# Waterhole

The origin of my SETI station can be traced directly to a book edited by Carl Sagan in 1973 called ‘Communication with Extraterrestrial Intelligence (CETI)’. In one of the papers in this collection of papers, Bernard M. Oliver from Ames Research, described project Cyclops and cited a 1959 paper in Nature by Cocconi and Morrison that suggested the use of the hydrogen line at 1420 megahertz as the natural frequency on which to search for beacons.

On page 280 of CETI Oliver said “It is important to realize that microwaves are superior for *fundamental* reasoned, not just because they represent a more mature art.”

He went on to list the following reasons:

* Galactic noise (synchrotron radiation) at a minimum
* Thermal noise (receiver and isotropic background noise) at a minimum
* Quantum noise (spontaneous emissions or shot noise) at low level
* Star noise at a low level

He presented these findings in an iconic image of what is called the Water hole – the preferred interstellar radio communications channel.

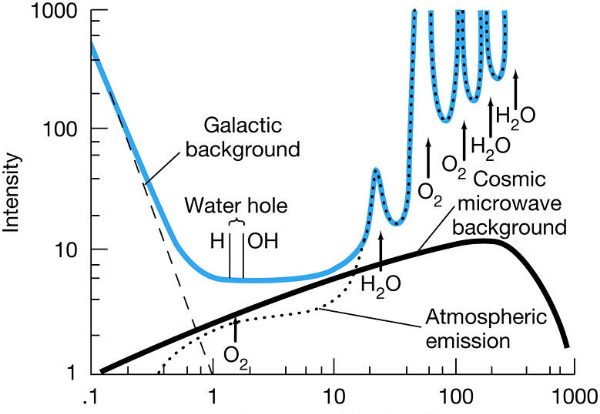


Figure Waterhole

The minimum noise lies between 1 and 2 GHz where the hydrogen (21 cm or 1420 MHz) and the hydroxyl (18 cm or 1662 MHz) lines reside.

Oliver then went on to point out that although the preferred search area cannot be narrowed down for technical reasons to be any less that between 1420 and 1662 MHz there are other rather romantic or poetic ways to narrow it down. The 242 MHz area between the hydrogen line and the hydroxyl lines are the quietest part of the spectrum and there are no other known spectral lines in that area. He says:

**“What more poetic place could there be for water-based life to seek its kind than the age-old meeting place for all species: the water hole”**

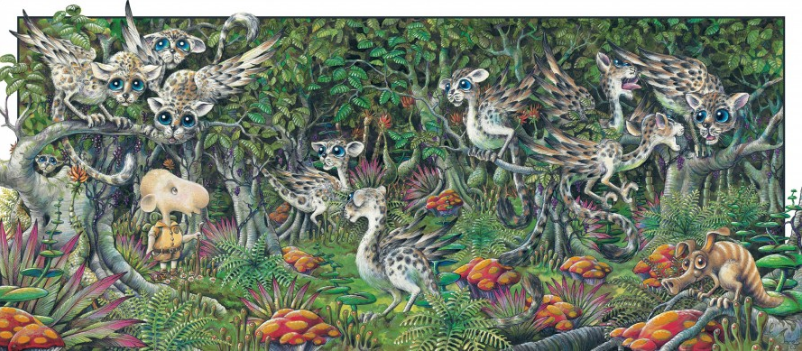


Figure Uno's Garden. When Uno arrived in the forest one day, many extraordinary and beautiful animals were there to greet him – and one entirely unexceptional ...

* [Graeme Base](https://www.facebook.com/graemebaseofficial). Used with permission.

To this list of reasons to search the water hole I add the following:

Dish – After about 1980 a large number of L-Band antennas became available when the switch to cable distribution of TV signals was made and the move to higher bands for satellite to Earth (DirecTV) transmissions was completed. The, now surplus, TV Receive Only (TVRO) dishes can be purchased for a fraction of the price when new and provide a good basis for a SETI system.

LNA – The technology used to construct the original TVRO ground stations for home use forced a leap in technology in the development of Low Noise Amplifiers. A superior LNA can now be purchased for about $250 with a very acceptable noise figure of 0.3 dB and a gain of 35 dB.

Receiver – Not long ago, 10 years or so, the best receiver for SETI work was the ICOM IC-R7000 or receivers of that type. Even a used R7000 would cost over $500 on EBay and would be prone to leaking capacitors, broken filters and a general fragility of these rather complex receivers. In the last few years a new breed of receiver, the Software Defined Receiver (SDR) has been developed that has the same or better receiving capabilities of the older R7000 but are nearly free. You can order one from Amazon for $20 that covers the water hole and is fully controllable from a local computer. The generally cover the spectrum from 1 MHz to 1,500 MHz.

I have selected a rather high end receiver from this group that covers more spectrum (1 MHz to 6 GHz) and is tunable in 1 Hz increments:  


This receiver also has the added advantage of being able to be ‘locked’ to an external 10 MHz reference standard. The importance of this is that the SETI search algorithms work with FFT bin widths on the order of 1-2 Hz wide and depend on the receiver being able to hold its place with better than that resolution.

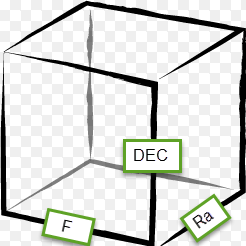
This SETI station further reduces the available search area with the use of a Band Pass Filter just after the LNA that narrows the search area to 100 MHz



This makes the spectrum where SETI Net station DM12jw can search to the 100 MHz segment of 1375 and 1475 MHz. Lest you think this is too limiting – read on.

# Address Space

In your personal computer ‘Address Space’ refers to the two-dimensional address of each minimal unit of memory in all of memory – Byte: address 20142343 for example. In SETI it a three-dimensional cube where the minimal unit of unit is the width of one segment of the spectrum captured for analysis and the other two are Declination (DEC) and Right Ascension (Ra). The resulting address cube can be thought of like this.



the total address space of this SETI station is then:

Addr = F \* DEC \* Ra where

* F = 20 KHz. Each capture of the water hole for analysis is 20 KHz wide
* DEC = 0 to 90 Deg / HPBW. The Half Power Beam Width of the antenna is 3.8 degrees at 1420 MHz
* Ra = (24 hrs \* 15 deg/Hr)/ HPBW

Or: ~ 20,340 places to look.

Since each 20 KHz is examined for about 20 minutes that’s:

T = Addr \* Scan Time

Or: ~ 6,780 Hours for the cube.

Take a break for sleep and repairs and a year is about right for one pass.

ET itself can be lurking in any of the 20 KHz frequency chunks but is expected to occupy on the order of 1 Hz. Since each 20 KHz chunk, when passed through the station FFT and stored in the search buffer, creates 16,384 bins then ET can be in any of:

Bins = Addr \* 16,384

Or: ~333 million bins.

That seems like a satisfactorily large enough number to be a challenge. The task of the SETI station is just how to search those 300 million bins that make up the waterhole in a reasonable amount of time.