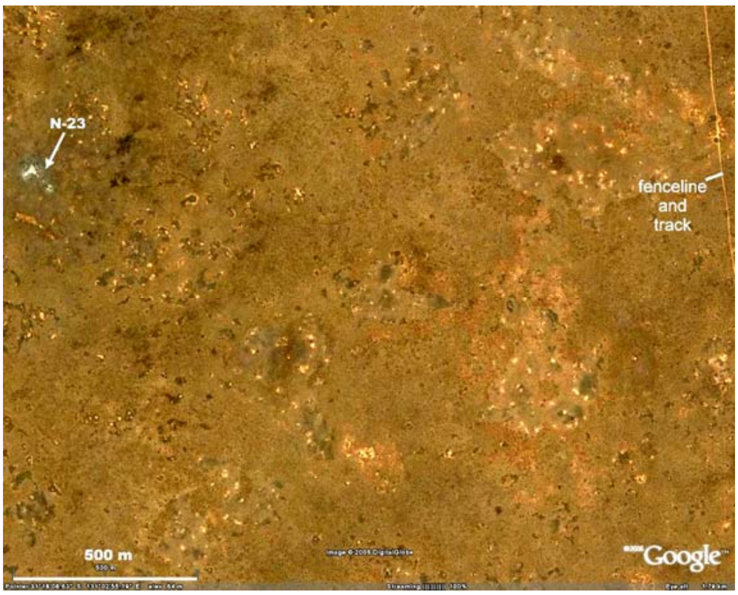


Google image of northern entrances of N-23 illustrating a pixel size of 0.6m

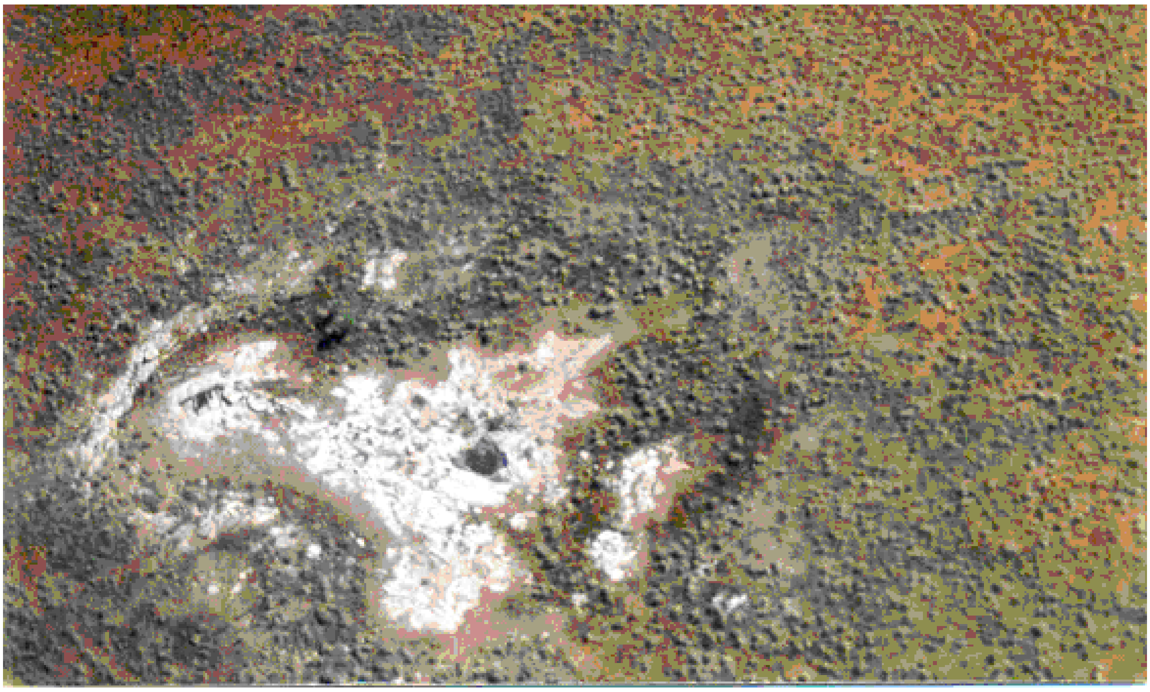
1957 simplified Jennings map of N-23

The satellite coverage of the N-23 Atlas location does not give any indication of the 4 dolines shown on the map. It does show the many forays by people searching the site for the cave!

The CEGSA Records location is: “1.2km south of number-6 gate take the right-hand track. Cave is on the right after 2.4km”. Without knowing which gate in number 6, it is difficult to determine if the given location agrees with this, but it is 2.4km along a track west of a fence and 100m north of this which does fit part of the description. Using Google Earth to expand the range of the search, a patch of exposed rock 2km to the north can be seen that closely matches the pattern and size expected from the cave map.



On closer inspection, we can see that this feature is just north of a 2.4km long track coming from the north-south fence and that the track takes off from a point 1.2km south of another fence – probably the location of number 6 gate. No known feature is within 2km of this new location. Zooming in on the feature, 4 possible blowholes in small dolines can be located and measured.



N-23 from an aircraft ©Max G Meth

N-23 overlay of dolines as measured from the satellite image and from the map

Because the Jennings cave map has surface dolines and blowholes plotted on it, the surface map can be overlaid onto the satellite image. Adjusting the map to match the satellite image by rotating 3° west (magnetic north was about 3° east when the survey was made) and enlarging the scale by 13% gives a very close fit: This means that Google Earth was used to improve the orientation and accuracy of a cave map!

To establish accurate locations for the cave entrances from the satellite data, we need some way to calibrate the Google Earth locations. This can be determined by assuming that the Global Positioning System is accurate to within 5m on the Nullarbor after the deliberate errors were removed in May 2000. Such an assumption is validated by the research done by others on GPS location accuracy and by the repeated re-readings made at specific points over the Nullarbor over the last few years by many people using different GPS units. N-23 has no known accurate GPS readings within its satellite strip but we can get an estimate from the adjacent strip.

Table 1 gives the locations of features read off GPS units and measured from Google Earth on the same image strip. It is vital to use the same strip and to keep away from the merged edges in obtaining good calibration figures.

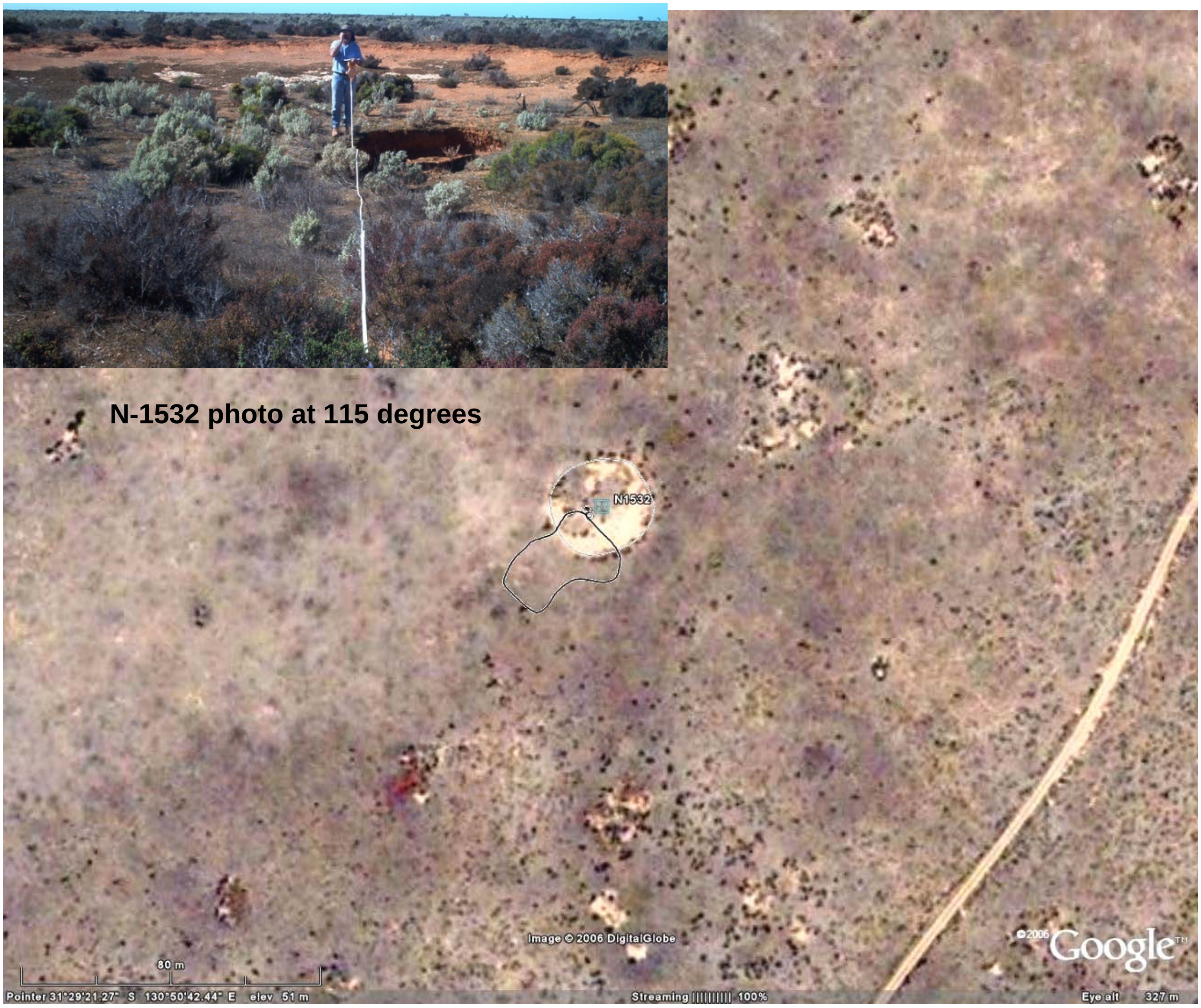
TABLE 1

			Google Earth location						Datum WGS 84				difference	
Area	**#**	**Where**	**lat**	**min**	**sec**	**long**	**min**	**sec**	**sat E**	**sat N**	**GPS E**	**GPS N**	**E**	**N**
N	14	centre	31	25	29.60	130	59	29.56	689295	6521580	689302	6521582	7	2
N	61	blowhole	31	25	12.05	130	58	25.89	687623	6522151	687632	6522155	9	4
										correction to satellite location			**8**	**3**
N	1532	blowhole	31	29	21.27	130	50	42.44	675252	6514689	675259	6514699	7	10
N	1528	blowhole	31	29	0.64	130	48	48.38	672256	6515375	672263	6515387	7	12
N	1529	blowhole	31	28	42.93	130	48	39.70	672036	6515924	672040	6515937	4	13
N	121	centre	31	31	9.67	130	46	1.61	667791	6511475	667798	6511491	7	16
										correction to satellite location			**6**	**13**
N	2046	blowhole	31	9	11.81	127	53	30.04	394359	6552870	394365	6552879	6	9
N	83	tag	31	9	12.09	127	57	33.46	400804	6552924	400817	6552932	13	8
N	1306	blowhole	31	9	16.57	127	58	28.87	402273	6552800	402282	6552812	9	12
N	2181	blowhole	31	11	30.79	127	48	32.46	386526	6548509	386528	6548509	2	0
N	1779	blowhole	31	13	8.74	127	58	46.00	402792	6545656	402798	6545653	6	-3
										correction to satellite location			**7**	**5**
N	131	blowhole	31	41	30.73	127	56	57.87	400433	6493226	400427	6493234	-6	8
N	192	blowhole	31	43	33.42	127	54	17.66	396253	6489406	396252	6489413	-1	7
N	739	rockhole	31	43	53.03	127	50	9.46	389727	6488735	389726	6488740	-1	5
										correction to satellite location			**-3**	**7**

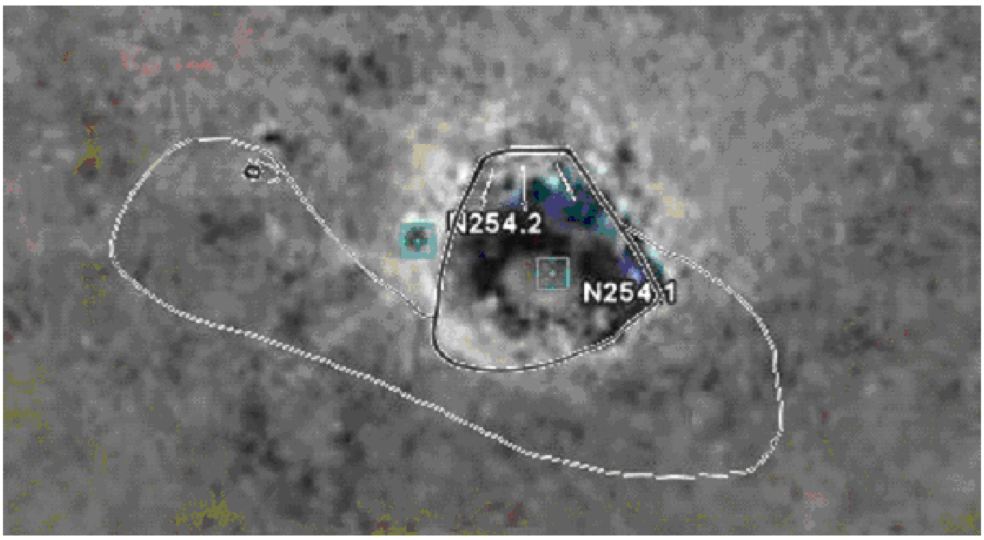
From this table we can estimate that the best N-23 adjustment to the Google Earth location is to add 7m in easting and 5m in northing to end up with the location of each blowhole to within about 5m without having to go to the bother of actually travelling out there.

Following are some examples of map overlays and ground photos:

N-213 satellite image with doline outline N-213 photo at 190 degrees



In the case of N-254, by comparing the map and satellite image it was found that the ATLAS had the north arrow pointing south! A few other maps where also shown to have an incorrect orientation and Google Earth has been used to correct them. With N-254 both the doline shape and the blowhole entrance could be used but in most cases an accurate doline outline is required. Many cave maps neglect the surface component and just show the survey of the underground part of a cave. These cannot be checked for orientation unless they have more than one entrance (or are not South Australian caves but have rivers flowing into them!).

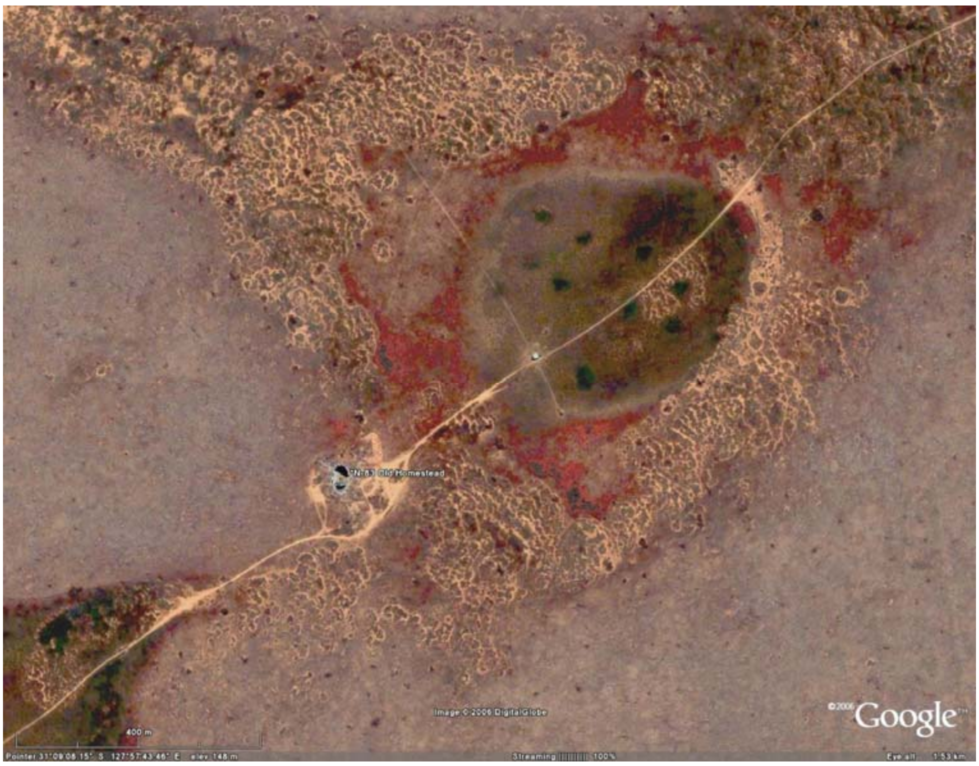


N-254 satellite image with corrected map overlay

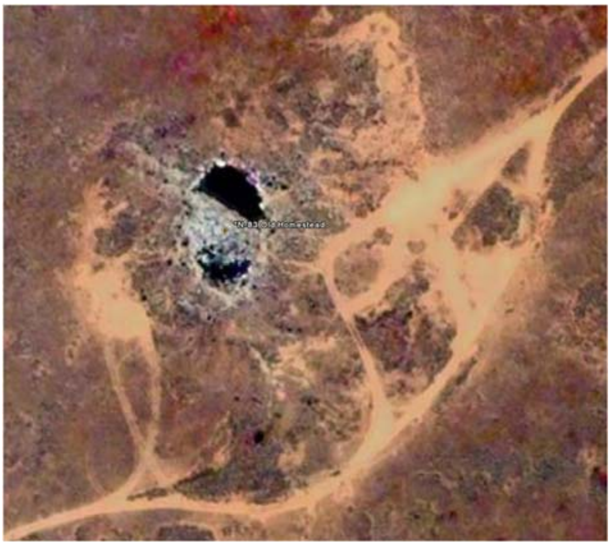
Gross scale errors are also easily fixed by reference to Google Earth. A good example is N-22, Knowles Cave. The map of the southern lobe of N-280 was grossly in error.

N-22, N-280, N871 Google image and 1986 ATLAS map

An example of more complex Google Earth use is given by the Old Homestead Cave (N-83) area:



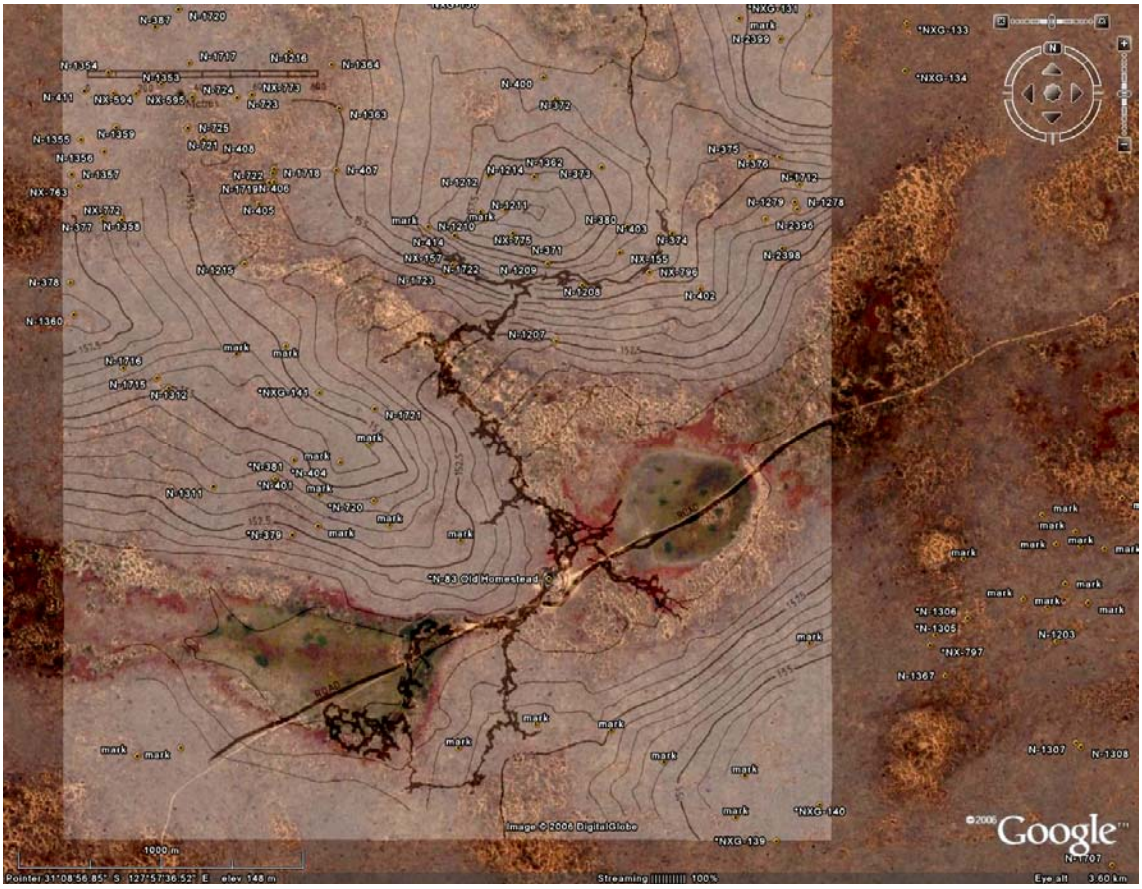
N-83 entrance and hut site



N-83 entrance and hut site

The image illustrates the quality of the satellite image by looking at the track definition. You can see the 2x1m toilet to the south of the hut and even where the chicken wire was removed from the area east of the track to the toilet. This image also shows that Nullarbor tracks are more ephemeral than most people thought: the main road from Mundrabilla to Forrest, used several times a week, passed just south of the hut site, looping around the debris of the original collapsed hut; part of this can still be seen but has vanished since 1986 when the site was cleaned up and the current track put back into operation.

The final image shows a composite of satellite image, feature location markers, cave map (as of 1991), and land-surface contours (at 0.25m, this is the Nullarbor!). It illustrates the close match between cave passage and topography 70m above it.



Summary of what Google Earth can be used for:

- Establish feature location as accurately as on site GPS (after calibration using GPS).
- Measure the relative positions of features as accurate as of twice the pixel size – typically 1m – over distances of kilometres.
- Measure the size and shape of large surface features such as dolines, more accurately and more detailed than most ground surveys, and in less time, while not having to spend valuable field time doing it. However, field data is usually needed to complete the surface map.
- Measure the size of small surface features, such as blowholes, when no field data is available and the pixel size is adequate. Eg in the N-23 zoomed-in image shown earlier, the most northern entrance blowhole can be measured as about 2x1.5m and the smaller one at no more than 0.5m diameter.
- Correctly align maps to true north.
- Uncover and possibly eliminate gross mapping errors.
- Improve map scales and orientation where estimated distances and/or bearings were used, especially for surface features and caves with more than one entrance.
- See what tracks are available for close approach and to determine the best way to get to a feature to avoid problems such as bluebush, dense scrub, cliffs and creeks.
- Locate large previously unknown features, allowing a more accurate determination of feature spatial density and type as well as new caves to explore.

Notes:

"ATLAS" refers to "The CEGSA Nullarbor Caving Atlas, 1986".

N-23 was named "Jimmy's Cave" in 1952 (after Jimmy Scott, who discovered it in 1937), not "Jimmies Cave" as is now used.