



BROODMINDER

USER GUIDE

BroodMinder User Guide

May 2021

Version 4.21

BroodMinder – Because Every Hive Counts

Document Revisions

Date	Version Number	Document Changes
1/28/2016	0.10	Initial Draft
1/29/2017	0.11	Added MyBroodMinder.com and Database sections
1/30/2017	0.12	Fixed Graphs to fit on page and incorporate Theo's updates
2/2/2017	1.00	Release to the world after a few typo corrections
2/16/2017	1.01	Add BLE advertising info to Appendix B
2/26/2017	1.02	Add scale temperature compensation info
6/15/2017	2.60	Update for version 2.60 app
10/12/2017	2.70	Update for version 2.70 app
12/20/2017	2.77	Update includes BroodMinder-APIARY app
5/23/2018	2.90	Cosmetic updates, new video pages, clarifications
7/9/2018	2.91	Correct a detail in the BLE advertising section
11/20/2018	2.91	Add BroodMinder-T2 and Android app controls
1/3/2019	2.98	Add Real Time Mode Notes & T2 turn off
3/20/2019	2.99	-T2 Upgrade info, Routine Maintenance
8/27/2019	3.00	Standard App version 3.00 information Apiary App version 1.80 information
4/22/2020	3.10	New versions, T2 Firmware updates
11/19/2020	4.01	W2, TH2, W+, DIY, Repair additions, Cell antenna
1/22/2021	4.10	Add SubHub info, add more DIY info
2/3/2021	4.11	Add W2 disassembly instructions
2/5/2021	4.12	Add DIY to broken scale instructions
2/10/2021	4.15	Tin Whiskers in repair
2/20/2021	4.16	Battery Power and more information on -SubHub
3/19/21	4.17	Update DIY, add swarm minder details, a couple of repair notes, - SubHub range testing.
4/28/21, 5/25/21	4.20 – 4.21	Update DIY

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1 Introduction

1.1 Welcome

Congratulations on the purchase of your BroodMinder product. We are happy that you have joined our movement to improve bee health and to share data to enhance our understanding. This manual is intended to fill in many gaps to make your BroodMinder experience more pleasant and productive.

This manual is provided for folks who love written manuals. We strongly suggest watching the videos posted on MyBroodMinder.com. They will contain many tips beyond the scope of this manual.

If you still have questions or suggestions, or just want to chat about bees, then contact us at support@broodminder.com. We are there to help.



1.2 What's New in November 2020?

There are many changes to the Apps and to MyBroodMinder in this update.

- BroodMinder-W2, BRM-49, Full Hive Scale
- BroodMinder-TH2, BRM-56, Temperature, Humidity with swarm detection
- BroodMinder-W+, BRM-57, updated version of -W
- BroodMinder-DIY, BRM-58, Do it yourself weight scale kit and PC app

1.3 What's New in January 2021?

There are many changes to the Apps and to MyBroodMinder in this update.

- BroodMinder-WH, BRM-52, -SubHub
- 4 hive -DIY instructions

1.3 The absolute easiest way to get going (requires a BroodMinder-CELL)

We have done our best to make the installation and usage of your BroodMinder intuitive and easy. For the absolutely easiest way to get going, you must purchase a BroodMinder-CELL along with your sensors.

- 1. Watch the video help that you will find at MyBroodMinder.com.**
- 2. Create a MyBroodMinder.com account** by going to MyBroodMinder.com. Go ahead and create an apiary and hive if you have time. (You can do this step after installation.) You will receive 30 days of MyBroodMinder.com-Premium for joining.
- 3. Load the BroodMinder-Apiary App** to your cell phone or tablet and enter your MyBroodMinder.com information in the settings menu.
- 4. Install the BroodMinder-CELL** within 30 feet of your sensors. Make certain the solar panel faces south.
- 5. Activate the CELL device** using the BroodMinder-Apiary app.
- 6. Activate the battery** in your BroodMinder devices by pulling the tab (BroodMinder-TH) or snapping it in (BroodMinder-W) or pushing the button (BroodMinder-T2)
- 7. Install your BroodMinder** into your hive.
 - a. Place one BroodMinder-TH or -T2 on top of the frames in your lower brood box.
 - b. Place a second BroodMinder-TH on top of the frames in your upper brood box.
 - c. Place your BroodMinder-W under the front of the hive with a 2x4 or other pivot under the back (or vice-versa). Place the BroodMinder in the shady side so that the outside temperature reading is not affected by the sun.
- 8. Go to MyBroodMinder.com in about an hour** and add your devices (by ID) to the hive you created. Wait for your BroodMinder to appear.
- 9. That's it, you are now part of the solution!**
- 10. Bee sure and share** your hive data with your friends using our public domain viewer at BeeCounted.org

1.3 Quick Start if you plan to share your data (THANK YOU!)

We have done our best to make the installation and usage of your BroodMinder intuitive and easy. Here are the basic steps that we will review in detail below.

11. **Watch the video help that you will find at [MyBroodMinder.com](#).**
12. **Create a MyBroodMinder.com account** by going to [MyBroodMinder.com](#). Go ahead and create an apiary and hive if you have time. (You can do this step after installation.) You will receive 30 days of MyBroodMinder.com-Premium for joining.
13. **Load the BroodMinder-Apiary App** to your cell phone or tablet and enter your MyBroodMinder.com information in the settings menu.
14. **Activate the battery** in your BroodMinder device by pulling the tab (BroodMinder-TH) or snapping it in (BroodMinder-W) or pushing the button (BroodMinder-T2)
15. **Install your BroodMinder** into your hive.
 - a. Place one BroodMinder-TH or -T2 on top of the frames in your lower brood box.
 - b. Place a second BroodMinder-TH on top of the frames in your upper brood box.
 - c. Place your BroodMinder-W under the front of the hive with a 2x4 or other pivot under the back (or vice-versa). Place the BroodMinder in the shady side so that the outside temperature reading is not affected by the sun.
16. **Open the apiary app** and wait for your BroodMinder to appear. You must be within 10 of the hive. It will show the current temperature/weight.
17. **Retrieve the Hour-by-Hour (HbH) data** after the BroodMinder has been running for a couple of hours. (*If you don't have internet connectivity in your apiary, go to the manual section on the Apiary App for further instructions.*)
 - a. Tap the cloud with the up arrow in the upper right corner of your screen (or tap the individual sensor text for reading a single BroodMinder).
 - b. The app will present a status page and start collecting all of your BroodMinder data. You can work on your hives while it completes automatically.
18. **That's it, you are now part of the solution!**
19. **Bee sure and share** your hive data with your friends using our public domain viewer at [BeeCounted.org](#)

1.4 Quick Start if you plan to keep your data private

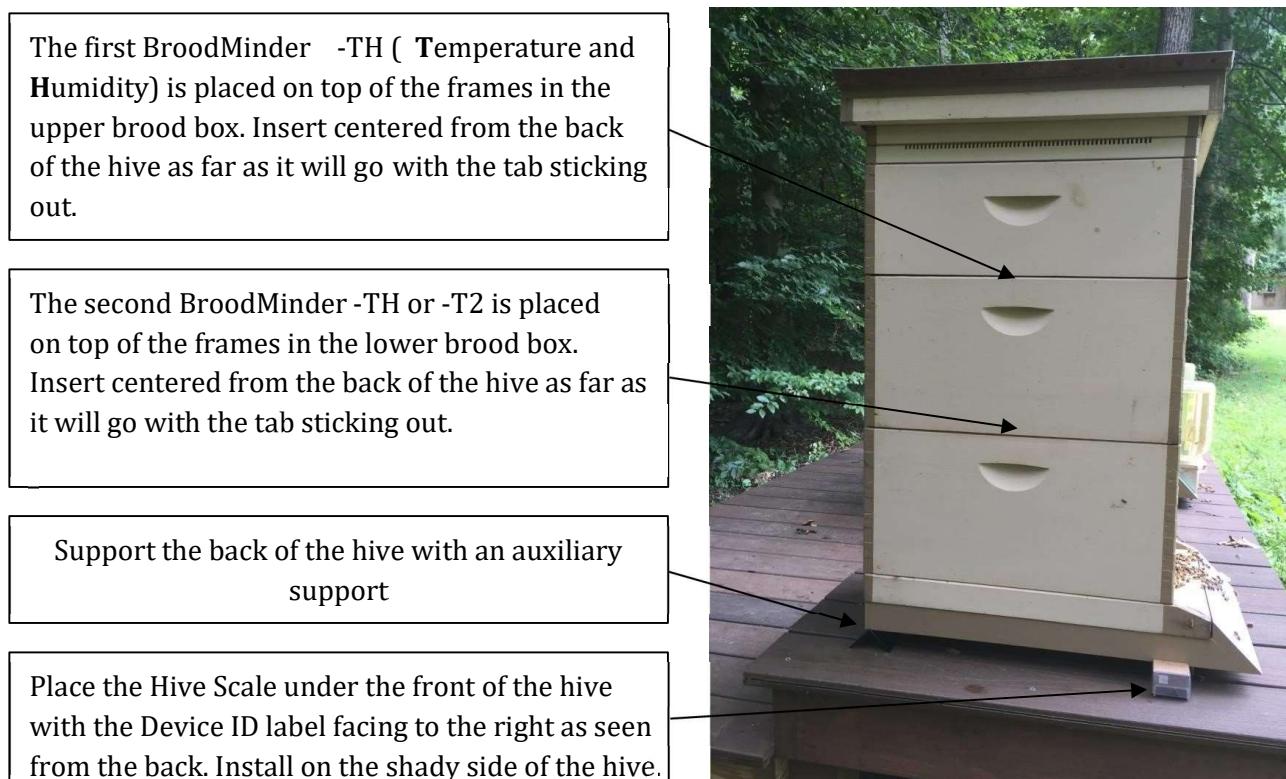
Here are the basic steps using the BroodMinder-Lite app.

1. **Watch the video help** that you will find at MyBroodMinder.com
2. **Load the BroodMinder-Lite App** to your cell phone or tablet.
3. **Activate the battery** in your BroodMinder device by pulling the tab (BroodMinder-TH) or snapping it in (BroodMinder-W) or pushing the button (BroodMinder-T2)
4. **Install your BroodMinder** into your hive.
 - a. Place one BroodMinder-TH or -T2 on top of the frames in your lower brood box.
 - b. Place a second BroodMinder-TH on top of the frames in your upper brood box.
 - c. Place your BroodMinder-W under the front of the hive with a 2x4 or other pivot under the back (or vice-versa). Place the BroodMinder in the shady side so that the outside temperature reading is not affected by the sun.
5. **Open the app** and wait for your BroodMinder to appear.
6. **Retrieve the Hour-by-Hour (HbH) data** after the BroodMinder has been running for a couple of hours.
 - a. Tap the device text to bring up the graph page.
 - b. Tap SYNC to retrieve the data.
 - c. You should see the data on the graph when Sync is complete.
7. E-mail your data from the device settings page (optional).

2 Installing your BroodMinder – Location, Location, Location

2.1 Sensor Locations

The Citizen Science Package contains two BroodMinder-TH (temperature and humidity) or T2 (temperature only) Devices and a BroodMinder-W hive scale. Here is where you install these devices:



2.2 BroodMinder-TH (BRM-42)

Note: In 2020 we began shipping BroodMinder-TH2SM discussed below. All BroodMinder-TH device IDs start with 42 so they should be easy to recognize. The normal placement of the sensor is on top of the frame near the middle of the hive box of interest. This position is chosen for several reasons:

- Heat rises, therefore the sensor will feel the heat of the brood below
- The brood tends towards the middle of the hive and then surrounds the brood with pollen and honey. Placing the temperature sensor here has the best chance of sensing the brood.
- Using this standardized position allows for cross-hive comparisons across the world.

If you are in a cold climate and you overwinter in more than two boxes, then you may want to move the sensors up during the winter. This is because as the cluster moves above a sensor, that sensor tends to sense the outside temperature (since heat rises).

By placing the BroodMinder-TH sensor right below the inner cover, you will sense the heat of the entire hive. Condensation is very likely when it reaches 100% and you may want to inspect the hive and take appropriate action if necessary.

Note: Relative humidity (RH) depends both on moisture in the air and temperature. As temperature goes down, RH goes up. A good example is when RH = 100% outside dew forms. The same thing will happen in your hive.

If you move the BroodMinder-TH to the top, then you may want to move the other BroodMinder-TH to right below the top box. That way you will see as the cluster moves up past this box.

As a final note, the BroodMinder-TH is thin enough that if you want to experiment with different positions such as between the frames you can. We would love to know how this works for you and what you learn.

Whatever position you choose, you can add a tag to the data using the BroodMinder app. We'll talk about doing that in a later chapter.

The CR2032 battery is replaceable by opening the wrapper. It should last more than a year and we recommend replacement each fall before the low temperatures of winter.

2.3 BroodMinder-T2 (BRM-41)

Note: In 2020 we began shipping BroodMinder-T2SM discussed below. All BroodMinder -T2 device IDs start with 41 so they should be easy to recognize. The BroodMinder-T2 (**Temperature**) is a cost reduced version of the BroodMinder-TH. It will sense the hive temperature which will indicate brood rearing during the season and winter survival during the winter. Place it above where you believe most of the brood activity will be. In the winter we suggest that you put it on the frames of the upper most hive box so that it catches all of the rising heat from the cluster.

To turn on the BroodMinder-T2, press the button for 5 seconds. **The LED will flash for one minute to indicate success. IF YOU DON'T HOLD THE BUTTON LONG ENOUGH, YOUR T2 WILL SHUT DOWN AFTER ABOUT 10 SECONDS.** If you ever want to know if the -T2 is operating, press the button again, and the LED will flash momentarily to indicate the battery is fine and the device is operating.

To change the battery, simply cut the tape on three sides around the circuit board. Then swing the board out and replace the battery with a new CR2032. Be sure to seal the circuit board again using packing tape.

If you want to turn off the T2, you must do it with the BroodMinder app.

- Find the device and select the graph screen
- Choose device settings (the gear in the upper right corner of the screen)
- Choose Sample Rate then choose "Power Off". This is only available for T2 devices
- Go back to the graph screen and sync the device. After it finishes, it will power off the T2.

2.4 BroodMinder-T2SM (BRM-47) & TH2SM (BRM-56)

We introduced the BroodMinder-T2SM in May of 2020 and the BroodMinder-TH2SM in December 2020. This sensor is just like a BroodMinder-T2 except it will also watch for temperature events such as swarms. Any time the sensor sees a 4 degree F (2C) bump in temperature following a few specific rules then the sensor records the 30 minutes before and 40 minutes after with 1 minute resolution and sets a flag indicating a temperature event has occurred. The flag is stored in T2 Sample State. The sample states are listed in the appendix.

NOTE: The temperature event trigger will only operate if the device position is assigned to the upper or lower brood box. Since the algorithm is really only meant for brood areas, this prevent spurious triggers when the SwarmMinder devices are located elsewhere.

See the data interpretation section for more information. Version 5.26 and less contain an oversensitive algorithm. We didn't want to miss swarms, so we were cautious about making the rules too tight. This means that you may receive nuisance alarms. 3/17/21 we are modifying MyBroodMinder.com to only show temperature events associated with lower/upper brood box temperatures. If you would like to disable the event alarms, then simply change the device location in MyBroodMinder to another location such as 'other' or 'custom(1)'. We will be updating the algorithms for next season based on 2021 results.

All BroodMinder -T2SM (or TH2SM) device IDs start with 47 (or 56) so they should be easy to recognize. The BroodMinder-T2SM (**Temperature**) is a cost reduced version of the BroodMinder-TH2SM. It will sense the hive temperature which will indicate brood rearing during the season and winter survival during the winter. Place it above where you believe most of the brood activity will be. In the winter we suggest that you put it on the frames of the upper most hive box so that it catches all of the rising heat from the cluster.

To turn on the BroodMinder-T2, press the button for 5 seconds. **The LED will flash for one minute to indicate success. IF YOU DON'T HOLD THE BUTTON LONG ENOUGH, YOUR T2 WILL SHUT DOWN AFTER ABOUT 10 SECONDS.** If you ever want to know if the -T2 is operating, press the button again, and the LED will flash momentarily to indicate the battery is fine and the device is operating.

Note: If you don't see any flashes, the button may be the issue. Please see the appendix for troubleshooting tips.

Note firmware version 5.26 and after makes the change that following a firmware update, the T2 will not shut down like it did in prior versions. This will make updating firmware in the hive more convenient.

To turn on the BroodMinder-TH2SM, remove the battery blocking strip and the unit will automatically start up.

To change the battery, simply cut the tape on three sides around the circuit board. Then swing the board out and replace the battery with a new CR2032. Be sure to seal the circuit board again using packing tape. We recommend stapling the end of the tape so that it doesn't pull off as you unstuck the T2 from where the bees glued it down.

To change the battery for the TH2, remove the device from housing, change the battery and fold it back into the housing and tape the flaps in place.

If you want to turn off the T2 using the app.

- Find the device and select the graph screen
- Choose device settings (the gear in the upper right corner of the screen)
- Choose Sample Rate then choose “Power Off”. This is only available for T2 devices
- Go back to the graph screen and sync the device. After it finishes, it will power off the T2.

Following firmware version 5.26 you can also turn off the T2 by holding the button for 10 seconds.

You will see this...

- 4 quick flashes
- After 5 seconds the led will light for 3 seconds and turn off
- Now release the button and the T2 will be in deep sleep
- You can verify this by pressing the button briefly. No flash is good. 4 quick flashes will indicate it is not sleeping.

2.5 BroodMinder-W (BRM-43 & BRM-57)

The BroodMinder-W (Weight) goes under the hive. There is an extensive writeup about positioning the scale in appendix A. That is a good thing to read, but if you are in a hurry, here are the basics.

The CR2032 battery is replaceable. It should last more than a year and we recommend replacement each fall before the low temperatures of winter.

NOTE: the most typical error source is inadequate support under the scale. This can result in strange behavior as the hive flexes as it expands and contracts due to sun, rain, temperature, etc. Providing a flat support will improve results. An easy fix is to place a $\frac{3}{4}$ " plywood sheet (or equivalent) under the scales.

ADDITIONAL NOTE: If all you want to see is honey flow, good support is not required. You will just have to ignore the daily fluctuations. Pick a time of day such as midnight to compare daily change. You will still be able to observe the overall change in weight.

2.5.1 Place the scale in the shade

The BroodMinder-W has a temperature sensor inside which reads the local temperature. For the temperature to be accurate, it should be shaded from direct sun. This temperature is also used to compensate the weight sensors so avoiding the temperature spike created by direct sunshine will improve performance.

Being in the shade will also extend the housing life. We use UV resistant plastic, but in the direct sun even that will become degraded. If this happens, you can order a new housing on BroodMinder.com.

2.5.2 Get the BroodMinder-W level

We have done our best to make installation simple. However, you need to pay attention to a couple of things.

Make sure the hive is level. This doesn't mean "crazy level" but if your hive looks like the Leaning Tower of Pisa, then you won't get good results. 2x4's and shims are your friends. By using a few 2x4's and shims creatively, you can level almost anything! We also find that screwing the 2x4's together makes life better and more stable.

After you install the BroodMinder -W, look at the end of it. Through the plastic cover, (remember... install it *with* the plastic cover), you will see the upper wooden piece and the lower aluminum piece. Make sure that they do not touch. This will ensure that all the weight is sitting on the two little buttons on top of the aluminum base and not somewhere else.

2.5.3 Typical installation, not as accurate

Using the typical installation, you will see small changes to the hive however, the absolute accuracy will not be as good. For improved accuracy, see the recommendations of the next section.

The BroodMinder-W is designed to measure ½ of the hive weight. To do this, we want you to support one side of the hive (front or back, left or right) with a 2x4 or similar [However, we recommend that you use a piece of 2" angle for the support. By orienting it so that the point of the angle iron is up, it gives a very precise pivot point. You should be able get this at your local hardware store. Aluminum is extra nice because it won't rust. A great place to get just what you need for less than \$5 each is [Speedy Metals](#) (1/8" {A} x 2" {B} x 2" {C} Angle 6061-T6 Aluminum, Extruded).]

The BroodMinder-W is placed under the opposite side.

There is a nice explanation of the math and physics involved in Appendix A, however it boils down to this. **Do your best to place the support and the scale directly under the wall of the hive body.** That will give good results.

2.5.4 Better installation, more accurate

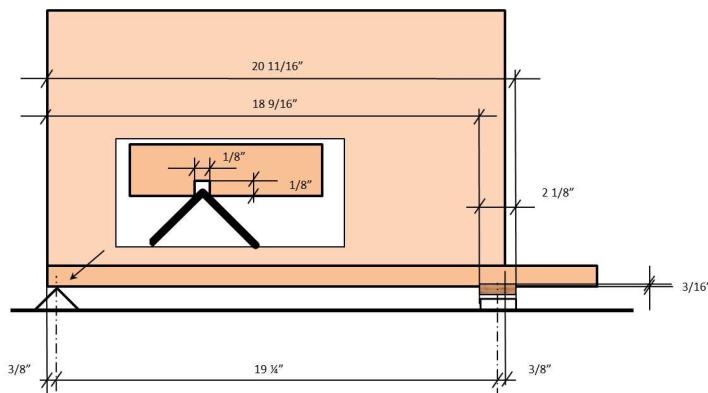
A better way to install will require a few modifications to your bottom board. You will make a couple of small cuts that will be used to accommodate precise and repeatable placement of the scale and support.

First off, we recommend that you use a piece of 2" angle for the support. By orienting it so that the point of the angle iron is up, it gives a very precise pivot point. You should be able get this at your local hardware store. Aluminum is extra nice because it won't rust. A great place to get just what you need for less than \$5 each is [Speedy Metals](https://www.speedymetals.com/pc-2186-8344-2-x-2-angle-6061-t6-aluminum-extruded.aspx) (<https://www.speedymetals.com/pc-2186-8344-2-x-2-angle-6061-t6-aluminum-extruded.aspx>) (1/8" {A} x 2" {B} x 2" {C} Angle 6061-T6 Aluminum, Extruded).

Now we want to make the cuts in the bottom board. For this setup we recommend using front and back supports and not side to side. That given, you must choose whether to place the BroodMinder-W under the front of the hive, or the back of the hive.

In general, it is better to place the BroodMinder-W out of the sun. This is because the sun will heat the scale and give you a false reading of the outside temperature. Placing it in the shady side of the scale avoids this problem. It will also make the housing last longer.

Next you will cut the bottom board. For the angle iron side, you will cut a groove the width of your saw blade that the point of the angle will fit in. For the scale side, you will cut a notch 3/16" deep that ends 1" inside the center of the hive body wall. See the images below.



2.6 BroodMinder-W2 (BRM-49)

The BroodMinder-W2 (Weight) goes under the hive or in the hive stack.

1. Remove -W2 from plastic bag. Keep this weather resistant bag if you intend to use the -W2 under the hive. **The -W2 is not weatherproof unless installed in the hive stack!**
2. Pull tab shown in red circle below. This will activate your BroodMinder-W2.



3. Install -W2 in the hive in your choice of location.
 - A. On top of the bottom board under the hive bodies (recommended)
 - B. Above the brood boxes and under the honey supers
 - C. Below the bottom board – **Place -W2 inside the zip lock bag and seal against weather.**



Note: 2 AA batteries are located under the drip ledge with the two screws (near the battery tab shown above). Remove the screws and the aluminum drip ledge to replace the batteries. We recommend Energizer Ultimate Lithium batteries. After you replace the drip ledge, be sure to tape the corners to protect against rain.

2.7 BroodMinder-SubHub (BRM-52)

Brief Explanation: It is a Bluetooth range extender and a high speed data vault in a box about the size of a TV remote.

The BroodMinder-SubHub will listen for all your BroodMinder devices and retransmit them using its long range transmitter. This means you can 'hear' your BroodMinder devices over 1000 feet (330 meters) away.

Secondly, the -SubHub stores all of this data, and you can read the data using our new turbo-transfer protocol (releasing spring 2021). You can read a month's worth of data from 50 devices in 2 minutes.

Thirdly, adding a -SubHub allows one to place the sensors in battery saver mode. Battery saver mode will reduce the advertising duration of your T2 & TH2 sensors to only 10 minutes per hour. By doing this we can extend battery life of the coin cells to over 5 years. Battery saver mode is being introduced in spring 2021. All T2 & TH2 (47:xx:xx & 56:xx:xx) devices (but sadly not the original T & TH) can be upgraded to use this mode.

And finally, it also records the temperature of itself, allowing you to see your apiaries micro-climate, or even place it inside a swarm box to see when bees move in.

The subhub is shipped in a non-waterproof case. If you want to mount it outside, we recommend installing inside a solar shield. The La Crosse Technology 925-1418 Sensor Protection Shield with Mount (\$18) is a very good choice and the subhub fits perfectly in it. It also fits in the Acurite version (06054M \$17). A third possibility is a Hammond 1554C2 (\$11.57) waterproof box available at Digikey.com. You can also just put it in a zip lock bag as the least expensive solution. The -SubHub enclosure is 1.05" x 1.85" x 5.00" (47 x 26 x127 mm).



La Cross Solar Shield



Hammond 1554C2

Why does the BroodMinder-SubHub exist?

It's all about maximizing the value of hive monitoring. From the data our citizen scientists have been collecting over the last six years, we have learned that internal temperature tells us the most. We have learned to detect brood rearing, swarms, hive strength, and mating flights. And this is only the start.

Fortunately, temperature is cheap and easy to measure. However, that data only does good if you can get it to the beekeeper. The -SubHub makes that easier. Here are a couple of scenarios.

SCENARIO 1

Setting: Your BroodMinder enabled hives are 500 feet from a building with power and you have an old cell phone.

Configuration: Put the -SubHub in the middle of your hives and the cell phone in the building. Run the apiary app in hub mode.

Outcome: Your hive data will be sent up every 10 minutes. In the event of a swarm, you will receive an email or text message as soon as it is detected.

SCENARIO 2

Setting: This apiary is remote and there is no power nearby. You are already set up with a BroodMinder-Hub, however some of your hives or swarm traps are 700 feet away.

Configuration: Put the -SubHub near the hives. Since the -SubHub also measures temperature, you can place it inside the swarm trap to detect when bees move in. You can have multiple -SubHubs feeding the BroodMinder-CELL/WIFI hub if you wish.

Outcome: More of your apiary can be monitored with minimal cost. Temperature increase in swarm traps will show on MyBroodMinder.com when bees move in.

SCENARIO 3

Setting: This apiary is remote and there is no power and no cell tower nearby..

Configuration: Put the -SubHub near the hives. It will record data from all the nearby BroodMindlers.

Outcome: When you visit your apiary, you can read all of the the data from all of the hives, typically in less than a minute. You will be able to view this data with the new BroodMinder-Bees app in a manner similar to MyBroodMinder. Then you can send the data to MyBroodMinder when you arrive back in civilization.

How did you do all of this magic?

It wasn't easy. Our team has been working on the BroodMinder-SubHub and MyBroodMinder ecosystem for over a year. That time was split between solving the technical challenges and making the system flexible and easy to use. We feel it is a game changer and that you will love it.

For the folks that love all of the technical details, here they are.

The -SubHub is using the same circuitry that our BroodMinder-W2 uses. It uses a Silicon Labs, long range Bluetooth Low Energy (BLE) module. We have measured the advertising range of the module with an iPhone 11 at greater than 1000 feet. We got usable data at 1700 feet.

By using 4 AA batteries, we have much more power to play with. This enables us to listen for BroodMinder devices for 20 seconds every ten minutes with anticipated battery life greater than a year.

There is a one megabyte memory added to store the log data. This allows us to store 35,000 records or roughly data from 100 devices for two weeks (or less devices for longer, you can do the math). The -SubHub has the capacity to keep track of 128 BroodMinder devices at one time.

The data will be read using BLE SPP (Serial Port Profile). We have timed transferring the entire 35,000 record log to take about 120 seconds using iOS and less than that for new Android devices (longer for phones 4 or 5 years old).

The final piece is in Advertising the data from the -SubHub. As mentioned above, the -SubHub listens for new data for 20 seconds every 10 minutes. It then modifies it's BLE advertisement packet to 'mock' all of the BroodMinder devices it heard. The -SubHub advertises a different device every 5 seconds thus allowing data from 12 BroodMindlers to be sent every minute which means over 100 devices in 10 minutes.

We have established these parameters in order that the batteries last at least a year. While they will be adjustable for special circumstances, we feel that the standard setup will cover 99% of the cases.

That is basically how it works. Of course there are many, many details in making the pieces fit together seamlessly and to be supported by the equipment in the field. And, as always, during deployment we will be watching closely.

If you have a CELL or WIFI device, the subhub will amplify the data sent from the devices and extend the normal 10-15 foot range up to 300-500 feet (depending on obstacles in the way). Multiple subhubs can be located in the apiary to ensure complete coverage.

Installation

Installation is simple. Open the box and pull out the battery tabs and the -SubHub is running. You will see it show up in the phone app with an ID beginning with 52:. Once running, it will listen for other BroodMinder devices and add their data to it's internal log. The cool part is that the -SubHub will now advertise (send out) that data to be received by another BroodMinder hub, either a BroodMinder-CELL/WIFI, or a BroodMinder app.

If you are watching with a BroodMinder app, you will see your devices show up on the list. Each device is advertised for 5 seconds, rolling through all the known devices one after the other. You will see them marked in the device list as coming via the -SubHub.

Since this is only sending current data, you cannot connect to the remote BroodMinder sensor to retrieve stored data. To do that, you must visit the apiary and connect directly to the sensor.

However, you *can* take an old cell phone, connect it to your local Wi-Fi (or with a cell subscription) and run the BroodMinder Apiary app in Hub Mode. It will push the sensor data to MyBroodMinder.com every 10 minutes. Since the phone can be plugged into the wall for power it becomes very simple.

We have seen better performance with iOS (Apple) phones ro tablets. Some of the older Android devices work find, but some have problems with Bluetooth locking up.

If your apiary spans a long distance, you can employ multiple -SubHubs, one for each group of hives. They do not daisy chain, but they work directly to the central -CELL/WIFI or app.

Range Testing

If you are going a long distance, we have a few hints for you.

- 1) The -SubHub's radio waves are directional. The batteries block the antenna. This means that the -SubHub circuit board should be on the side of the -Hub or phone receiving the data.
- 2) A super way to test the range is using an app and your phone. Nordic Semiconductor has an app called "nRF Connect" for both iOS and Android. It is the best Bluetooth app out there. Here are a couple of usage notes.
 - a. Go to *Settings | Scanner | Scanner Timeout >>* set to *Never*
 - b. Start scanning in the "*Scanner*" tab at the bottom of the app
 - c. BroodMinder sensors will be named by their ID (e.g. 57:01:01)
 - d. Press the up arrow beside "*No Filter*" and put a ":" in the *Name* field and flip the switch beside it. This will only show devices with a ":" (such as BroodMinder devices.). You can also limit it to a specific device this way.
 - e. Now select the RSSI Graph and you will see each time the phone gets an update from the BroodMinder.
 - f. There are many other great options in the program to explore if you like this sort of thing.
- 3) Another useful method to test range is using the -Apiary app (Version 2.26 and newer).
 - a. Run the app in normal (not hub) mode.
 - b. As you move farther away, keep clearing the list using the "X" button at the top. This Makes it much easier to monitor changes.
 - c. The -SubHub ID, Signal Level, and Time of last contact will be shown above the BroodMinder Devices.

As a general note, detecting advertisements does not mean that you can connect to a device. Connections require stronger signals. This means that if you want to download the log, or update firmware, you may need at least a 40-50% signal level.

Section 10 contains more information on the technology of the BroodMinder-SubHub.

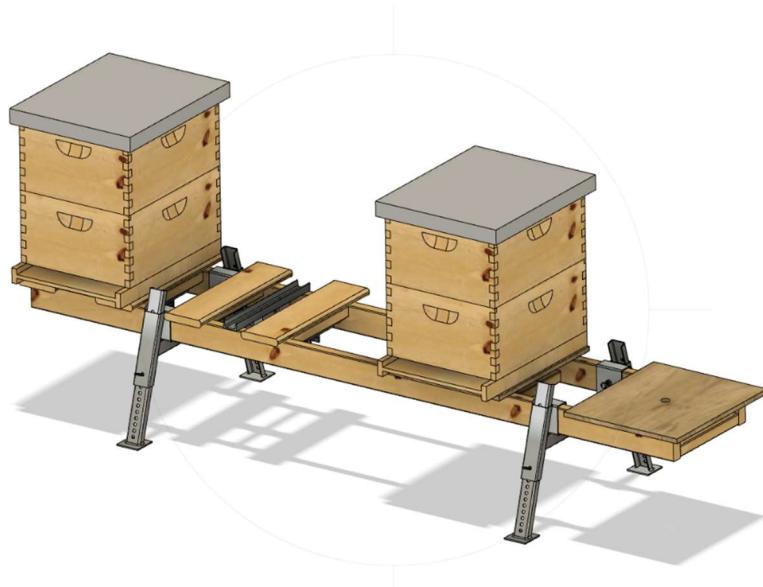
Good luck, we are very excited about the BroodMinder-SubHub and hope it will be of use to you.

2.8 BroodMinder-DIY (BRM-58) – Do it yourself weight scale.

The DIY is the raw circuit board that we use in the BroodMinder-W2. With it you can build your own scale and it will work with all of the standard BroodMinder software.

- Proven design, 5-year battery life
- No software to write
- Works with most standard load cells
- Integrates into the vast BroodMinder ecosystem

See below in section 11 for details on utilizing the DIY kit.



3 Routine Maintenance

There is not much routine maintenance that is required. Please note that if your batteries are lasting less than 6 months, something is wrong and you should contact Support@BroodMinder.com for replacement or refurbishment.

3.1 Spring

We have a video talking about spring maintenance on the support page at mybroodminder.com/resources.

In the spring, it is a good time to clean up your devices. You can use 91% or better Isopropyl or Ethyl Alcohol, it will not harm the electronics.

You can place the wrappers in the freezer and then propolis will break off more easily.

Ensure that the scale wrapper is not cracked, that will allow rain to harm the sensors. You can seal any cracks with packing tape.

We also have replacement wrappers for all the devices on our website at BroodMinder.com.

We also offer Refresh service where we replace the housings and batteries and test the devices. And we offer Refurbished units if the devices are unfixable. Contact Mike at support@broodminder.com and he will help you with this.

3.2 Fall

Prior to winter, replace all of the batteries in your BroodMindlers. (A good place to buy them is Amazon.com or Digikey.com. You can get them for less than \$0.50 each). All of the batteries are of type CR2032. For the AA and AAA batteries we recommend extra long life cells, Energizer L91 and L92 with good pricing from TheBatterySupplier.com.

Ensure that the scale wrapper is not cracked, that will allow rain to harm the sensors. You can seal any cracks with packing tape or order replacement wrappers at BroodMinder.com.

4 Device Software Updates

The BroodMinder-T2 and the BroodMinder-Hub devices have provision for Over-The-Air (OTA) upgrades. These are performed by the -Apiary app or the -CELL app. For more information, go to this link.

mybroodminder.com/resources

5 BroodMinder-APIARY App

5.1 Overview

Introduced in 2018, the BroodMinder-APIARY app is our most powerful app. We strongly recommend using it as opposed to the BroodMinder-Lite app.

For all users, you can see the current state of the sensors and also upload them easily to MyBroodMinder.com. It also allows basic control of the sensors as well as firmware updates.

For MyBroodMinder-Premium users, it will read and upload every BroodMinder device in your apiary directly to MyBroodMinder with a single keypress. It can also be used to automatically send your live data to MyBroodMinder.com every 10 minutes.

Once the data is transferred, review of data and keeping hive notes can be done directly on MyBroodMinder.com. We recommend this because of its ease of use.

Please note that this app only stores your hour by hour data in the cloud and does not keep a copy on your phone and/or tablet.

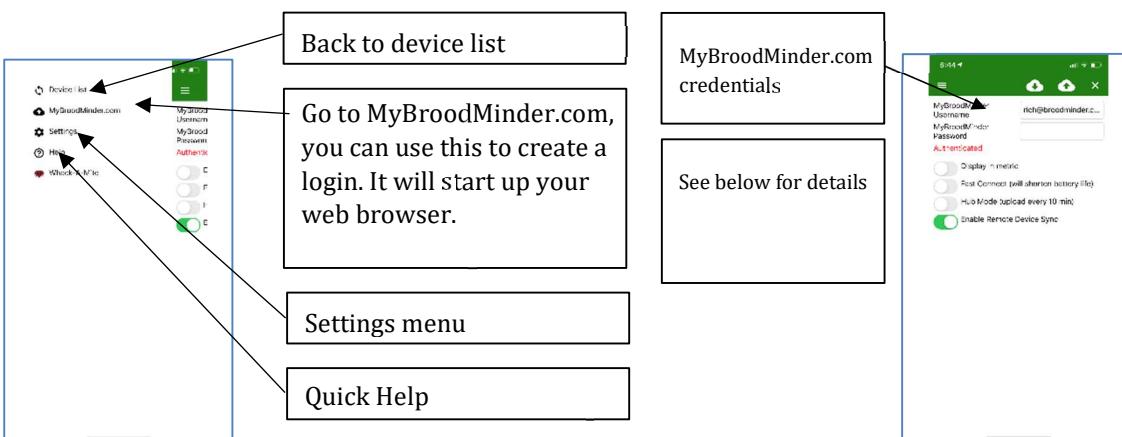
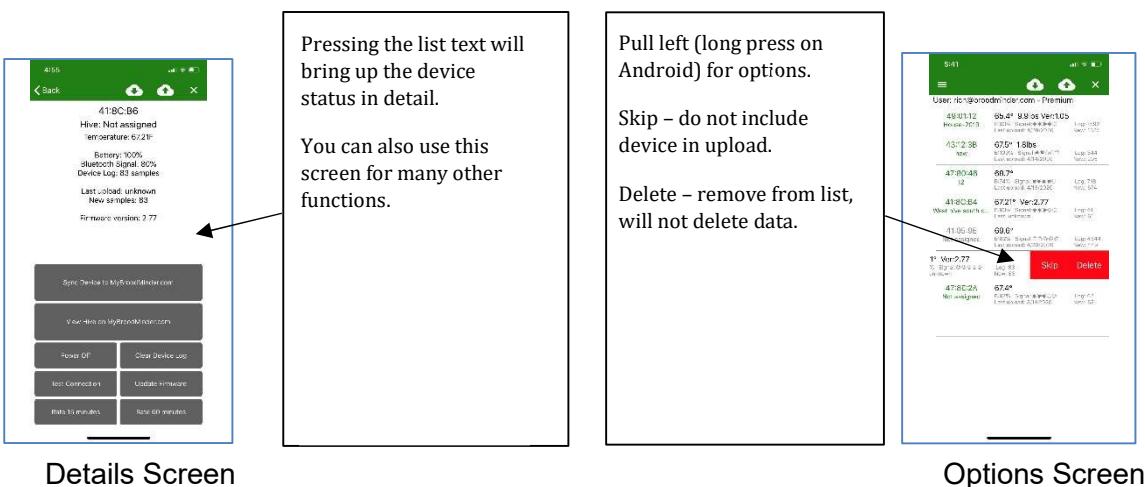
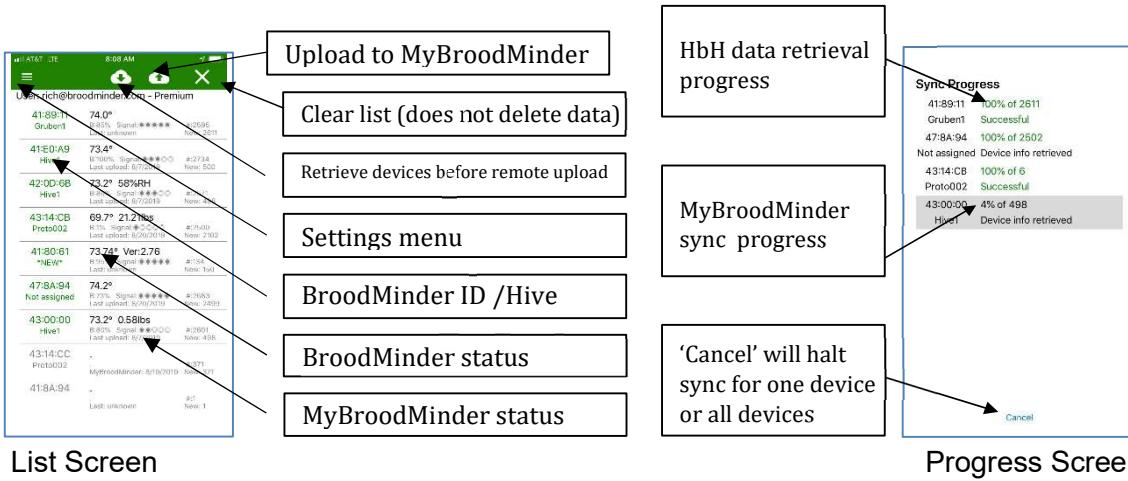
New features have been added in 2019-2020.

- Many more device details displayed including hive name
- Remote uploading – The apiary app now works with or without internet connectivity (premium users only).
- Hub mode – You can use any internet connected iOS or Android device to send data every 10 minutes from your apiary (premium users only).
- CELL wakeup – The BroodMinder-CELL device can be taken out of deep sleep.
- Change sample rate from 60 minutes to 15 minutes
- T2 firmware updates to SwarmMinder
- Power off control for T2

Usage of the app is super simple.

- 1) Go to MyBroodMinder.com and create an account (this is free).
- 2) Download BroodMinder-Apiary from your app store.
- 3) Start the app and press the gear icon and enter your MyBroodMinder credentials.
- 4) Return to the list screen and in a few seconds it will automatically find every BroodMinder device in the area and display them on the screen.
- 5) After the BroodMinder IDs turn green, press the cloud icon  in the upper right of the screen or tap on the device text to begin upload to MyBroodMinder.
- 6) Now the app will show you a upload progress screen. The top line is status while harvesting the BroodMinder data. The lower line shows the transfer to MyBroodMinder status. 6) After all of the devices have uploaded you will see a transfer complete message.

After the transfer is complete, the data will show up in MyBroodMinder. If you have already set up your devices, all you do is look. If these are new devices, you will need to find them in your MyBroodMinder “Device Inventory” and assign them to an apiary and to a hive. See the next section on MyBroodMinder.com for more on that.



FAST CONNECT – This will speed up connection time by making the ‘advertising rate’ faster. This means the BroodMinder will send out a signal every one second instead of every 5 seconds. The downside is that it will also shorten battery life. You might want to set this fast in the summer and slow in the winter.

HUB MODE – See below.

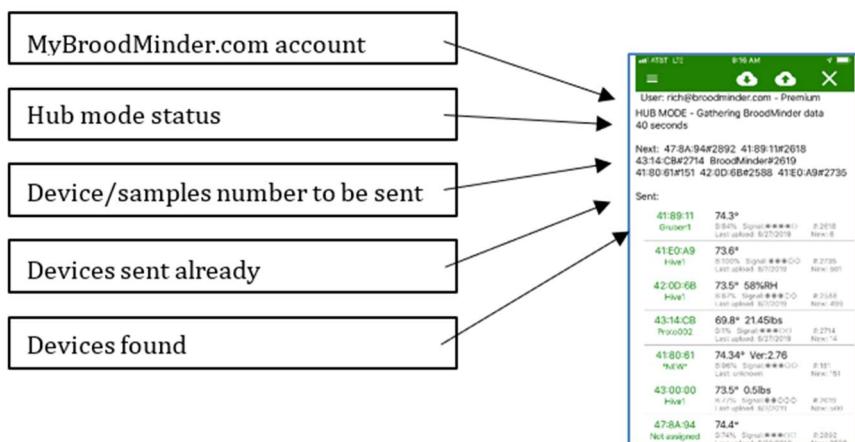
ENABLE REMOTE DEVICE SYNC – You can retrieve data even when there is no internet connection or cell coverage in your apiary.

- 1) Before going to the apiary – go to the device list and press the cloud with the down arrow . This will load the list with all of your devices and the last time data was retrieved. (If you don’t do this, all of the data will be retrieved from your BroodMinder. This could be a full year of data!)
- 2) When in the field, sync your devices like normal. They will fail upload since you don’t have internet, but that is OK.
- 3) When you return to civilization, restart the app and it will suggest that you upload to the cloud now. Do this and MyBroodMinder.com will get updated.

HUB MODE

Hub mode lets you use an old phone or tablet to automatically send your BroodMinder data to MyBroodMinder once every 10 minutes. This way you can see how your bees are doing 24/7 from anywhere in the world.

Just enable hub mode and return to the list screen.



6 The BroodMinder App

NOTE: We recommend using the BroodMinder Apiary app. It is more reliable and will work for most people.

6.1 Device compatibility

6.1.1 Apple – iOS

The BroodMinder app will work with any Apples device that has Bluetooth Low Energy (BLE) available. It will work with iPhone model 4s or newer and with iPads 3rd generation or newer although the newest ones work most reliably.

6.1.2 Android

Android is a bit more complicated. Android introduced BLE support in Version 4.3 (Jelly Bean, July 2012). Devices before that will not work. Devices after that may work. Most new devices (2015 or newer) do work. However, there are many flavors of phone and we have found a few that give us problems. If your device does not work, then contact us at Support@BroodMinder.com.

A new feature has been added to both apps to optionally increase the “advertising rate” of your BroodMinder devices. As shipped, the BroodMinder sends a message out once every five seconds that contains temperature and weight information. The General Settings page now has a Bluetooth Config button which allows you to change the advertising rate to once per second. This will speed device connection and will make data retrieval faster. It will however reduce battery life to 3-6 months.

We have also added a “Reset Android Bluetooth” under the Bluetooth Config button. This will do a system reset of the Bluetooth function. We have found that on some phones this will help re-establish communication.

There is more information at MyBroodMinder.com/resources.

6.2 Installation

The BroodMinder app is available at the Apple App store, or the Android Play Store, or the Amazon Play Store, depending on your device. It is called BroodMinder Lite you will find it. Install it just like you would any other app.

After it is installed, start the app. The app should present you with a warm and congratulatory welcome message. You can choose to watch our Queen Bee, Laura Davis demonstrate installation, or you can dismiss the message and let the app do its thing.

The app will start scanning for BroodMinder devices in the area and will automatically fill the screen with any that it finds within the area.

If none show up:

- Make sure that the battery tab has been removed from the BroodMinder-TH and make sure that the battery is pressed into place on the BroodMinder-W
- Make sure that your phone/tablet has Bluetooth turned on
- Make sure that you are within 10-20 feet of the BroodMinder device

6.3 Home Screen of BroodMinder App

BroodMinder-T will display Temperature

BroodMinder-TH will display Temperature & Humidity

BroodMinder-W will display Temperature & Weight

The + sign lets you add any BroodMinder to your list that is stored at MyBroodMinder.com

This icon will take you to the global settings page.

The ? will give you a brief help message and a link to the video



You can add your own name by tapping here

You can add your own picture by tapping here

When this turns green, you are close to a BroodMinder

Tapping here takes you to the device details/graph screen

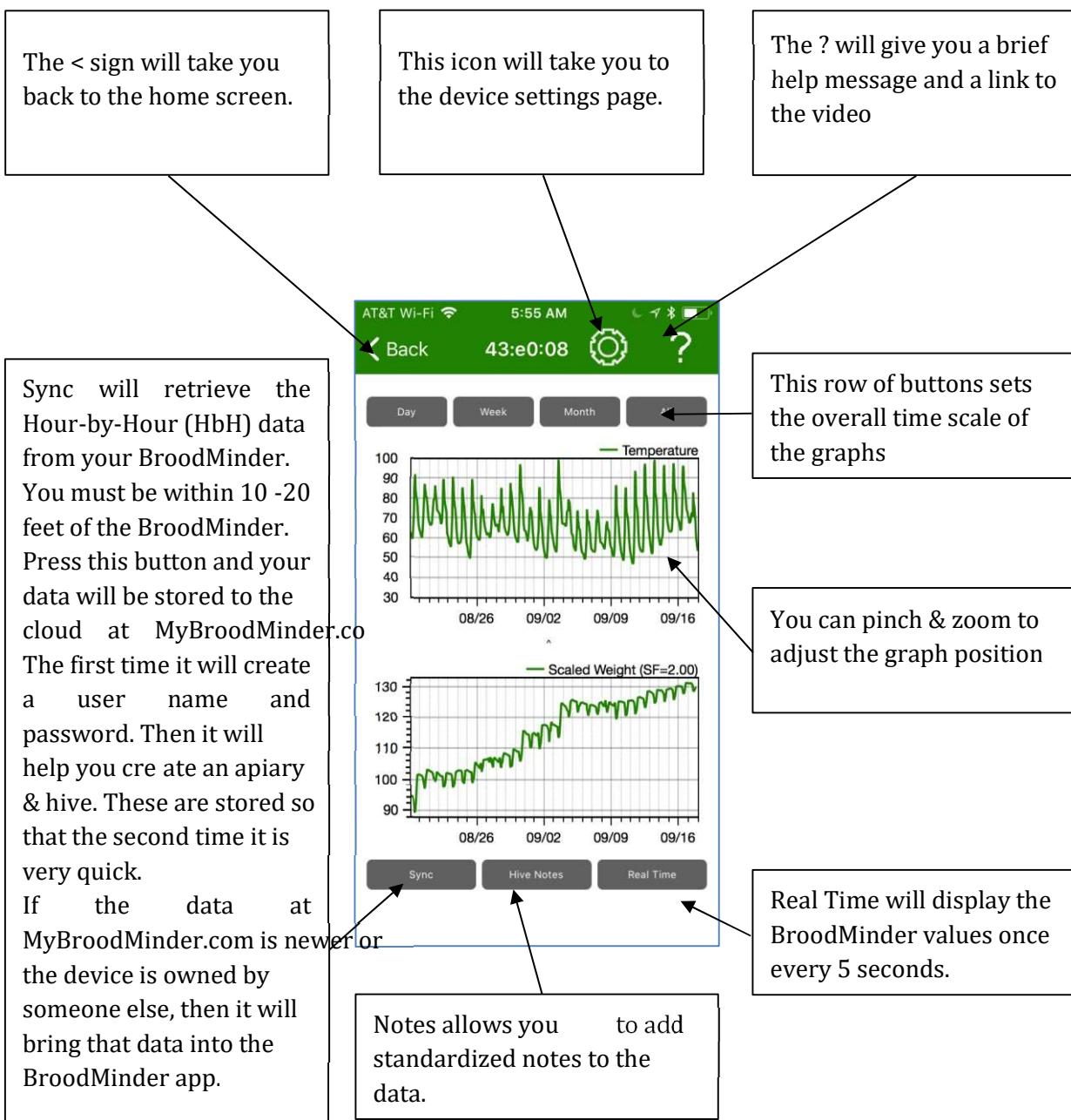
This is the signal strength from your BroodMinder. It will get stronger as you get closer.

If you name your device, the ID will move to here.

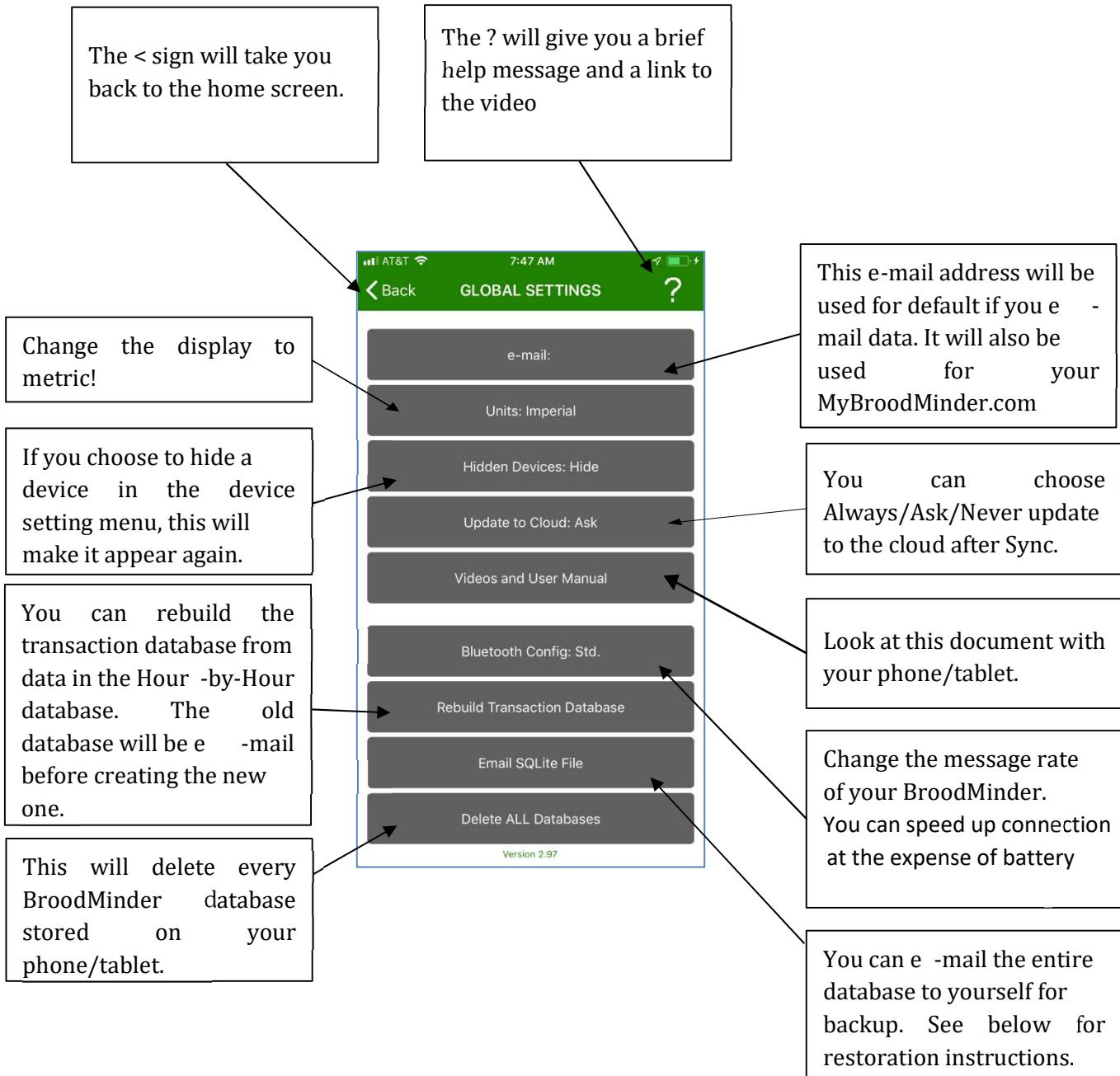
Battery level.

Swipe left to delete a device or access the graph screen. (Android is a long press)

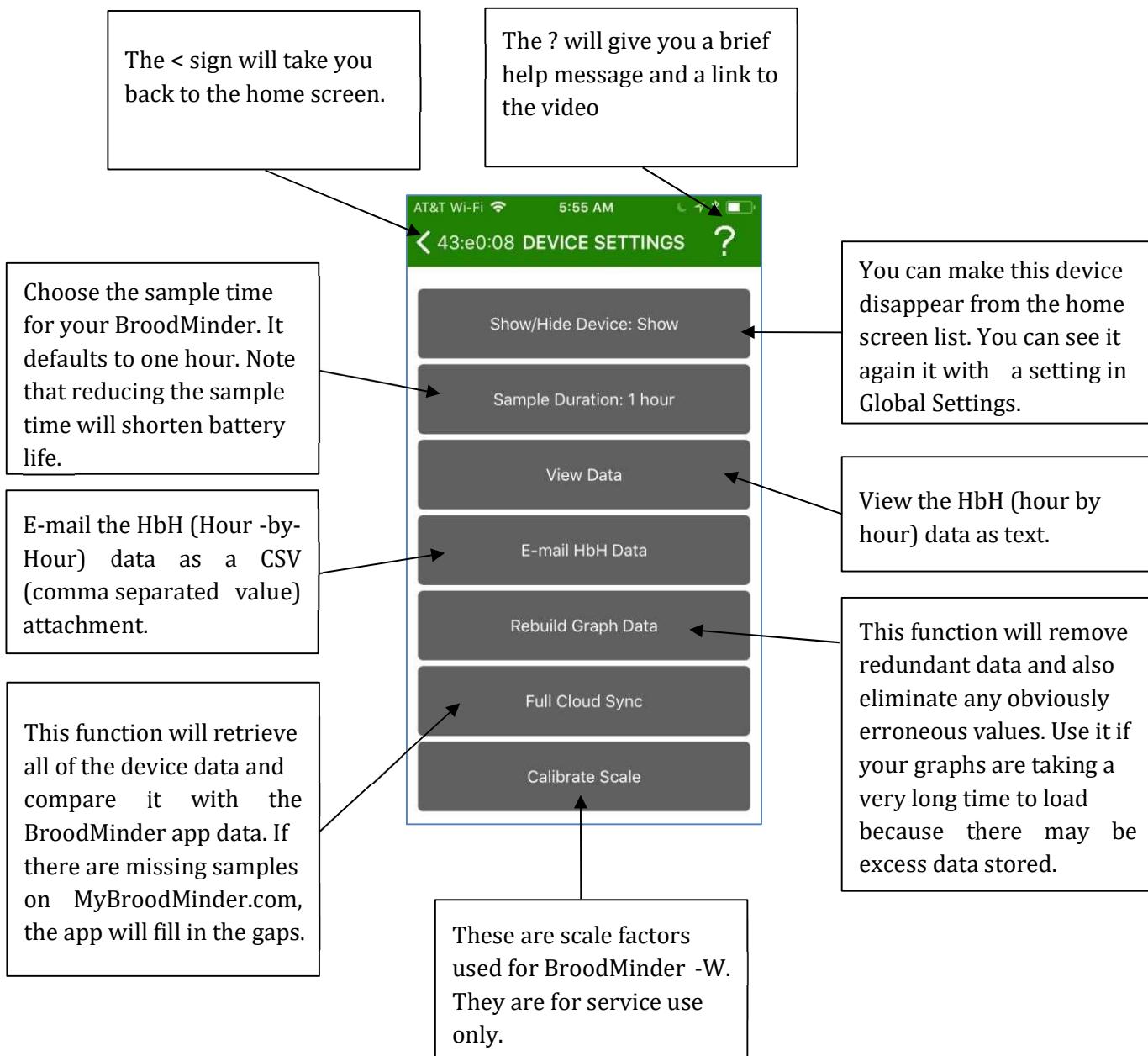
6.4 Details/Graph Screen of BroodMinder App



6.5 General Setting Page



6.6 Device Setting Page



6.7 Real Time Mode

If you would like to see “Live” data, you can use the “Real Time” button on the Graph screen.

Pressing this button will change the sampling rate to 5 seconds and then show a display of values in the lower section of the screen.

B: Battery level

T: Temperature (currently only F)

H: Relative Humidity in %

L/R: Balance between left and right sensors. Adds to 100% (-W scale only)

W: Total weight (currently only pounds) (-W scale only)

Delta: Change in weight from when Real-time started. (-W scale only)

This data will also be saved in the log file.

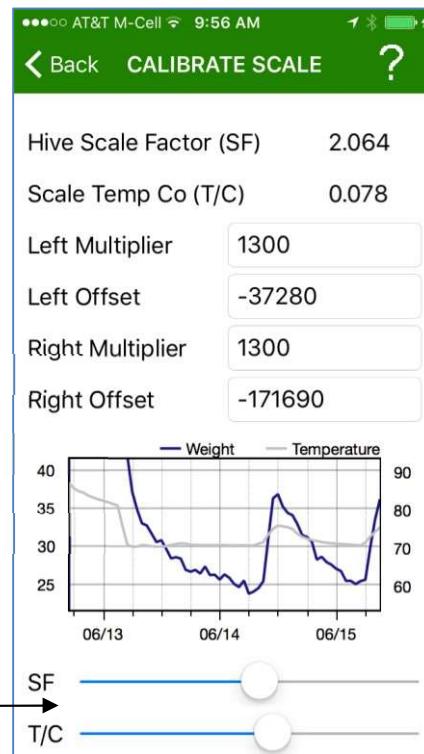
Pressing the “Real Time” button again will leave this mode and set the sampling rate back to 60 minutes.

6.8 Setting the BroodMinder-W scale factor

These two controls will adjust the BroodMinder - W scale factor (SF) and temperature compensation (T/C). You will see the graph update as the sliders change.

The Left/Right Multiplier & Offset values are for reference only.

For advice on how to adjust these , keep reading below.



By default, the BroodMinder-W scale factor is set to 2.0. This means that any weight the BroodMinder-W sees is doubled to reflect the full weight of the hive. From looking at the physics of the situation (see appendix below) we know that this is an approximation and not totally accurate. In most cases, it is close enough since small changes will still be seen and a 5-10% error in total weight is not important.

A more accurate total weight display can be obtained by adjusting the scale factor to account for the hive specific situation.

Go to the Graph Screen of the scale and press the real time button. In a few seconds, the app will begin to display the scale reading once every 5 seconds at the very bottom of the screen. You can also see the % load on each load cell.

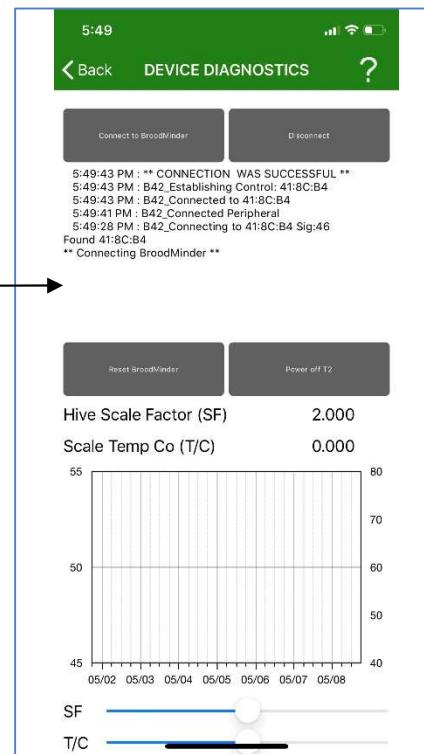
Now add a known weight of 10-20 pounds to the top center of the hive. You should see this weight change in the app readout. Then you can adjust the scale factor to exactly match the weight change.

Example:

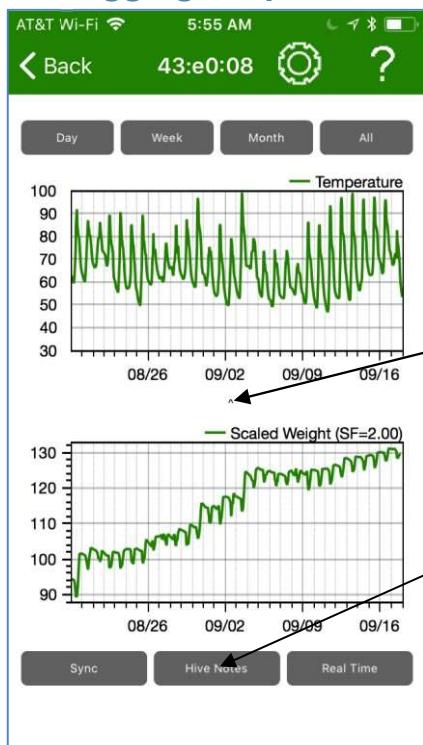
Weight	Delta Weight	Scale Factor	Notes
121.2	0.0	2.0	Start of Real Time
132.2	11.0	2.0	We added the weight
			Now we go change the scale factor
129.5	10.0	1.82	Now the calibration is closer
117.0	0	1.82	After the weight is removed, we see the new more accurate hive weight

6.8 Device diagnostics

A new diagnostic feature will allow testing of connection to the BroodMinder device as well as powering off T2 devices. Please note that after you connect, you must disconnect prior to testing connect again.

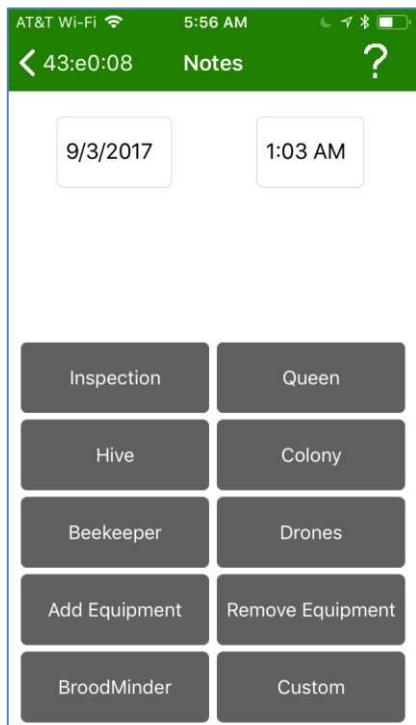


6.11 Tagging Graphs



Note Time Indicator

Hive Notes allows you to add standard notes to the data.



Pressing the Hive Notes button lets you add text to any point in time on the graph. This is useful to explain abrupt changes in the data or whenever you do a hive inspection.

This button will bring up a sub-menu with eight groups of possible occurrences or actions. Select the one most appropriate for your situation and choose the corresponding tag. Use "Custom" if the list does not cover your situation. The selections in the app will be updated as time goes on to best reflect the tags most used.

The time shown in the top half of the screen is the current time if the graphs have not been moved by pinching or swiping before the "Tag Graph" button has been pressed. It can be adjusted by clicking on it.

When noting a past event, it is useful to move the chart and line up the time of the event with the "Note Time Indicator" and then press Hive Notes. In this case, the note time in the notes window is the time at the "Notes Time Indicator" and not the current time.

Of particular interest is the "Inspection" button. This button will walk you through a 6 easy to answer questions about the state of the hive. The list was shared with us by Dick Rogers and we think it is a quick and effective way to document the hive.

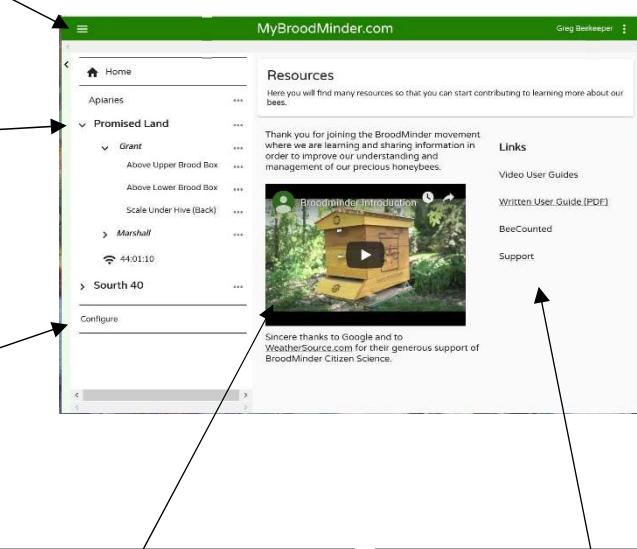
7 MyBroodMinder.com Cloud Storage

The true power of the BroodMinder movement is in the data from thousands of hives stored for public consumption at MyBroodMinder.com.

We have done our best to make it as simple as possible for you to transfer the data there. **From the BroodMinder App, you only need to push the Sync button and answer a few questions.** The app will create a new MyBroodMinder account for you and everything needed to get going. After that the data will be transferred. *You do not need to create a MyBroodMinder account before pushing data.*

Once the data is on MyBroodMinder.com you can see it and combine the data from the sensors into one easy to read graph for each hive.

With any web browser, go to MyBroodMinder.com. You will need to enter the same username (e-mail) and password. After that you will see a menu similar to the image below.



Show/hide the side bar

The side bar allows you to navigate to all of your hives and devices. Click on the > to reveal hives and devices.
... (three dots) to the right let you do quick changes.

Use configure to view BroodMinder inventory and move devices between hives.

Our jazzy intro video

Lots of helpful resources 😊

The screenshot shows the MyBroodMinder.com website. The top navigation bar includes 'Home', 'Log Out', and a user profile icon for 'Greg Beekeeper'. The main content area has a sidebar on the left containing 'Home', 'Aparies', and a expanded section for 'Promised Land' with items like 'Giant', 'Above Upper Brood Box', 'Above Lower Brood Box', 'Scale Under Hive (Back)', 'Marshall' (with a signal strength icon), and 'Sorth 40'. To the right of the sidebar is the main dashboard, which features a 'Resources' section with a 'BroodMinder Introduction' video thumbnail, a 'Links' section with 'Video User Guides' and 'Written User Guide (PDF)', and a 'Support' section with 'BeeCounted' and 'Support'. At the bottom of the dashboard, there is a note of thanks to Google and WeatherSource.com. The bottom of the page has a footer with 'Our jazzy intro video' and 'Lots of helpful resources 😊'.

You will see a graph like this that combines all of the sensors in a hive into one report.

This is the hive being displayed.

You can add lots of notes here and they will show up on the graphs.

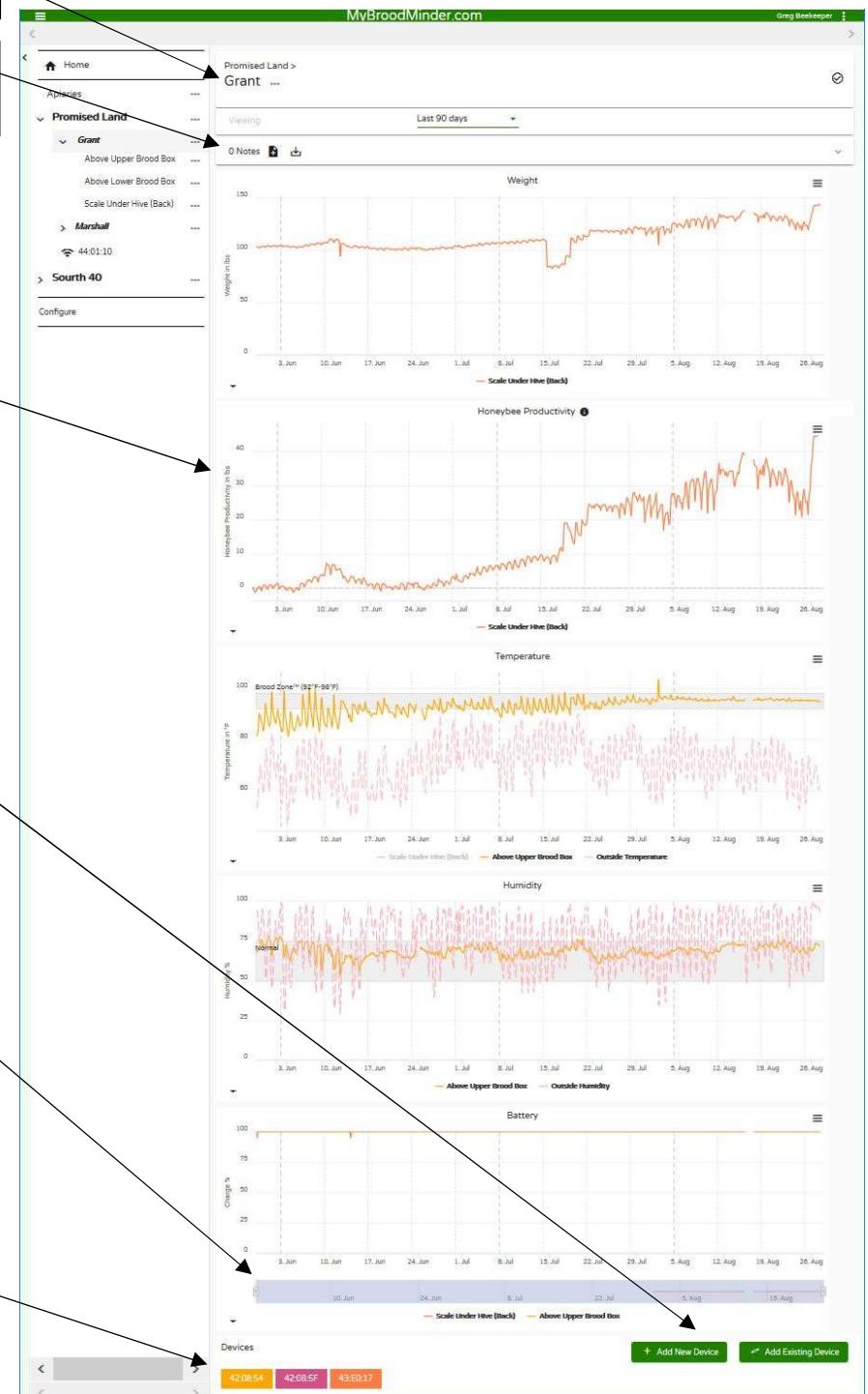
Honeybee Productivity is the weight change created by the bees, not the beekeeper. Any time there is a change in one hour > 10 pounds, it is left off the graph.

Add existing device will find a device that was uploaded already that is new.

Add New Device will create a new device that has not been uploaded yet.

Use this bar to change the graph range. You can also drag with your mouse left button pressed over the graph to zoom in on a region.

These are the devices assigned to this hive that are being displayed.



Put your real name here. You can also renew your premium subscription here.

Choose metric/imperial. Interpolate graphs will fill in missing data. This can be confusing but some people like it better.

In this menu you can add and delete apiaries. If you get the zip code wrong, ask support@broodminder.com to change it.

Add or delete hives here.

These are all of your devices.

Location history lets you move them.

With edit you can change the name.

Download Devices will create a text (CSV) file with all of the devices and locations in it.

Use the filter to see only certain devices.

Use the configuration menu to set everything about your MyBroodMinder.com universe.

The screenshot shows the MyBroodMinder.com dashboard with several sections:

- Left Sidebar:** Home, Apiaries, Promised Land (expanded), Grant, Marshall, Sorth 40, Configure.
- Configure Panel:**
 - My Account:** Username: juice@broodminder.com, First Name: Greg, Last Name: Beekeeper, Subscription Type: Premium expiring on 08/31/2020. Save button.
 - My Preferences:** Timezone: Browser Default, Units: Imperial (Fahrenheit/Pounds). A checkbox for "Interpolate Charts (connect all points, even if data gaps over 8 hours)" is checked, with a Save button.
- Apiaries Section:** Add Apiary, table with rows for Promised Land (zip 53534) and Sorth 40 (zip 53534). Actions: Edit, Location History, Delete.
- Hives Section:** Add Hive, table with rows for Grant (Promised Land) and Marshall (Promised Land). Actions: Edit, Location History, Delete.
- Devices Section:** Filter, Add Device, Download Devices. Table with columns: Device Name, Device Address, Current Location, Date Last Received, Edit, Location History, Delete. Rows include:

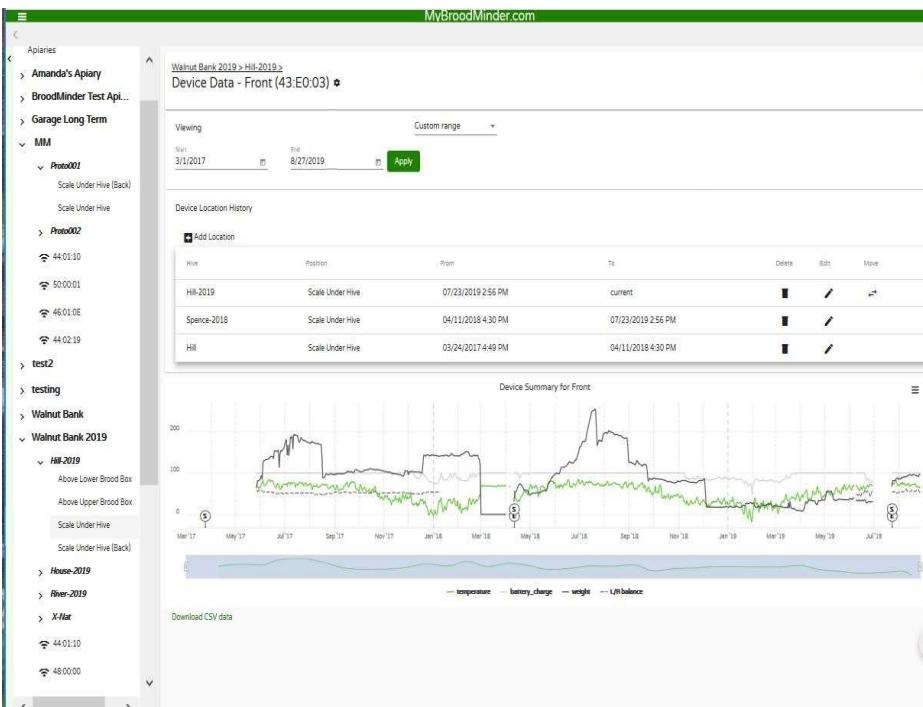
42:08:54	42:08:54	Promised Land > Grant > Above Upper Brood Box	Tue 08/27/2019 8:50 AM	<input type="button" value="Edit"/>	<input type="button" value="Location History"/>	<input type="button" value="Delete"/>
42:08:5C	42:08:5C	Promised Land > Marshall > Above Lower Brood Box	Tue 08/27/2019 8:50 AM	<input type="button" value="Edit"/>	<input type="button" value="Location History"/>	<input type="button" value="Delete"/>
42:08:5F	42:08:5F	Promised Land > Grant > Above Lower Brood Box	Tue 08/27/2019 8:50 AM	<input type="button" value="Edit"/>	<input type="button" value="Location History"/>	<input type="button" value="Delete"/>
43:E0:17	43:E0:17	Promised Land > Grant > Scale Under Hive (Back)	Tue 08/27/2019 8:00 AM	<input type="button" value="Edit"/>	<input type="button" value="Location History"/>	<input type="button" value="Delete"/>
A4:E3:F8	A4:E3:F8	Promised Land > Marshall > Scale Under Hive	Tue 08/27/2019 8:50 AM	<input type="button" value="Edit"/>	<input type="button" value="Location History"/>	<input type="button" value="Delete"/>

When you navigate to the device level, you will see the location history.

In this example, you can see 43:E0:03 BroodMinder-W started in the hill hive in 2017 and then moved to two different hives. On the graph, you will notice the 'S' and 'E' which stand for start and end times in a hive.

You can change these dates with the edit function.

If you are moving it to a new/different hive, use the MOVE function.



8 Databases!

Everybody loves databases! We know we do!

In the BroodMinder-Lite app there are two databases. There is no database stored in the BroodMinder-Apiary app, all data is stored at MyBroodMinder.com.

- Transaction database – This database holds all of the interactions between you the operator and your BroodMindlers. Each time you go to retrieve data it will keep a record of it.
- Hour-by-Hour (HbH) database – This one holds all of the HbH data that you retrieve from your device using the SYNC button.

8.1 Database operations

There are several things that you can do with the database using the BroodMinder App. Here is a quick list. We will follow-up with details.

Some of these operations are tricky! If you are not confident of doing them, send us a note at Support@BroodMinder.com. Mike or Theo will be happy to help.

- Send CSV (Comma Separated Variable) text file to yourself (or others) o Transaction Database o HbH database
- Send SQLite file to yourself (or others) – The SQLite file is the main database that is used by the App. This holds all of the data in one file that can be read and modified by a compatible program.
- Import HbH CSV file from e-mail – You can send a file to yourself, modify it, and then read it back in.
- Import SQLite file from e-mail – You can send the SQLite file to yourself, and then read it into a different device.
- Rebuild database o Transaction database – When you rebuild the transaction database, it deletes it and then creates a new one by reading the newest data point from each device in the HbH database.
 - o Rebuild HbH database – When you rebuild the HbH database, it reads the MyBroodMinder.com data and adds it to the current HbH data on the device. Then it deletes redundant points and gets rid of clearly anomalous values.
- Delete database o Delete device – you can delete data from a single device. o Delete All – you can delete the entire database and start over.

8.2 Send CSV (Comma Separated Value) Text File

The easiest way to get to your data is to e-mail a CSV file to yourself. You can either send the Transaction database, which contains all of the devices and all of the observed data when you visit the hive (but not the HbH data). Or you can send the HbH data which is all of the data from a specific device. You will find these buttons in the Global Settings and Device Settings menu.

When you press either button, you should see the device e-mail app come up and it will generate an email with a file attachment. It will send it to the e-mail address that you gave in the global settings screen, or you can add any other e-mail address that you would like.

Here are definitions of the file contents.

8.2.1 Transaction Database Fields

UUID – This is the device ID that is written on the circuit board

Model – The device Model and firmware version. E.g. 42-2v56, Model 42, Version 2.56 (Model 41=BroodMinder-T, Model 42=BroodMinder-TH, Model 43=BroodMinder-W, Model 44=BroodMinderCELL)

TimeStamp – Timestamp of transaction in text readable format

Unix_Time – Timestamp of transaction in UNIX format

Sample – Sample number of data from BroodMinder

Signal – Bluetooth signal strength from BroodMinder

Battery – Battery voltage (0-100%)

Metric – 0 for Imperial, 1 for Metric

Temperature – Temperature from BroodMinder

Humidity – Relative Humidity from BroodMinder (0-100%)

Weight – Total weight from BroodMinder including scale factor

Weight Scale Factor – Scale factor for Scaled_Weight

Hidden – TRUE if hidden flag is set which hides device from home screen

Name – The name that you gave the BroodMinder device

Notes – Various notes

SamplePeriod – The sample period of the BroodMinder in seconds, defaults to 3600

(Note: If you look directly at the SQLite database, you will find time in "ticks". To convert to excel time you can use the equation =(A1*POWER(10, -7) / 60 / 60 / 24)-693593 where A1 contains ticks)

8.2.2 HbH Database Fields

App Ver – This is the version of the BroodMinder App that wrote this record

UUID – This is the device ID that is written on the circuit board

Model – The device Model and firmware version. E.g. 42-2v56, Model 42, Version 2.56 (Model 41=BroodMinder-T, Model 42=BroodMinder-TH, Model 43=BroodMinder-W, Model 44=BroodMinderCELL)

Record_Type – Type of data in record *Logged_Data* or *Sample_Period* or *Time_Stamp* or *Note*

DownloadTimeStamp – UNIX time that the data was SYNCed

TimeStamp – Timestamp of sample in text readable format

Local_Excel_Time –Timestamp of sample in Excel readable format

Unix_Time – Timestamp of sample in UNIX format

Logging_Period – BroodMinder logging period in seconds

Sample – Sample number of data from BroodMinder

Metric – 0 for Imperial, 1 for Metric

Battery – Battery voltage (0-100%)

Temperature – Temperature from BroodMinder

Humidity – Relative Humidity from BroodMinder (0-100%)

Scaled_Weight - Total weight from BroodMinder including scale factor

Weight Scale Factor – Scale factor for Scaled_Weight

Weight – Non-scaled weight (Weight = WeightL + WeightR)

WeightL – Non-scaled weight from left sensor

$(\text{WeightL} = ((\text{WeightLRaw} * \text{MULT}) + \text{OFFS}) / 100,000 / 100)$

MULT & OFFS are written on the scale label

WeightLRaw – Raw 24-bit ADC value from left sensor

WeightR – Non-scaled weight from right sensor

$\text{WeightR} = ((\text{WeightRRaw} * \text{MULT}) + \text{OFFS}) / 100,000 / 100$

MULT & OFFS are written on the scale label

WeightRRaw – Raw 24-bit ADC value from right sensor

Hive_Name – The name that you gave the hive or the default UUID name

Notes – Various kinds of notes including tags

8.3 Send SQLite file

The SQLFile sends just like the CSV files do. The big difference is that before it is sent, it is zipped (compressed). This file contains both the Transaction database and the HbH database of all of the devices.

If you want to look at the contents, after you decompress the .gz file (you can use 7-zip for this) you need to add .DB3 to the end of the filename. If you are going to transfer the file to another device running the BroodMinder App, you don't need to do anything.

There are a couple of nice (free) readers out there. “DB Brower for SQLite” (<http://sqlitebrowser.org/>) for PC and “SQLPro for SQLite Read-Only” ([http://sqlpro-sqlite-read-only-sql-and-coredatabase-manageditor.softwar.io/manageditor.softwar.io/](http://sqlpro-sqlite-read-only-sql-and-coredatabasehttp://sqlpro-sqlite-read-only-sql-and-coredatabase-manageditor.softwar.io/manageditor.softwar.io/)) for Mac are two examples.

The great use of this file is that you can transfer all of your information to a new device! See the next section.

8.4 Import HbH CSV or SQLite file

So once you have e-mail the SQLite file to yourself, how do you get it back into the app. This can be to your normal device, or to a new one.

When you install the BroodMinder App, it adds the ability to import CSV & SQLite files. The import process is similar, but what happens when it imports is different. First let's talk about the import process.

Importing into the BroodMinder App is pretty easy. The process is slightly different between iOS and Android.

iOS

- Bring up your email reader and select the e-mail with the CSV or SQLite file.
- When you tap and hold the icon for the file attachment, a list of apps should pop up. On that list you should see “Import with BroodMinder” along with the BroodMinder Logo.
- Press the icon and this will bring up the BroodMinder App with further instructions.

Android

- Bring up your email reader and select the e-mail with the CSV or SQLite file.
- When you tap the file attachment you will download the file. It will retrieve the CSV file and place it in your Downloads folder.
- Next go to My Files and tap the file that you just downloaded.
- Now you may be asked what app to use, choose BroodMinder and this will bring up the BroodMinder App with further instructions.

8.5 Import HbH CSV

You can only import the HbH data. You cannot import the Transaction Database.

Note that the filename must be “BroodMinderHbHData.CSV”.

Before importing the CSV file, you can edit/delete values in the file that you e-mailed to yourself. This means that you can clean up data that should not be there. For instance if you started the BroodMinder in your house and then moved it to the hive later.

WARNING: When you import a CSV file, the app expects to see the standard columns that exist in the exported CSV file. This means that while you can change the values and delete lines, you should not change the columns.

Also note that import uses the UNIX_TIMESTAMP as the actual sample time. Other timestamps in the file

are only added for your convenience. They are not used by the BroodMinder App or by MyBroodMinder.com.

Note that the app will ask you if you want to ADD the data to the existing data or REPLACE the entire HbH data record for this device. Note that if you keep adding, you may get multiple copies of the data. You can clean this up with a HbH Database Rebuild.

8.6 Import SQLite File

When you import a SQLite file, it replaces the entire database in your device. The one thing it does not do is replace the pictures. You will have to do that manually.

Note that the filename must be “BroodMinder.gz”.

WARNING: Be sure to export the SQLite database in your device before replacing it with a new one. The old one will be DESTROYED.

The powerful aspect of being able to import a SQLite file is that if you have a problem, you can e-mail the SQLite file to us. Then we can fix the problem and send a new, repaired database back to you. Cool huh?

8.7 Rebuild Database

If you would like to clean up your database, you can try rebuilding it. Don’t do this unless you understand what you are doing. Feel free to send questions to Support@BroodMinder.com.

Rebuilding the Transaction Database – When you rebuild the transaction database, it is rebuilt from any HbH data that is on your device. The old transaction database is first e-mailed to you, and

then deleted. Then the App goes through all of the HbH data and creates an entry for every unique device it finds. Finally, it takes the newest data point for each device and adds it to the transaction database.

Rebuilding the HbH Database – The rebuild of the transaction database is a bit different. When you start the rebuild, you will be asked if you want to retrieve the MyBroodMinder.com data. If you do, it will be merged with the data already on your device. Once it is merged, the program will look through the data for redundant data points and remove them. It will also look for crazy values (for instance negative weight) and remove them. Once it has done this, it will replace the HbH data on the device with the new data.

Note that if you want to update MyBroodMinder.com with this data, you must first go to the MyBroodMinder.com website and delete the device. You can do this in the settings menu on the website for this device. Then you can press MyBroodMinder.com on the BroodMinder App and send the new data up.

WARNING: Only do this if you fully understand the process. Send a note to Support@BroodMinder.com if you need help.

8.8 Delete database

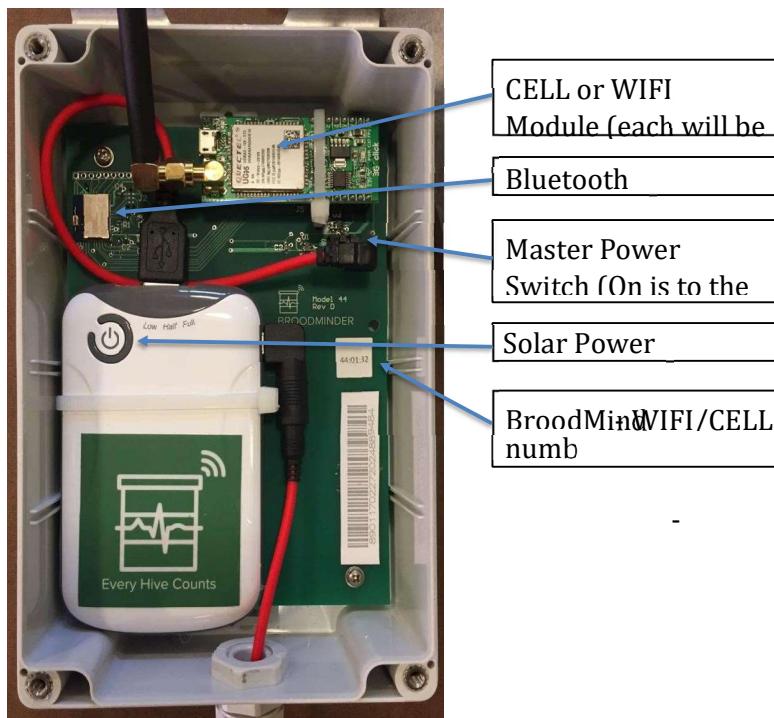
You can delete the databases. This should be pretty self-explanatory. Be careful, they really are gone once you do this. There is no “UNDO”!

9 BroodMinder-WIFI & BroodMinder-CELL

BroodMinder-WIFI/CELL is an optional component which sits in your apiary and relays data from your BroodMinders directly to MyBroodMinder.com via a WIFI or CELL connection. We have designed the BroodMinder-WIFI/CELL to automatically begin working when power is turned on.

We recommend setting up the BroodMinder-WIFI in your house prior to going to the apiary. It is a little tricky getting connected to the local WiFi. Once connected it will work reliably.

For best results, watch the installation video at
<https://mybroodminder.com/app/resources/video-guides>



9.1 Quick Start Instructions

- . IMPORTANT: Sync all devices & **post to MyBroodMinder.com** before starting your BroodMinder-WIFI/CELL
- . Place the BroodMinder-WIFI/CELL in the apiary with the solar panel towards the sun
- . Get the BroodMinder-CELL app (even if it is a WIFI/CELL unit)
- . Start the app, your BroodMinder-WIFI/CELL should show up on the list.
- . Press exit deep sleep
- . WIFI/CELL only – Enter your WIFI/CELL network name and password (matching capitalization is important)
- . DONE! - Data should start showing up in MyBroodMinder.com in about an hour.

9.2 Installation

You can install your BroodMinder-WIFI/CELL in many different configurations depending on circumstances. The bracket on the back of the electronics enclosure may be flipped as shown in some of the examples.



Here are a few installation considerations

- The solar panel will fully charge the battery with about 4 hours of good, direct sunlight.
- The battery should last 3-4 days with no good sunlight
- Wireless reception is hampered by trees. Mounting on a tree may be problematic if your signal is marginal.
- In extreme cases we can suggest a more sensitive antenna (Cellular only). Contact us at Support@BroodMinder.com.
- Tie wraps or pipe clamps may be used to secure the system
- A small 3' post like available at major hardware stores works well. They have tabs that can be slightly bent to allow the BroodMinder-WIFI/CELL to be inserted. Then, a tie wrap at the bottom secures the unit.

9.3 Solar Battery Always-On Mode

We ship BroodMinder-WIFI/CELL with the battery in **Always-On** mode. Under normal conditions, you will not need to open the electronics enclosure.

Note: Voltaic updated their batteries in 2021. The new V25 is always in “always on” mode. This makes us very happy. It is easy to tell a V25 because it is silver, not white.

The solar battery is a Voltaic V15 and features two power modes.

- In **Always-on** mode, the V15 power never turns off
- In **Auto-off** mode, the V15 power automatically turns off after about 20 minutes

It is important to have the V15 in **Always-on** mode so that the BroodMinder-WIFI/CELL continues to work 24 hour per day.

Let us repeat: We ship BroodMinder-WIFI/CELL with the battery in **Always-On** mode. If you never hold the V15 (solar) power button for more than 5 seconds, you do not need to change anything.

If you do hold the V15 power button for > 6 seconds, it will change the mode. It alternates from **Always-on** to Auto-off and back and it is a little tricky to figure out which mode it is in.

To tell the difference, watch the V15 lights AFTER the 3 flashes described below.

- Block the solar panel to make the lights less confusing
- Press and hold the power button
- After 6 seconds, the LEDs on the V15 will flash 3 times
- If the light stays on for a few more seconds, it is in **Always-on** mode. This is good!
- Release the power button

If after the 3 flashes, the V15 lights turn off, it is in Auto-off mode. This is not good. Try again and it should be correct this time.

You can find more information at <https://www.voltaicsystems.com/always-on/>

9.4

WIFI/CELL Indicator Lights

BroodMinder-CELL Status LED – After power on it does this...

- 1) Blink for each BroodMinder sensor that it finds
- 2) On while initializing cell modem, and then blink value of signal strength
 - a. 0-31, 0 = poor, 31 = good, 99 = no connection
 - b. Signal < 5 connection too poor to operate reliably



Cellular Status (operating) (yellow)

Cellular modem main power indicator (green)

Cell network (red)

Voltaic V15 LEDs (4 red)

- LEDs will flash when charging
- If you press 1/0 button, they will display state of charge (1-4)

7.5 BroodMinder-WIFI/CELL App

The BroodMinder-WIFI/CELL App allows you to closely watch how things are going. Some of the things that you can monitor include:

- Deep Sleep Mode – see below.
- Current status of BroodMinder-WIFI/CELL (Initializing, time until next data transfer, connecting to WIFI, sending data)
- Number of BroodMinders found in the apiary
- WIFIular signal strength
- Lots of diagnostic features

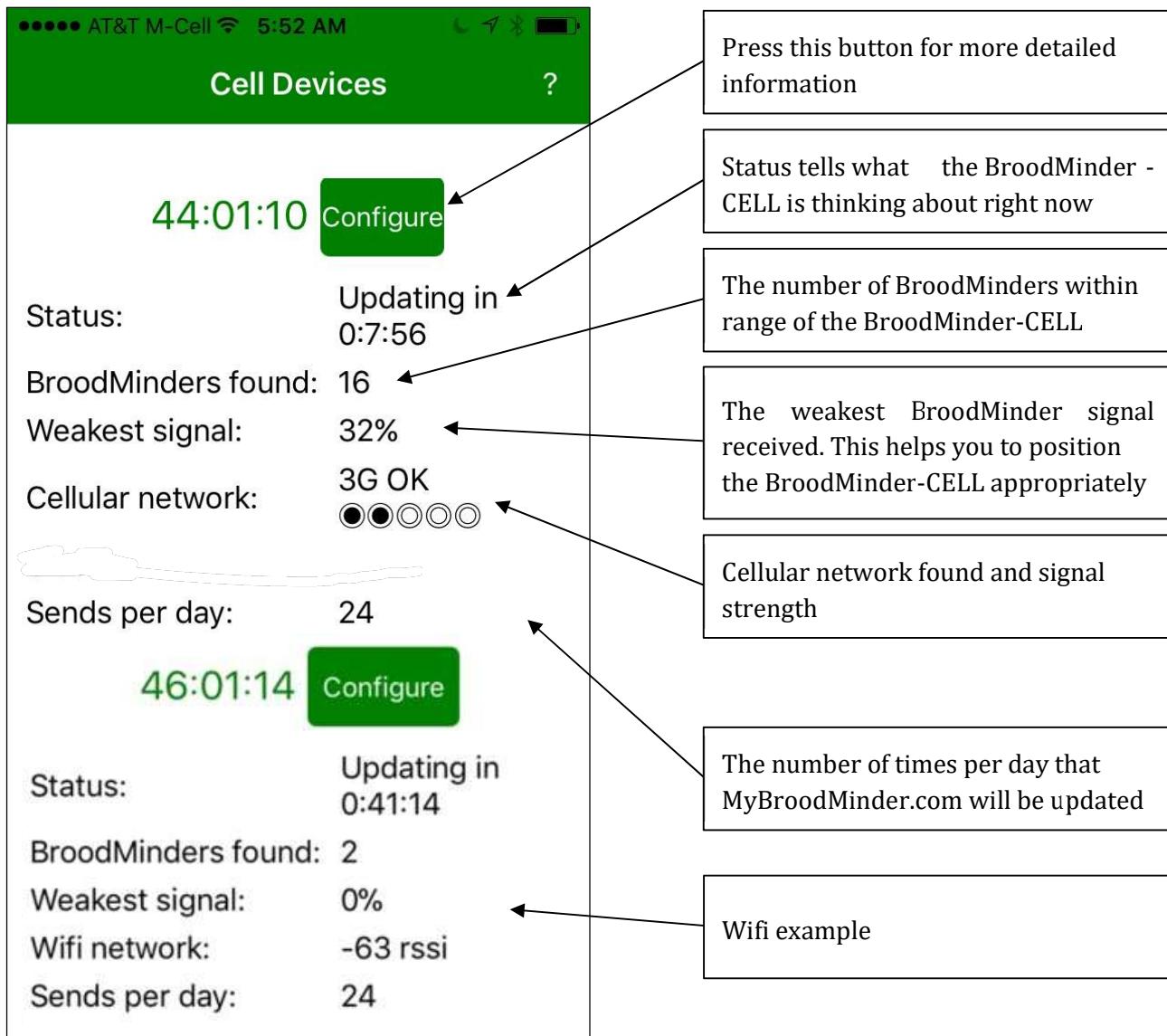
We won't go into a lot of detail in the manual because there is not much to adjust with the app. In fact, the only things that you can adjust is when and how often data is transferred to MyBroodMinder.com. The rest of the app is to aid our support personnel in diagnosing problems.

When you receive your BroodMinder-WIFI/CELL, it should be in Deep Sleep mode in order to conserve the battery during shipment. You will need the BroodMinder-CELL app to wake it up.

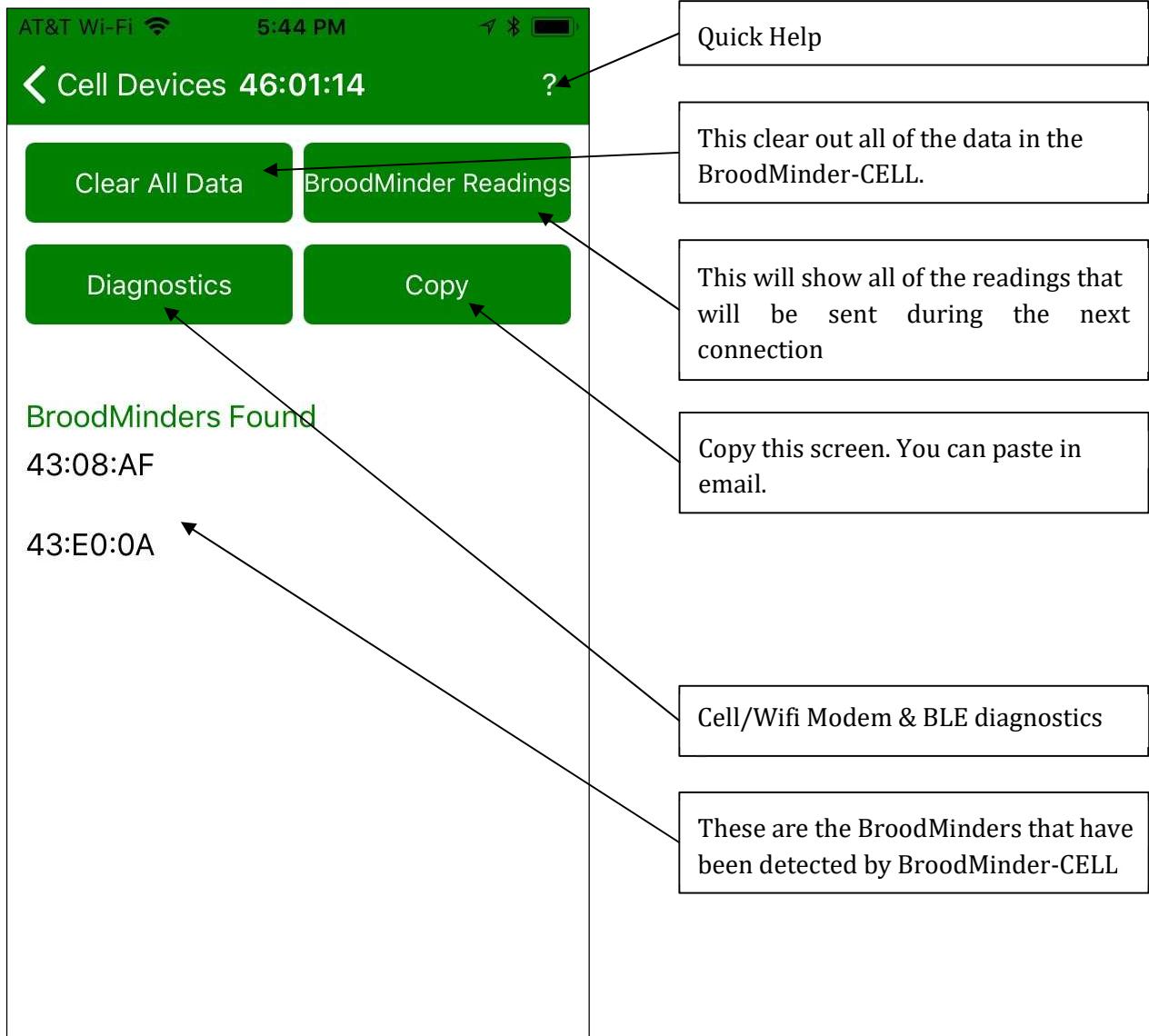
By default, the BroodMinder-WIFI/CELL will transfer data hourly.

9.6

WIFI/CELL App Home Screen

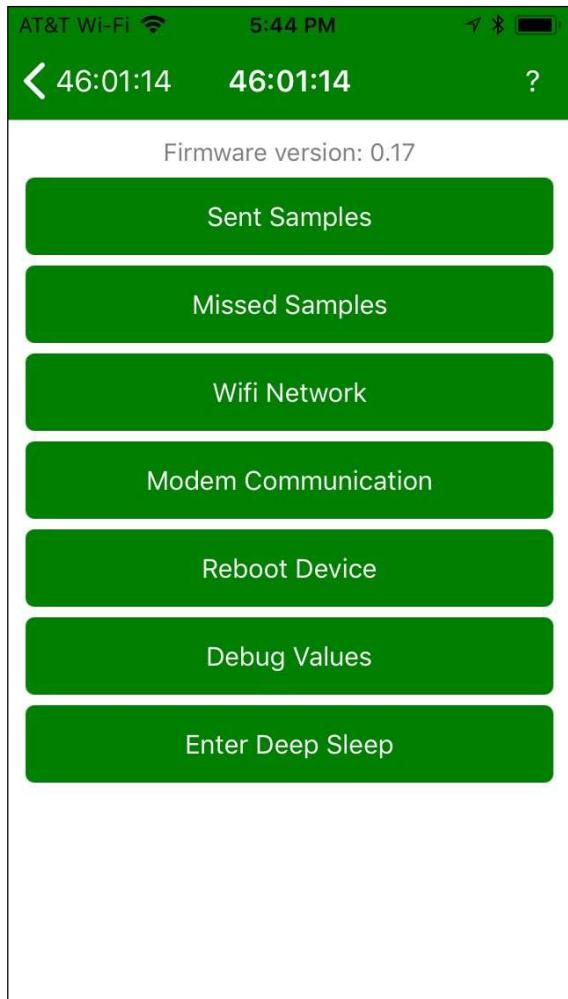


Note: if you left swipe on the screen you can delete unused BroodMinder-WIFI/CELL devices.

9.7**WIFI/CELL App Configure Screen**

9.8

WIFI/CELL App Diagnostics Screen



Firmware Version – This shows the version of firmware in the BroodMinder. (e.g. 0.17)

Sent Samples – The number of samples sent to MyBroodMinder.com

Missed Samples – The number of missed samples as indicated by missing sequence numbers.

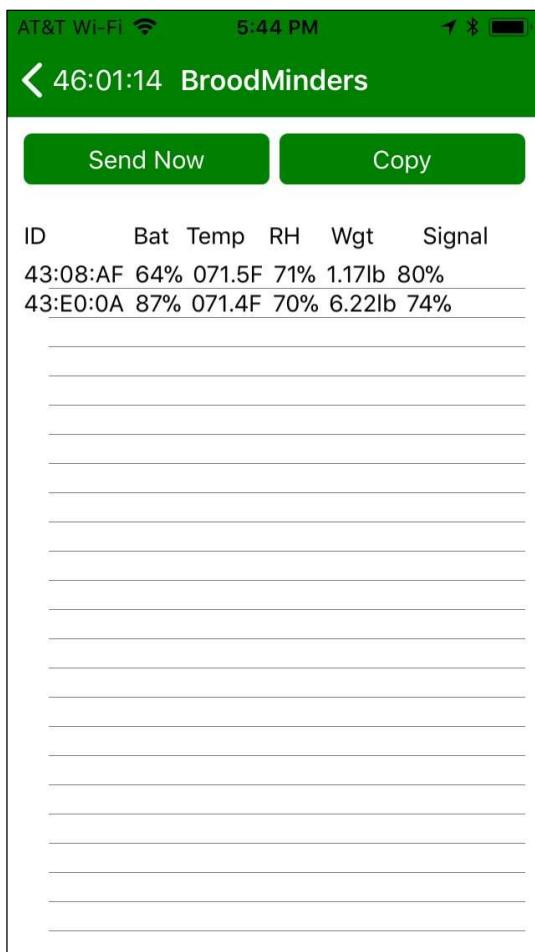
WIFI/CELL Network – WIFI/CELL diagnostics, see next page

Modem Communication – Watch the communications to the Wifi/Cell modem.

Reboot Device – This will restart the BroodMinderWIFI/CELL and purge it of all stored data.

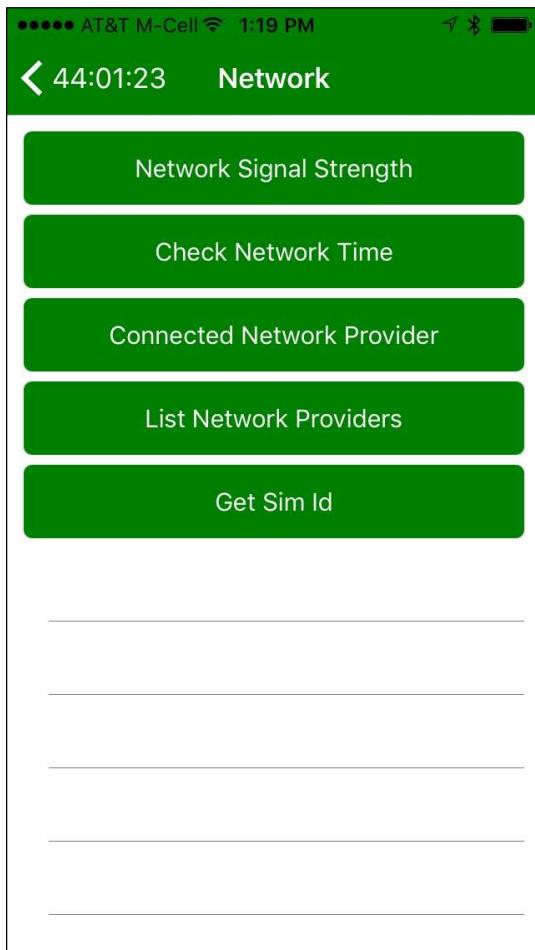
Debug Values – These are Amanda's secret debug values.

Enter Deep Sleep – When we ship the device, we put the -WIFI/CELL in deep sleep to suspend all WiFiular connection and thus save battery life so that when it shows us, it is ready to go.

9.9**WIFI/CELL App WIFI/CELL Network Screen**

Send Now – immediately connect the modem and send this data to MyBroodMinder.com.

Copy – Copy this screen. You can paste into e-mail.

9.10**WIFI/CELL App CELL Network Screen**

NOTE: These are commands to the CELL modem. See the next page for Wifi commands. If the modem is not on, invoking a command will turn it on. Give it a few seconds and then try the command again. The result will be printed at the bottom of the screen.

Network Signal Strength – for reliable operation, it should be 4, (maybe 5) or more.

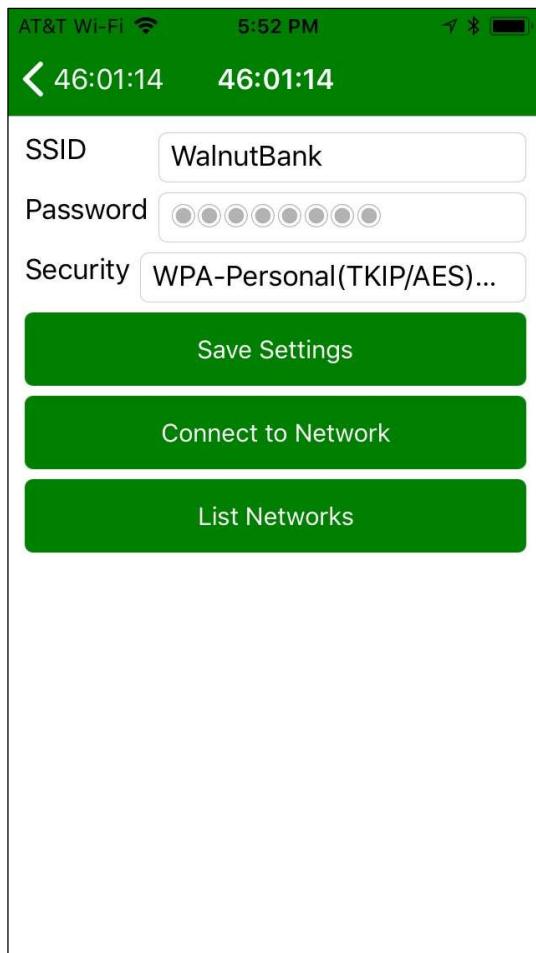
Check Network Time – Time from the WIFI/CELL network

Connected Network Provider – Typically ATT but may be others

List Network Providers – See all the providers in the area.

Get SIM ID – This should match the number stickered inside the enclosure.

9.11 BroodMinder-WIFI/CELL App WIFI/CELL Network Screen



SSID – Make sure that capitalization matches your network name.

Password – Password for your network

Security – Typically WPA-Personal but may be none or

WEP

List Network

9.12 Improving Cell Reception

We ship the cell with an internal (rubber ducky) antenna. If you are on a fringe area, we have found a better antenna that you can order and install. We suggest that you purchase it directly in order to save a few \$\$.

The RDA698/2700-1-SSM antenna from RFMax works very well. It must be installed external to the box so we suggest an extension cable also. Here are the links.

https://rfmax.us/products/rda698-2700-1-ssm-3g-4g-lte-antenna-for-cellular-iot-high-performance-high-efficiency-for-at-t-verizon-sprint-carrier-certification?variant=12357831688263&utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&gclid=EA1alQobChMII9i659XD6QIVzj6tBh3afA0CEAQYAiABEqlXH_D_BwE
and
<https://www.digikey.com/en/products/detail/rf-solutions/CBA-SMAMR-SMAF/5845762>

Here is a picture of an installed antenna.



10 BroodMinder-SubHub

BroodMinder-SubHub

The BroodMinder-SubHub is a Bluetooth range extender and a high speed data vault.



2

BroodMinder-SubHub

The BroodMinder-SubHub is NOT watertight. Install it under cover or inside a solar shield.

La Crosse Technology 925-1418 Sensor Protection Shield with Mount is a good choice. Available on Amazon and many other places for about \$18.

The BroodMinder-SubHub fits perfectly in this enclosure.

You may also mount it under a hive, but this may reduce the range.

A strong zip-lock bag or sealed container are also options.



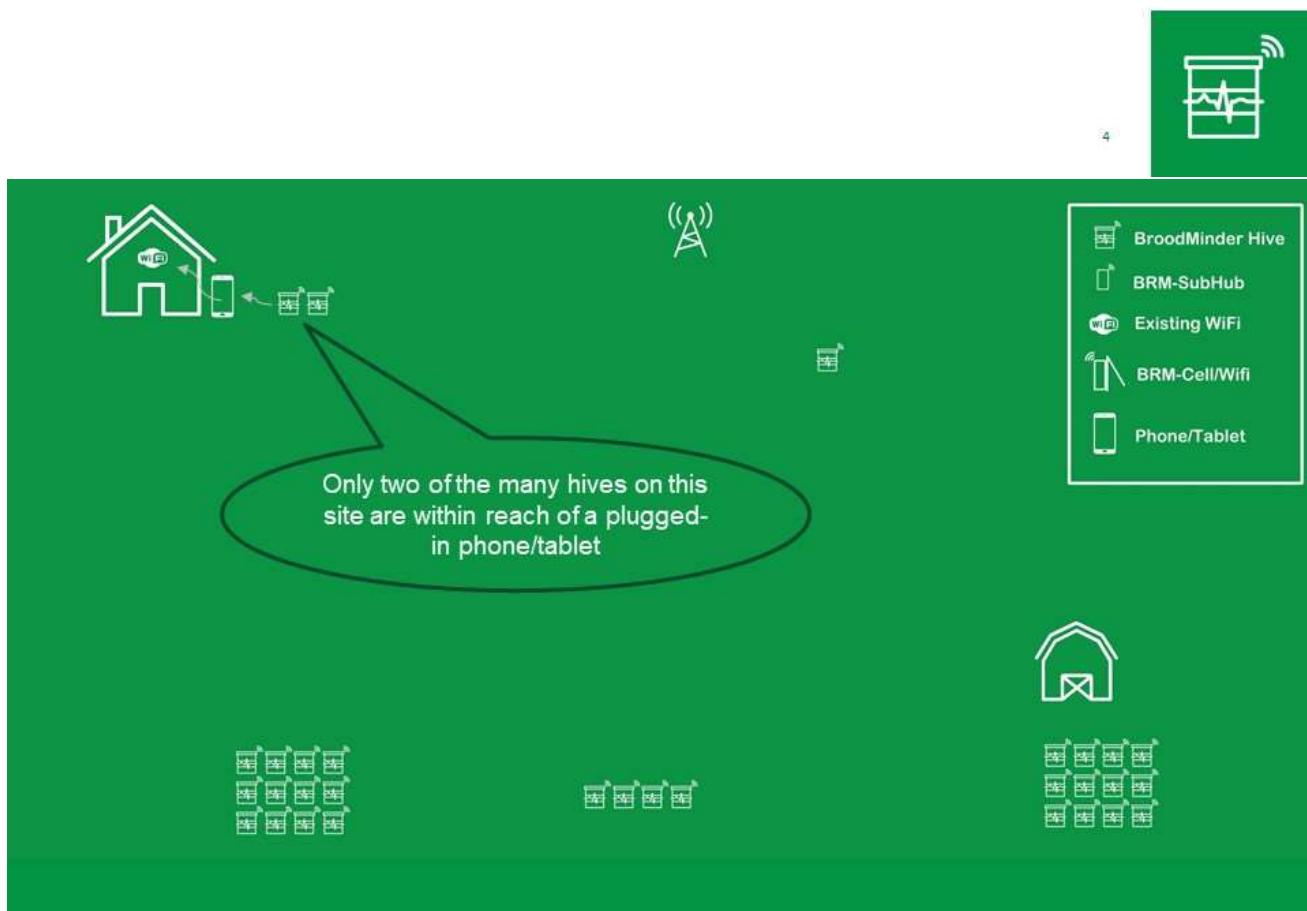
3

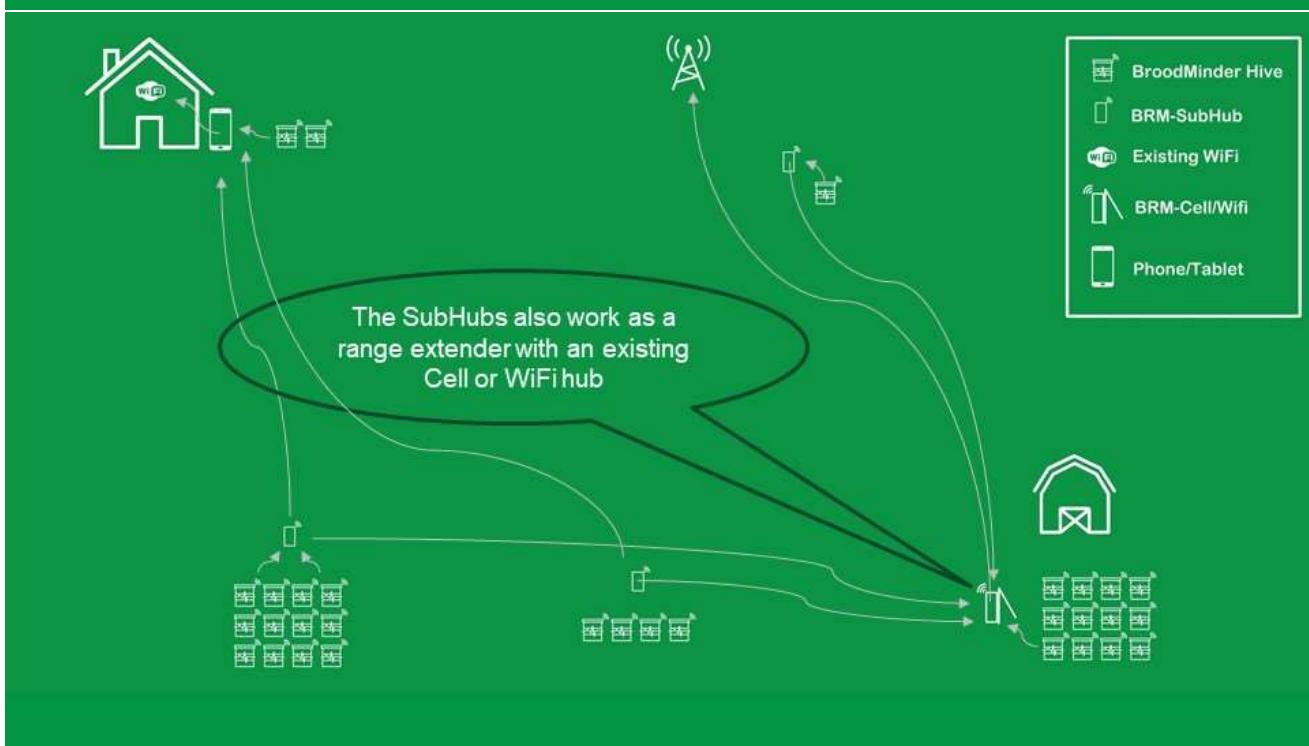
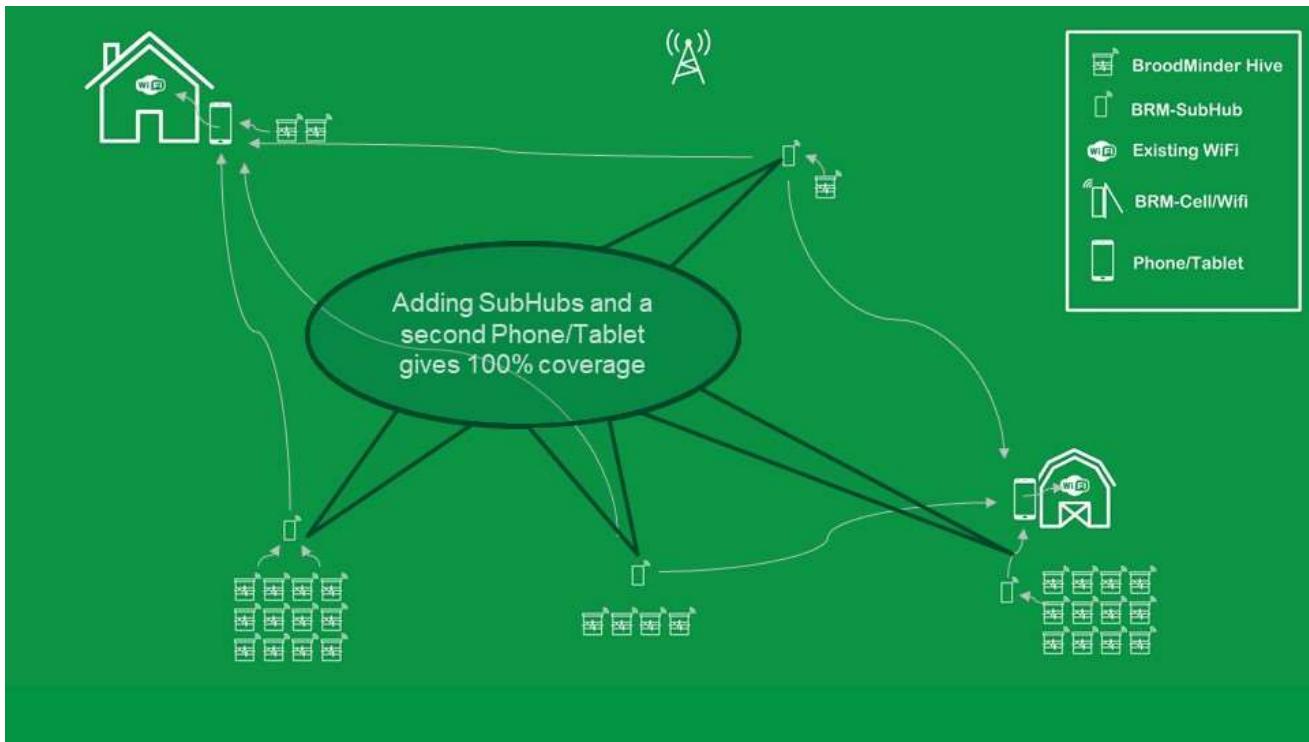
BroodMinder-SubHub

Without CELL or WIFI, this little treasure accomplishes two things:

- 1) It listens for all nearby BroodMinders and rebroadcasts them to a BroodMinder-CELL/WIFI or the Apiary app running in hub mode up to 1000 feet away. This is a very cost-effective way to get real-time data to MyBroodMinder.com.
- 2) The –SubHub stores all of that data locally and can be read by a fast Bluetooth protocol. You'll be able to read a month's worth of 50 devices in about 2 minutes using our forthcoming app.

Let's explore some likely setups for various apiaries.





11 Data Interpretation

In this section, we present some initial findings from Theo's hives. We are still very much in the learning mode and will appreciate your observations shared on the BroodMinder forum at BroodMinder.com.

We are constantly posting updates and videos at BroodMinder.com/pages/videos. Be sure to check there.

These reports were written in the summer of 2016. You can look directly at the data in MyBroodMinder.com by looking in the Claypoint apiary. This is available as a demo apiary.



Reports

- 5.1 Hive Weight Profiles
- 5.2 Swarm Detection with a BroodMinder TH Device in a Top Bar Hive
- 5.3 Avoiding Excessive Heat in the Hive During Summer Months
- 5.4 Detection of Cluster/Queen Movement and Spring Brood Buildup
- 5.5 Pull the Supers When the Dearth Hits
- 5.6 Promising Citizen Science Project Observations
- 5.7 Using BroodMinder Data to Optimize Hive Preparation for Winter

11.1 Hive Weight Profiles

By Ray Walker, May 2016

Hive weight trend charts contain repetitive shapes or profiles, depending on the season, floral resources, rainfall, temperature, humidity and other variables. By studying weight profiles, beekeepers can learn more about their apiary's foraging resources, colony's status, health and performance. Daily, weekly and monthly profiles of each colony can be compared with "typical" weight profiles for an apiary's local environment (based on historical scale trend data).

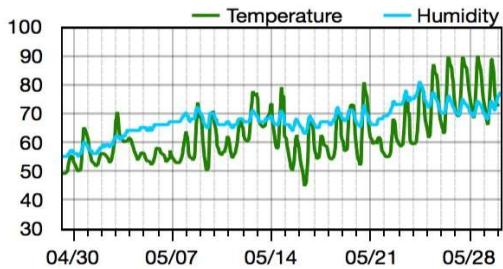
Hive weight trend data can be used to estimate bee populations, nectar collection and consumption rates, accumulated foraging hours, foraging performance and other colony characteristics.

During the past 3 years, I've been applying a variety of electronic hive scale systems to study and compile a library of "typical" weight profiles for my backyard apiary. Since the end of April, I've been using a BroodMinder hive scale prototype.

Monthly Profiles

The main nectar flows in northern Delaware occur during the months of May and June (typically about 50 days duration). For an overwintered nucleus colony to exploit the main flow, it's population must increase rapidly in March and April – peaking just before the flow begins.

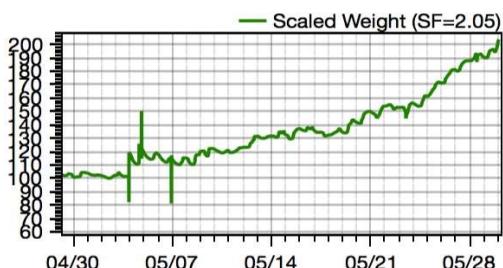
Weather conditions have a big impact on how well the colony's foraging population collects nectar from the variety of available blooms. Flying conditions (rain, wind, temperature, humidity, etc.) must be ideal when blooms are pervasive to maximize monthly foraging rate. By examining the shapes of the monthly profiles and observing when specific blooms occur, the major nectar resources for the apiary location can be determined (and compared year-to-year).



Monthly Trend Chart

Early May's cooler temperatures (50-60's) and rain limited foraging rates.

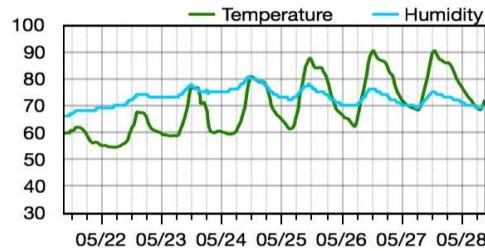
Increased daytime temperatures (70-80's) and less rainfall improved flying conditions during the end of the month. Best foraging rates were obtained when the bloom's nectary had warm day-time and cool night-time temperature cycles. The colony foraged ~90 pounds of nectar in the month (~3 pounds per day). Black locust and tulip-tree were both blooming during the end of May.



Weekly Profiles

By charting the week of maximum nectar flow, a series of repetitive profiles show routine day-time weight gains as nectar is collected then night-time weight losses as nectar is evaporated and the colony is consumes nectar. By comparing this season's maximum weekly profile to previous season's maximum weekly profile, a relative comparison of colony foraging performance is obtained.

Weekly profiles of maximum weight gains can be added to a library of trend charts for evaluating an apiary's foraging capability to other apiary location's capability.



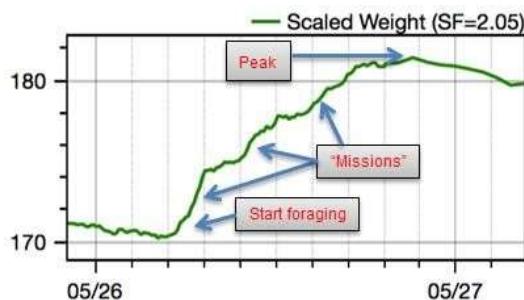
Weekly Trend Chart

Increased average temperature cycles with wider spreads in day & night temperatures as well as stable/lowest humidity produced the maximum nectar flow.

The average foraging rate for the best four days was about 10 pounds per day. This rate compares to previous year's foraging rates. However, the maximum nectar flow duration varies from year to year.

Daily Profiles

By charting the day(s) of maximum nectar flow, the typical daily routine of the colony can be studied. The colony's initial foraging flights occur at the same time each morning. Several foraging "missions" can be observed as the weight increases at various rates (depending on which blooms are available at different times of the day). Towards evening, the foraging force returns to the hive and the weight peaks for the day. During the night-time, moisture from the nectar is evaporated and bees consume nectar.



Daily Trend Chart

Daily profiles indicate which portions of the day-time hours the foragers are most active – providing the beekeeper insight when hive inspections would be most disruptive.

11.2 Swarm Detection with a BroodMinder TH Device in a Top Bar Hive

By Theo Hartmann, June 2016

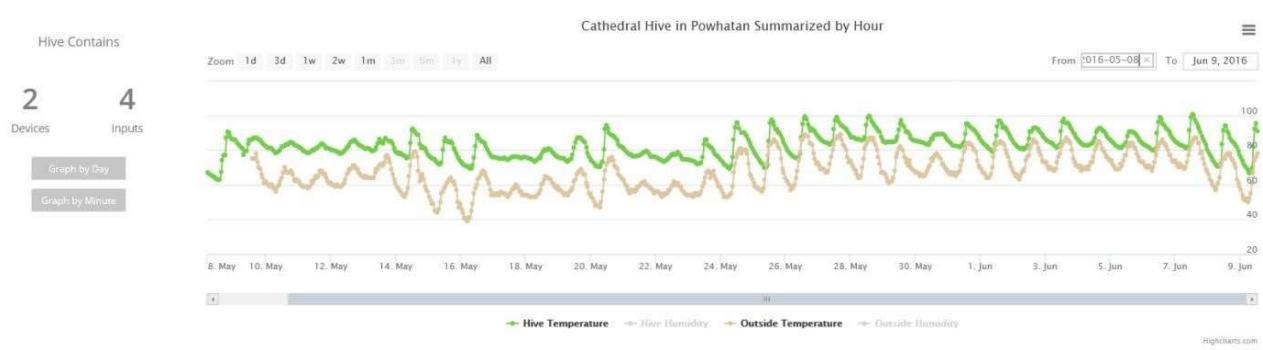
This is a case where a BroodMinder TH device in a top bar hive was helpful in tracking the progress of the

colony in a remote hive. The BroodMinder Temperature and Humidity Device was installed in a recess in the end board.

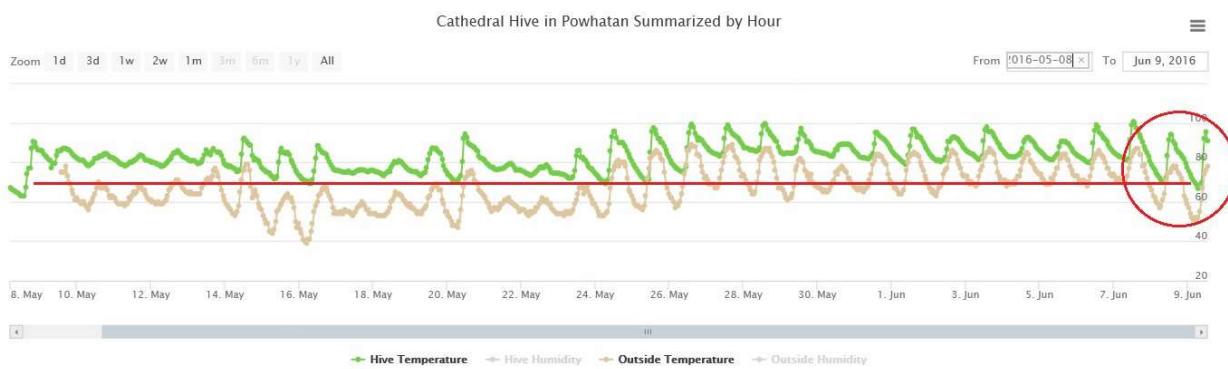
The colony was installed from a swarm into this hive and then moved to a remote location. My remote agent was kind enough to obtain the data from the BM device on a daily basis and upload it to MyBroodMinder.com



Below is a screen shot from MyBroodMinder.com showing the entire time period since the colony was in this hive:



Because of the nature of this hive and the location of the device at one end of the hive, it is not expected that the measured hive temperature stays at one level as it is the case in a Langstroth hive. What caught my eye were the last two days where the temperature dropped to the lowest level since the bees were introduced into this hive.



Granted, ambient temperature dropped, too but going back to May 16th, ambient temperatures were lower back then at the same or higher hive temperatures. I concluded from this that the colony had swarmed because lower temperature means less heat generated means less bees inside the

hive to generate heat and keep the hive temperature at a higher level at night. I went there for an inspection and this is what I found:



Few bees on the comb and two open swarm cells at the bottom of two combs.



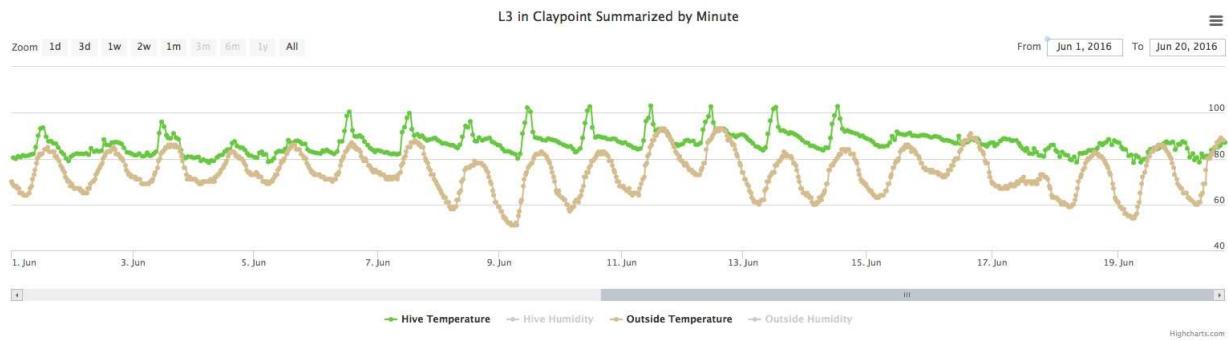
Clearly, a lot of bees have moved out to find a home elsewhere. This is not necessarily a bad thing because the bees which are left behind have ample resources in the hive (pollen, nectar, honey). The natural process of queen replacement has already begun since two new queens have hatched as evident from the open swarm cells. Also, the mite count in this hive will drop since the brood cycle has been interrupted.

The BroodMinder TH device together with a remote agent and MyBroodMinder.com proved to be effective tools to monitor this hive in a remote location.

11.3 Avoiding Excessive Heat in the Hive During Summer Months

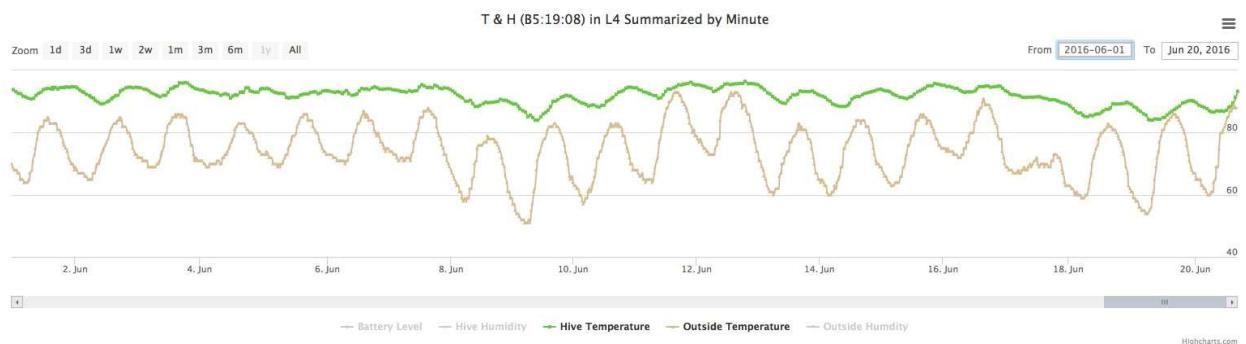
By Theo Hartmann, June 2016

This document describes findings on two hives which were started this spring. One was from package and the other one was a small swarm. Both colonies were introduced into Langstroth 8-frame deep box hives and were developing at a more or less identical pace and both hives were expanded to two brood boxes per hive pretty quickly. The BroodMinder Temperature and Humidity devices (TH) were placed on top of the upper brood box. There is no super above that, just the inner and outer covers. Temperature peaks started to appear on June 6th at times when the mid-day sun was hitting the outer cover of the hives as can be seen on the chart below.



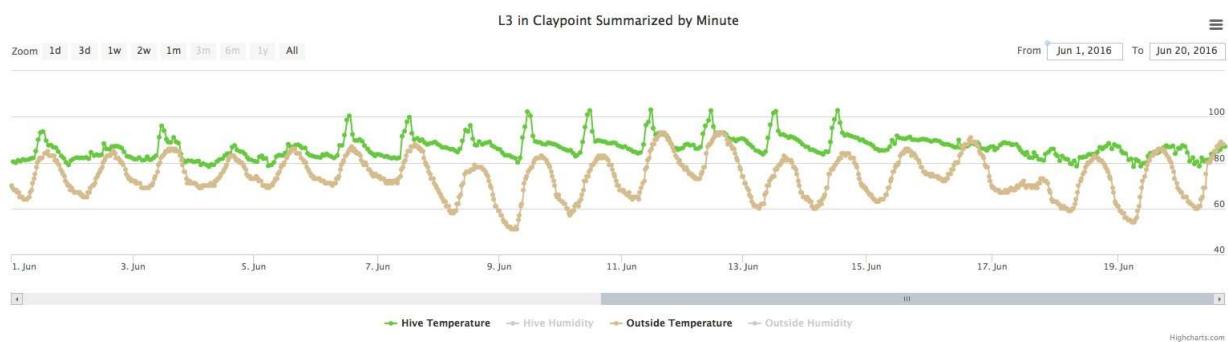
The peaks would reach 100+F almost every day between June 6th and June 15th. At times, these temperatures were 20F above ambient temperature and clearly, this must have put unnecessary stress on the bees. The hives essentially became greenhouses. This was surprising because both hives have screened bottom boards and screened and ventilated inner covers for the summer months. A 2" high density Styrofoam insulation was placed on top of the screened and ventilated inner cover on the starter hives on June 15th. This resulted in elimination of the temperature peaks.

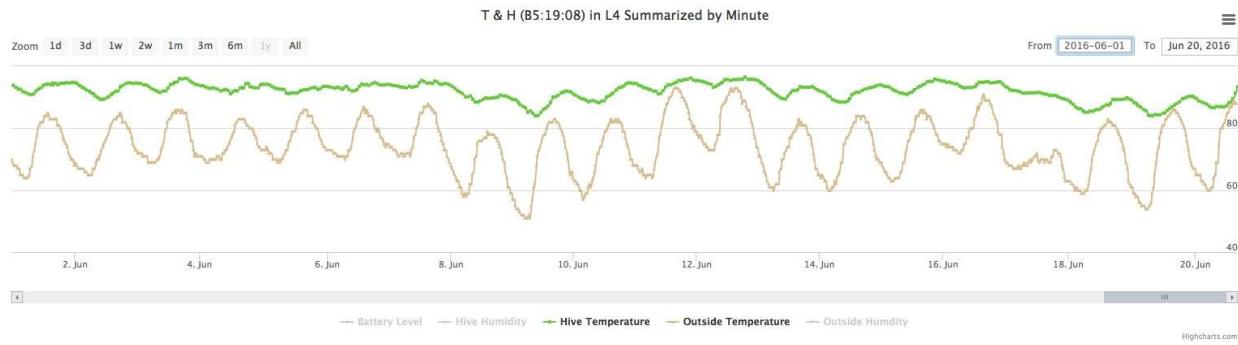
For comparison, here is a temperature profile from a mature hive with honey supers:



No peaks and a more mellow change in temperature.

These same to charts are shown again below and a few additional things can be concluded from them:





Notice that the difference between the hive temperature and ambient temperature generally is smaller for the starter hive (top) compared to the established hive (bottom). The reason is the number of bees in the hive. The starter colony is affected much more by changes in ambient temperature than the established colony.

The more gradual change in temperature on the established hive can be attributed to the fact that there are two honey supers above the TH device. These supers shield the brood nest from the temperature peaks seen in the hive which does not have any supers. The very top of the hive with the supers sees the same temperature peaks observed in the starter hives but these peaks never make it down to the TH device.

This discovery and subsequent corrective action was only possible because:

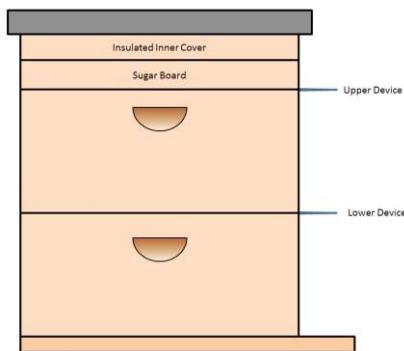
- BroodMinder TH devices are installed
- Data are collected on an hourly interval
- Plots of the data available instantly on MyBroodMinder.com
- Local weather data were added by MyBroodMinder.com for reference

The cost to do this analysis is the purchase price of the BroodMinder device, nothing more. All the other data and analysis tools are available to BroodMinder users for free.

11.4 Detection of Cluster/Queen Movement and Spring Brood Buildup

By Theo Hartmann, June 2016

This example shows how multiple BroodMinder devices in the same hive can be used to detect a number of things without actually opening the hive for physical inspection.

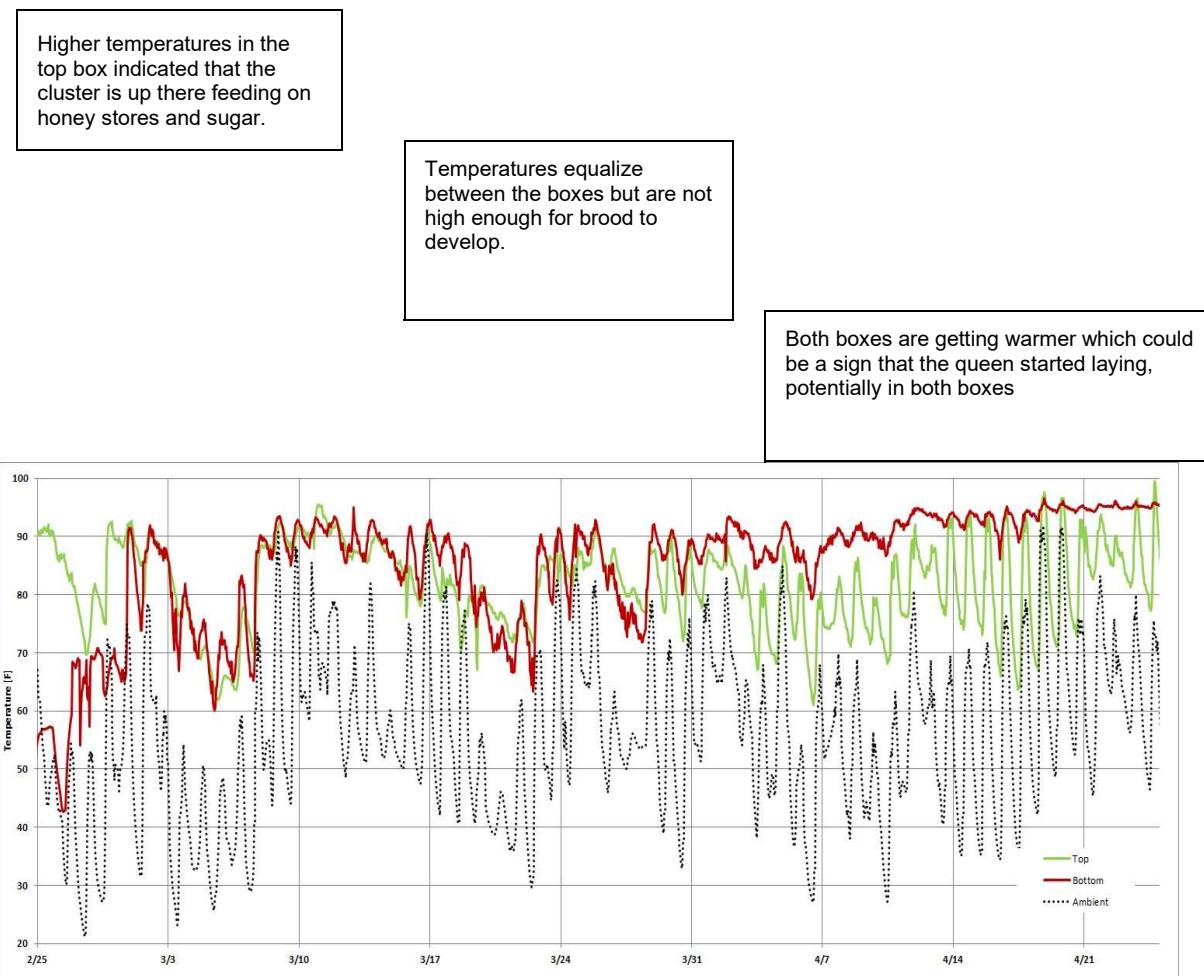


The setup is a 8-frame Langstorth hive with two deep brood boxes, screened (but closed) bottom board, sugar board with top entrance above the top box, insulated inner cover and outer cover.

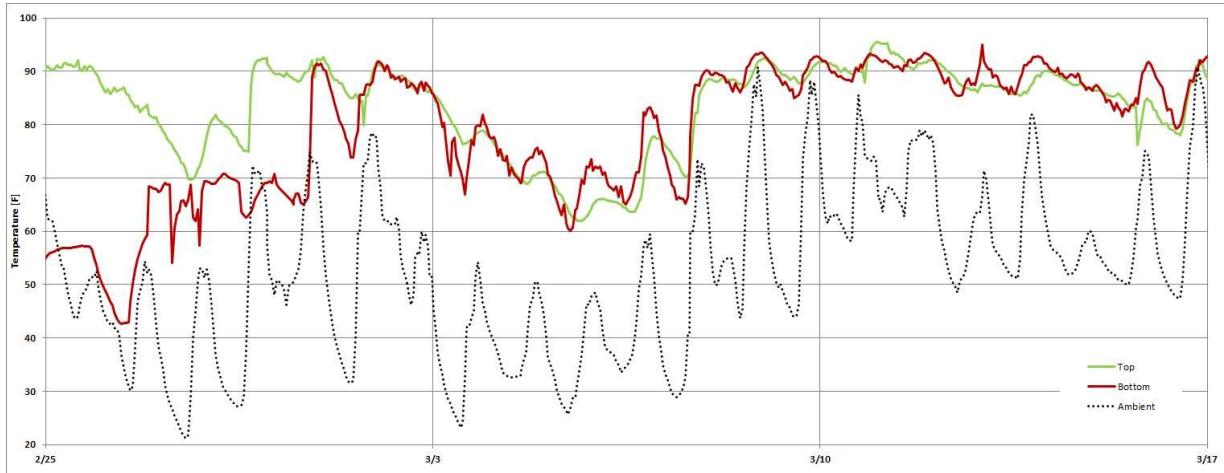
This was the configuration of the hive going into the winter. One BroodMinder TH device was installed between the top brood box and the sugar board and second BroodMinder T device was installed between the two brood boxes. MyBroodMinder.com was still in it's infancy at the time the test went underway and for this reason; another BroodMinder TH device was placed outside in a

protected area to gather ambient conditions.

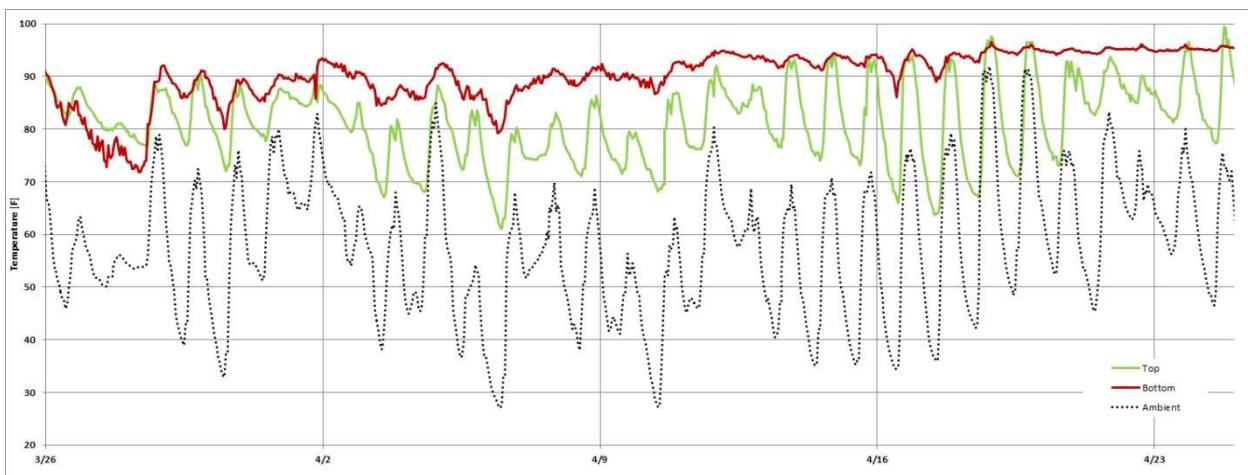
Here is an overview of the data collected. The green line represents the temperature above the top box, the red line the temperature of the bottom box and the dotted line is the ambient temperature.



This chart is broken down in sections for a closer look at the data and corresponding analysis.



← → ← → ← →



← →

Here a switch happens and the
begins to get up there.

that the queen has moved down
into the lower box.

← →

The bottom box is now kept at 90+F. Perfect conditions for brood to develop. The top box follows the ambient temperature swings. Not warmer than the top indication many bees up there.

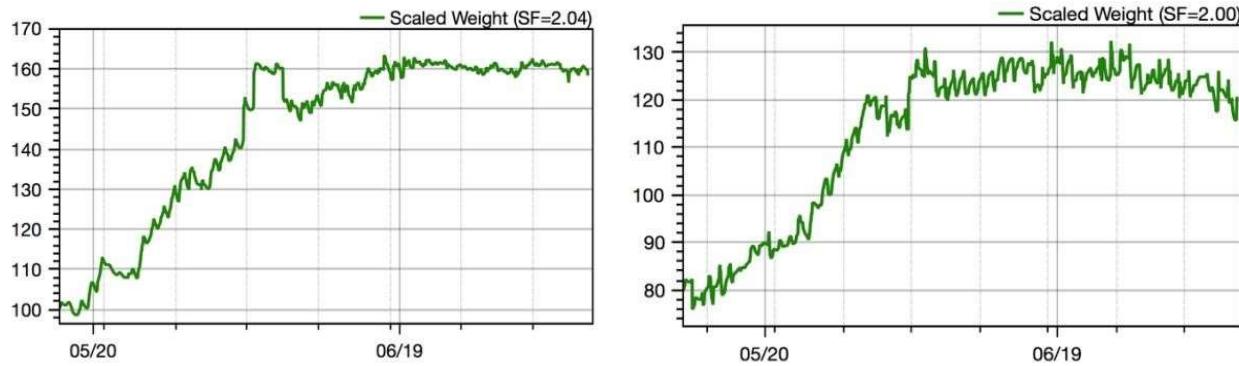
These data indicate a healthy hive and a subsequent inspection revealed that this is in fact the case and the colony is ready for the nectar flow.

11.5 Pull the Supers When the Dearth Hits

By Theo Hartmann, July 2016

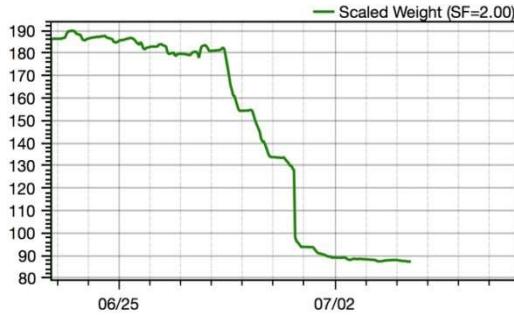
Every spring it is a pleasure for beekeepers to watch the bees going on their daily excursions and bringing back pollen and nectar. As we all know, this is to both feed the larva and also to produce honey stores for the next winter for the colony to feed on. Having the hive weight available is a great

help in making the decision when to harvest honey from the hive. There is a spring nectar flow which can produce large amounts of honey in a short time as seen in the charts copied from the mobile app below. The hive weight increased rapidly during the second part of May.



There are the daily ripples caused by the bees bringing in nectar during the day causing weight increase. Then, during the night, bees are busy reducing the water content and the hive weight decreases. There also are the larger jumps where the beekeeper added or removed frames or supers.

Longer term, the weight increase clearly ceased middle of June. The hive on the right even shows a decreasing trend in hive weight. This is a clear sign that the dearth has set in and there is not enough natural food available. The bees begin to consume the honey stores or ever worse, robbers grab what they can get. Below is a chart of such a situation.



The hive weighed a whopping 185lb when the dearth hit. Then, on June 28th the weight started to drop like a rock. It stabilized at about 155lb the next night. 30lb lost. The following day, again massive weight loss took place down to 133lb, another 22lb lost. The weight loss continued the following day until the beekeeper removed the honey supers and got the hive under control. The robbers knew exactly what they were doing after they discovered the venerable hive.

Take out what we can the first day, take a rest and then go back for more, day after day. There was no other hive with a scale nearby otherwise we would probably see where the loot went!

The above makes it clear that honey supers should be removed when the dearth hits, latest when the hive weight starts to decline. The BroodMinder-W scale is of great help to time the removal of the honey super(s). This will not only mitigate the robbing risk but also increases the bee density in the hive and the ability for the colony to defend their hive. It is also the time to install an entrance reducer and/or screens and close off any top entrances. With these measures, the robbing risk is minimized.

Here is an additional tip for BroodMinder-W users:

Removal of a full honey super results in a reduction of the hive weight by 40-60lbs which is a significant portion of the total hive weight. This is an excellent opportunity to get information for adjustment of the hive scale factor in the mobile app. Therefore, weigh everything you have removed from the hive as

accurate as you can with a bathroom scale, a postal scale etc. and record it. Visit the BroodMinder forum for advice on how to adjust the hive scale factor.

Getting back to the dearth, food is scarce for the bees during the dearth period and they may require supplemental feeding. Knowing the hive weight of established colonies is essential to determine if it is necessary or not. First year colonies require feeding irrespective of the hive weight.

On established colonies I would recommend to start feeding if the hive weight starts to drop. This will reduce stress in the colony since the food is readily available inside the hive. This is substitute food for the lack of nectar out there. Stop feeding when the hive weight increases. The bees have found another nectar flow.

When feeding in the summer I use 2:1 Sugar syrup. My thought is that a 1:1 is good for spring to get the queen thinking that there is a nectar flow and she will lay more eggs. In the summer and after the spring nectar flow is over, the bees are busy making honey out of the nectar they collected. During this process, the bees remove vast amounts of water from the honey before they can apply their seal of approval and cap the cells with an airtight wax cap. The last thing the beekeeper wants to do is give them more water. So, thicker syrup is better in the heat of the summer. Hint: Add 2 tbsp per gallon (1/2 tbsp per quart) of apple cider vinegar to the syrup. This lowers the PH to the level of honey and prevents black mold.

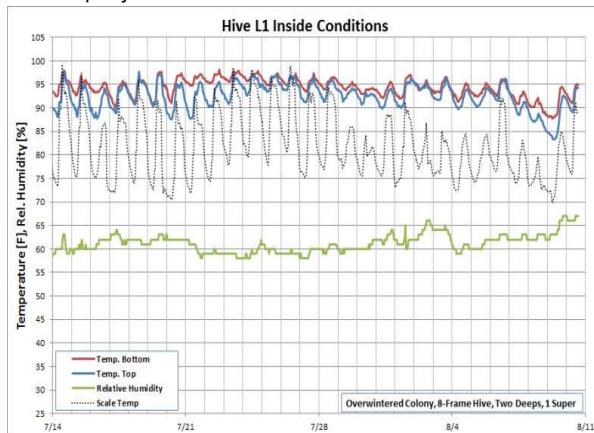
11.6 Promising Citizen Science Project Observations

By Theo Hartmann, August 2016

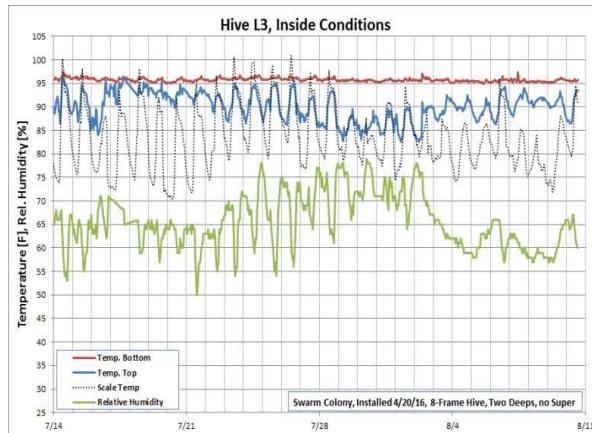
As an early adopter of the Citizen Science (CS) Project, I have seven hives set up in this configuration and data are collected on all of them on an hourly basis. This paper illustrates the power of this setup where multiple hives can be compared on an even basis to detect anomalies and define resulting actions.

True to their name, BroodMinder devices detect the presence of brood: The measured temperatures show that the bees hold the nest temperature at a constant 95-96°F when good brood is present. The charts below show both, the superb job the bees are doing raising babies and also the quality of the BM devices showing exact temperatures.

Hive with spotty brood in the bottom box

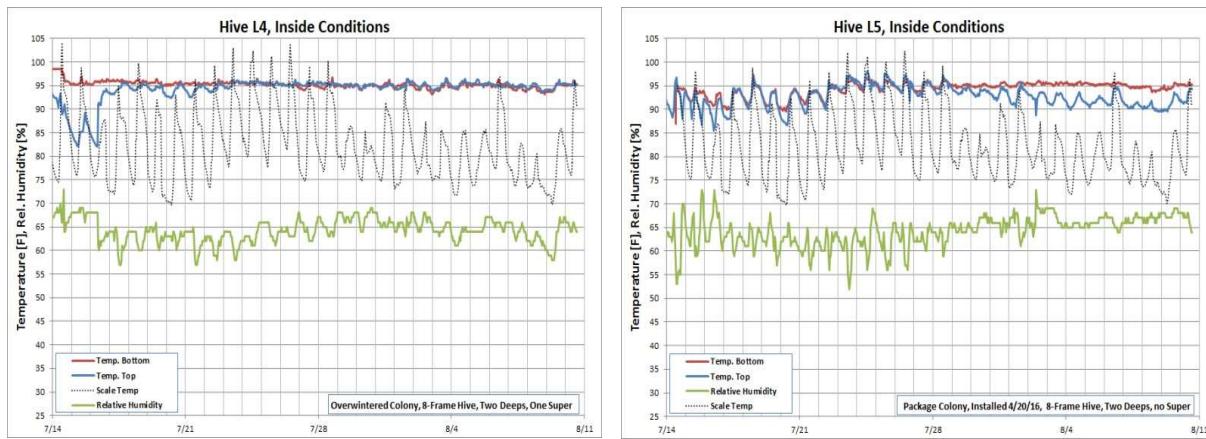


Hive with 5+ frames of solid brood in the bottom box



Hive with 5+ frames of brood in both brood boxes

Requeened hive finally coming "on-line" properly



11.7 Using BroodMinder Data to Optimize Hive Preparation for Winter

By Theo Hartmann, October 2016

This is the time of year when beekeepers are preparing their hives for the winter season. There are a few essential steps which typically take place:

- 1) Ensure adequate resource levels in the hives to be overwintered
- 2) Ensure that each hive has a laying queen and the brood nest in the bottom box and resources around and above it.
- 3) Consolidate weak hives for the winter and split them in the spring

Below are a few examples from my apiary showing how BroodMinder data help to plan the hive inspections and hive configuration changes to accomplish the above goals. The apiary discussed here has six active hives next to each other. Hive 2 is a control hive without bees. All hives are configured the same with two 8-frame deep boxes. Supers have been removed earlier and all colonies are fed with Boardman style entrance feeders. The combined weight of each hive hardware is just under 50lbs.

1) Using Measured Hive Weight to Determine Resource Allocation

The goal is to have about 60lb of resources in each hive going into the winter. This consists of capped and uncapped honey, pollen and supplemental food as needed. The situation as found after the summer is as follows:

Hive	#	1	3	4	5	6	7
Gross Weight	lb	100	130	70	100	80	80
Hardware	lb	50	50	50	50	50	50
Net Weight	lb	50	80	20	50	30	30
Over/Under	lb	(10)	20	(40)	(10)	(30)	(30)

Only hive 3 fulfills the 60lb resource requirement. All others need help. It was decided to remove some of the excess honey from hive 3 (4 frames) and put it in hive 4 (2 frames), hive 6 (1 frame) and hive 7 (1 frame). This resulted in this revised weight distribution:

Hive	#	1	3	4	5	6	7
Gross Weight	lb	100	110	85	100	85	90

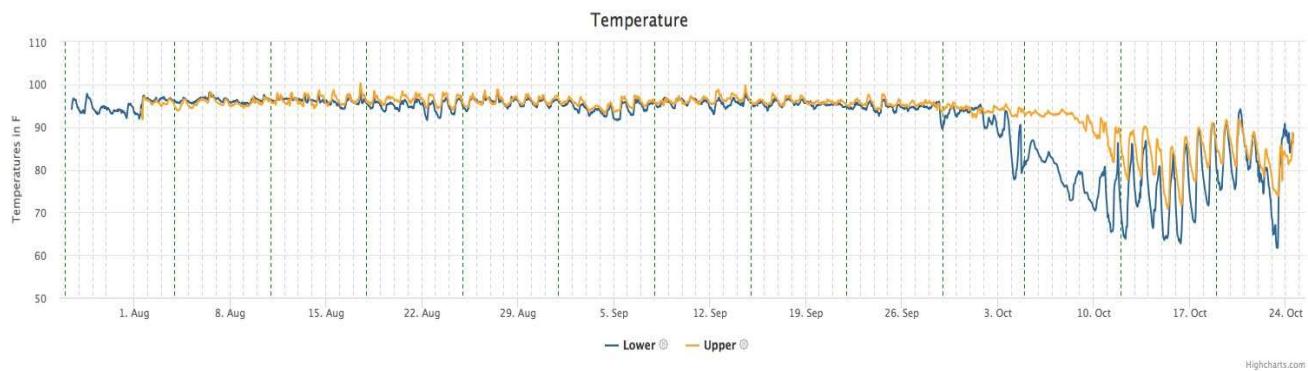
Hardware	lb	50	50	50	50	50	50
Net Weight	lb	50	60	35	50	35	40
Over/Under	lb	(10)	0	(25)	(10)	(25)	(20)

Most hives are still short of the 60lb resource goal.

2) Using Brood Box Temperature to Detect Queen Presence and Brood Nest Location

Hive temperatures indicate that the queens have slowed down their laying rates, which is normal for this time of year.

Below is an example to show this condition. The bee colony kept both brood boxes at around 96F until the end of September. Then the bottom box dropped off followed by the upper one. This would indicate that the queen stopped laying in the bottom box first followed by the top one. Beekeepers who use Oxalic acid to reduce the Varroah mite count in their hives can use this temperature drop as a trigger to start treating their hives because from that point forward there will be a minimal number of capped brood cells in the hive.



Taking a snapshot of the temperature levels before the queen laying rate started to decrease showed the following:

Hive	#	1	3	4	5	6	7
Upper Temp	F	<90	<90	>90	<90	>90	<90
Lower Temp	F	<90	>90	>90	>90	<90	>90

This was around the beginning of October

90F was taken as a threshold to determine brood/queen presence. The hive inspections confirmed open brood presence in the boxes indicated in green above and no or very little capped brood in the boxes shown in red.

3) Hive Reconfiguration and Consolidation

The following actions will be taken or were taken already:

Hive 1: Queenless hive. The two boxes will be combined with hives 4 and 6. Hive 1 will be closed for the winter.

Hive 3: No configuration change

Hive 4: Combine brood from both boxes to the bottom box. This creates a smaller brood location, easier to keep warm

Hive 5: No configuration change

Hive 6: Move brood to the bottom box

Hive 7: No configuration change

All live hives will get a 20lb sugar board with top entrance. This will take care of the missing resources. They also get a 2" Styrofoam hive top insulation. Bottom entrances will be reduced to $\frac{3}{4}$ " width, screened bottom boards will be closed and the Boardman entrance feeders will be removed.

Good night girls. Sleep well and see you in the spring!

All detailed charts from these hives can be viewed in the demo account of MyBroodMinder.com, use link below

<http://app.MyBroodMinder.com/apiary/detail/bEz8YnexZpjyiMd6s7ISFvqGVKkaIAp5>

12 BroodMinder-DIY

12.1 Overview

The DIY is the raw circuit board that we use in the BroodMinder-W2. With it you can build your own scale and it will work with all of the standard BroodMinder software. We hope that this board allows many home crafters to create wonderful devices to monitor the hives. Be sure to share your designs with us and we will share them with the world.

- Proven design
- 5-year battery life
- **No software to write**
- Works with most standard load cells
- Integrates into the vast BroodMinder ecosystem
- Utilizes a 4 channel 24-bit load cell IC (TI ADS1234)
- Data is available by BLE advertising
- Stored data is readable by BroodMinder apps

In order to utilize the BroodMinder-DIY, you will need to add your own load cells. The board should work with most load cell available, but beware, there are many bad choices. For example, if you try to use normal “bathroom scales” load cells, you will find that they have tremendous “creep”. Under load, the output values can change 50% overnight.

Theo and Lorenzo have also created some examples which we have included in our [public dropbox folder](https://www.dropbox.com/sh/nmhfpuy9s5x086f/AADkyDlcJfsqsd9yUJ-7Lr6a?dl=0) (<https://www.dropbox.com/sh/nmhfpuy9s5x086f/AADkyDlcJfsqsd9yUJ-7Lr6a?dl=0>). We will be posting many details including bills of materials and 3d models.

The metal hive stand is available from BetterBee: <https://www.betterbee.com/wooden-hive-equipment-10-frame/LYHE4033.asp>

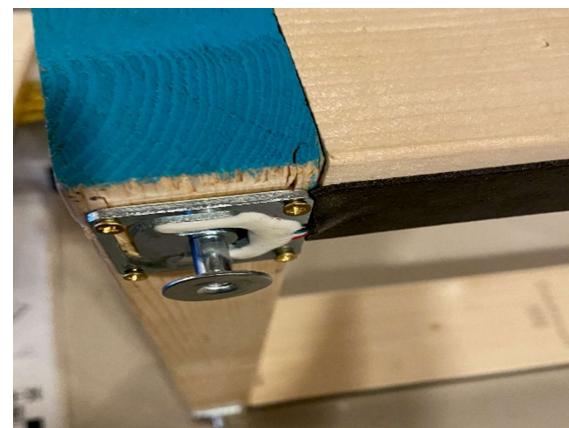
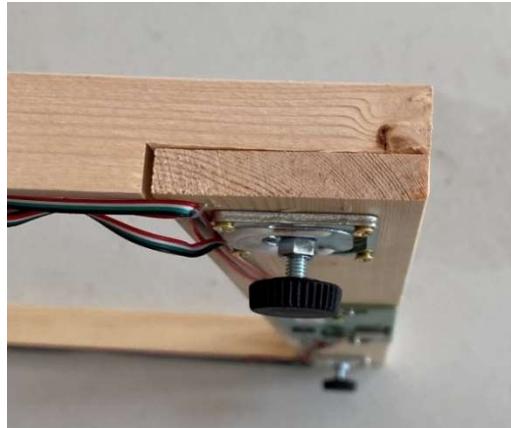


Here is another idea based on our BroodMinder-W2 scale taken to a minimal implementation using 5mm feet. Be sure to seal the electronics against weather if you decide to go this route.

(https://www.amazon.com/gp/product/B081TH35F9/ref=ppx_yo_dt_b_asin_title_o05_s00?ie=UTF8&psc=1)

We've now built a couple of versions of these and they work out very well and are very simple.

Qty	Item	Notes
1	BroodMinder-DIY (BRM-58) circuit board	BroodMinder.com
1	4x 50KG Load cells	BroodMinder.com
1	Box – Hammond Mfg 1554C	Digikey.com
6 ft	3M 4726 foam tape	Amazon.com
6 ft	2x4	
4	Feet with 5mm post - KNULED Adjustable Foot Screw M4 M5 M6 Bolt KNOB Screw Plastic Steel FEET 4MM 5MM 6MM (M5x10)	Amazon (\$1.00 each)
10	Wood Screws to connect 2x4s together and mount box	
16	#3 wood screws to attach sensors	



Alternative feet are below. Cheaper, but you have to order 100 (\$12.00). Weld nuts are pictured above right.

4	Weld Nuts p/n 90596A115 Steel Round-Base Weld Nut, Zinc-Plated, 10-32 Thread Size, 45/64" Diameter x 3/64" Thick Base	McMaster-Carr (100 for \$12.00)
4	Zinc-Plated Steel Pan Head Phillips Screw, 10-32 Thread, 1/2" Long	



Cut the 2x4s to length
2 at 16-3/4"
2 at 16-1/4"

Drill 1-1/8" holes deep enough to clear the nuts holding the feet.

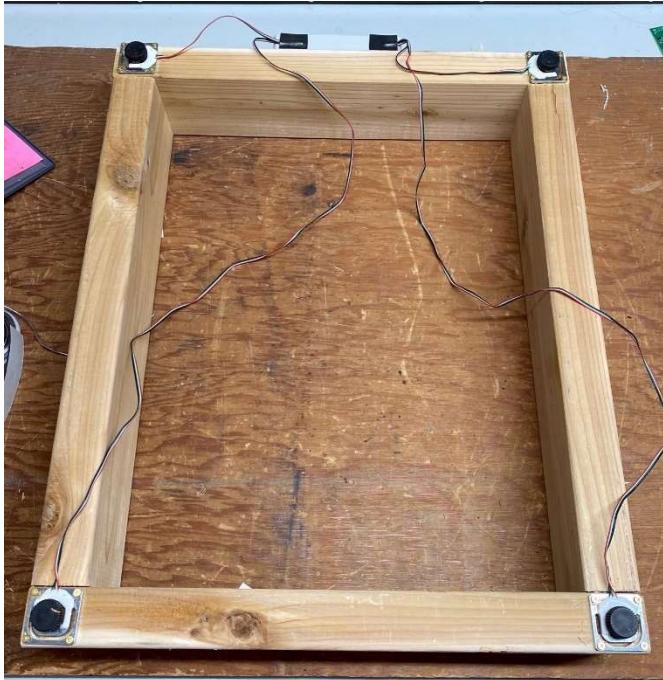


Place the 2x4s on a flat surface and screw them together.



Mount the electronics box.

NOTE: After doing this, I believe it is better to mount the box on the INSIDE. That way the temperature will not be affected by the sun and it is a little more less susceptible to damage.



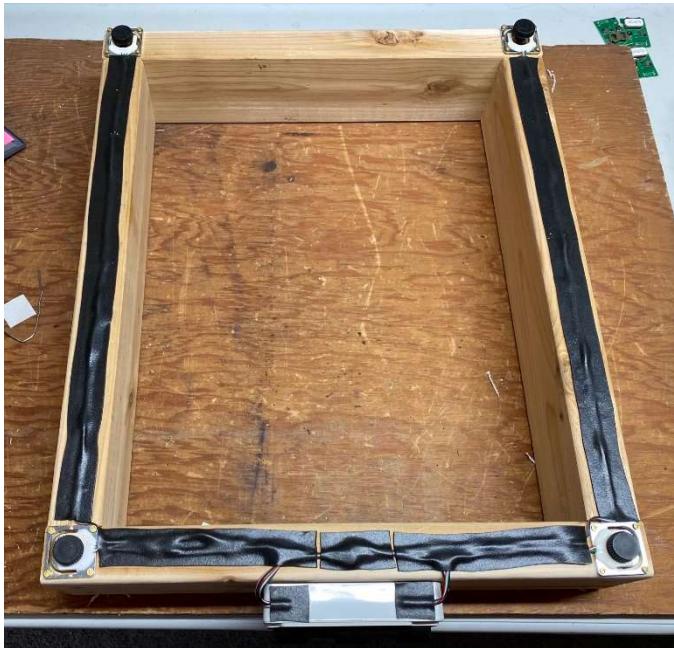
Mount the sensors using 4 screws each.

NOTE: Leave the screws slightly loose so that they do not bend the sensors.



Use weatherproof tape to protect and secure the wires.

3M 4726 is a great choice.





We used cedar in this one just for weather.



As stated above, it might be better to mount the box on the inside.

It is easy to create a space under the sensor for flex using 1-1/8" Forstner bit or even a regular spade bit.

The version on the left was created with 2x4s in about 30 minutes. You can cut channels for the wires and fill them with silicone or just leave them on the surface and protect them somehow.

We also recommend that you visit some of the open source beehive websites to get good idea for implementing your hive scale. Here are a few for you to investigate, or invent your own:

<https://www.honey-pi.de/>
<https://community.hiveeyes.org>
<http://www.openhivescale.org/>
<http://wiki.hivetool.org/>

Be sure to share your ideas. With your approval, we will add them to the public Dropbox site.

Weather is your enemy, so you will also want a box and cable glands, we recommend the following available from Digikey.com

- Bud Industries PN-1322-CMB \$11.20
- Waterproof box - Hammond 1554N2GYCL \$22.83
- Smaller Hammond, fits circuit board nicely 1554C \$10.00
- Not quite waterproof, but good size with ears - Hammond 1591CSFLBK \$5.50
- Bud Industries cable gland IPG-2227 \$0.50



Here is the Hammond 1554N2GYCL box installed on the Betterbee hive stand

NOTE: The initial DIY boards will be 4.50" x 1.77". The ones shipping in June will be slightly smaller (4.30" x 1.54"). It is possible to trim down the 4.50"x1.77" boards 4.30" x 1.62" without affecting operations, however we don't recommend it. Be sure you get a box of adequate size. There are many available on Digikey.com and Mouser.com.

NOTE THIS TOO... If you do decide to trim down the board, DO NOT use a normal circular saw. It will likely rip the board apart and injure you. I have used a tile saw (no teeth) with great success, or "penny shears" also work pretty well.

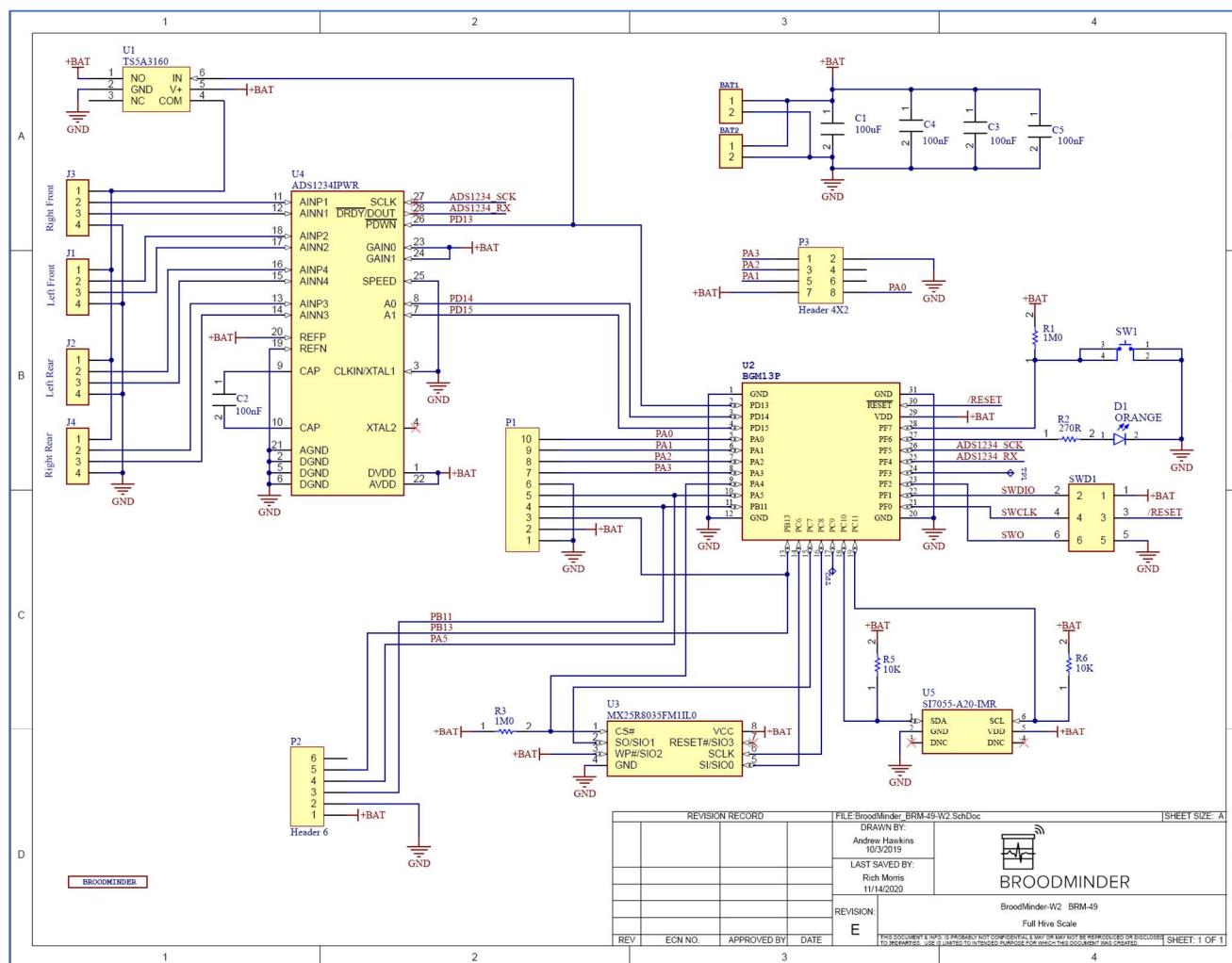
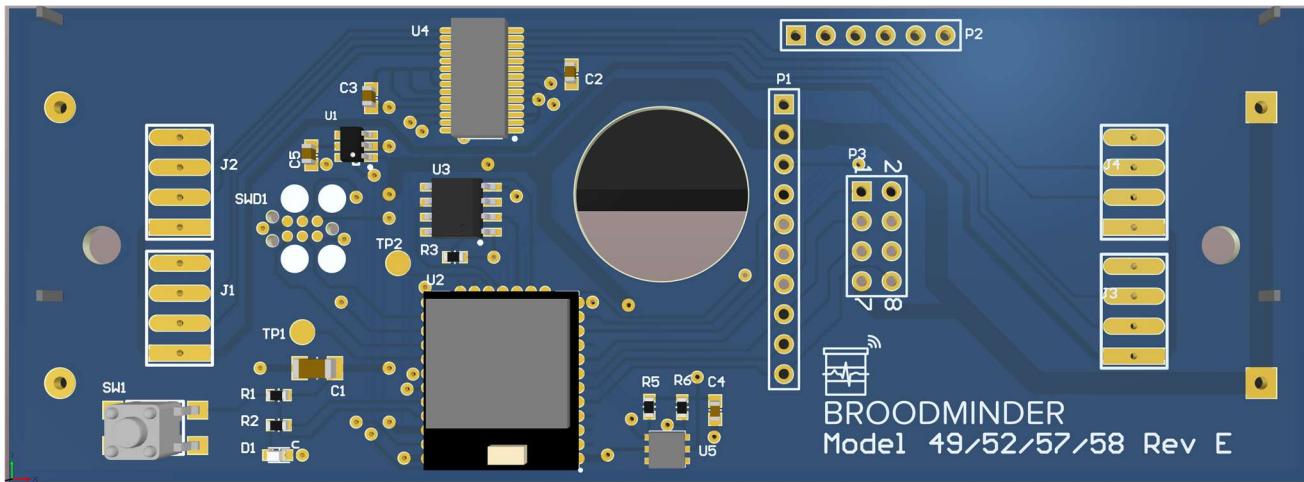
The board does not sport much in the way of electrical protection. We have found that in our configuration this is fine and we want to save as much cost as possible for our users. You may need or want to add additional protection circuits. We leave that to you.

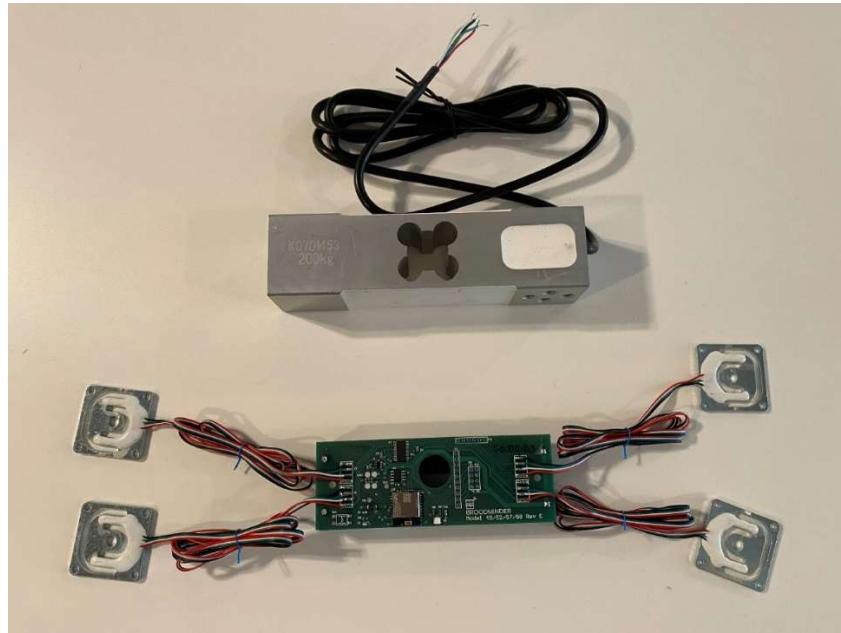
THE ABSOLUTE MAXIMUM VOLTAGE FOR THE DIY BOARD IS 3.8 VOLTS DC!

Digikey.com (or Silabs.com or TI.com) is a good place to start for gather the datasheets if you want to dig in deeper.

A final note, (stepping up on soap box), I (Rich Morris) hate connectors. They are almost always the first thing to fail. Personally, I try to solder everything but your milage may vary. (stepping down now)

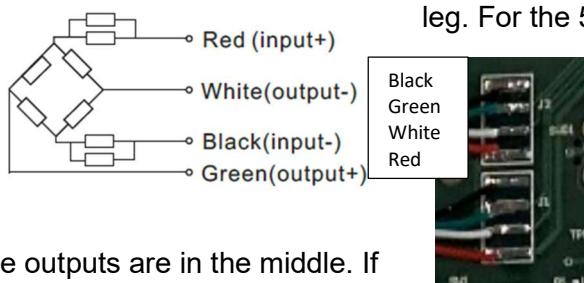
NOTE: On the next page you will find our circuitry. You may wonder why we share this... The truth is, the circuit doesn't get you very far. It requires lots and lots (and lots) of software to hold this all together. We hope the circuit helps you if you need it or want to learn more.





Here are two types of load cells (also called strain gauges). We are happy to provide you with either type. If you get your own, be sure that they are temperature compensated and have very low creep.

The resistance of the 200KG load cell is roughly 300 ohms per leg. For the 50KG load cells it is around 750 ohms.

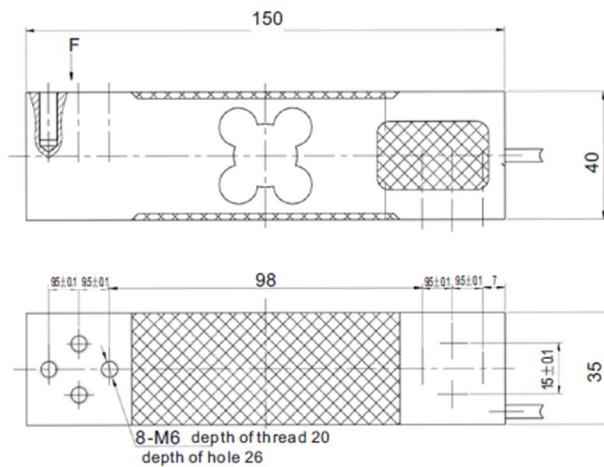
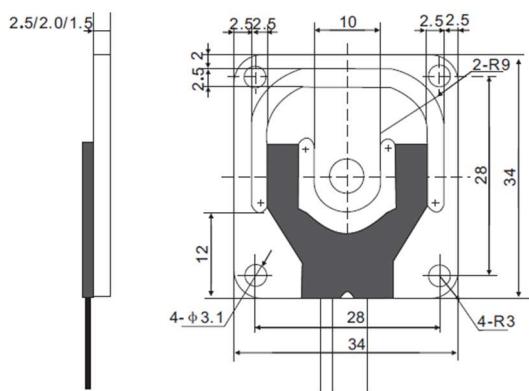


Most load cells seem to use this color scheme for the wires. If that is the case, then wire them like this.

Black, Green, White, Red (from top to bottom).

things are mixed up, usually it will be corrected

The outputs are in the middle. If during calibration.



Center hole of 50KG load cell is 5mm diameter

12.2 Calibration

Once you have your scale built, you will want to calibrate it. You do this by setting the offset and the scale factor for each ADC channel which are stored in flash memory in the processor. We are providing our in-house PC app to do this. Sorry, it is not available for Apple. However, it will run on a quite inexpensive PC. The PC App is available in our [public Dropbox folder](https://www.dropbox.com/sh/nmhfpuy9s5x086f/AADkyDlcJrfsqsd9yUJ-7Lr6a?dl=0) (<https://www.dropbox.com/sh/nmhfpuy9s5x086f/AADkyDlcJrfsqsd9yUJ-7Lr6a?dl=0>).

For BLE (Bluetooth Low Energy) communication you must have a Silicon Labs BLE112 dongle (Digikey 1446-1030-ND \$10.45)

Many of the controls are explained by hovering the mouse over the control. This app was not designed for external use, so you must forgive us for the ugly nature of it. It does work, we have calibrated thousands of scales with it.

NOTE: you don't need to execute the next page if you are using a 4-sensor setup. That is, 4 sensors on one hive, one on each corner. You should go to the "CAP-W2" tab of the program.

The next page explains calibrating single sensors.

The process is as follows:

- 1) Start the app and see that the BroodMinder-DIY shows up on the advertising list.
- 2) Make sure the ID (58:xx:xx) is in the “Device to connect to” box
- 3) Select the configure tab, the BRM-58 should connect automatically.
- 4) At the start, the log period is 3600 seconds. Set the log period to 3 seconds and click “update log period”.
- 5) Press “Start real time”, you should see the logging start and “Elapsed” increase every 3 seconds.
- 6) With your load cells unloaded, press “**Tare XLR**” (XLR is our name for the board). All sensors should read 0.0 pounds after this.
- 7) Put a known weight on the scale.
- 8) Adjust the divisor for each channel and press the “**Cal xx Weight**” buttons to transfer and store the scale factor.
- 9) Write down your divisor factors. At the current time, they can not be read from the BRM-58.

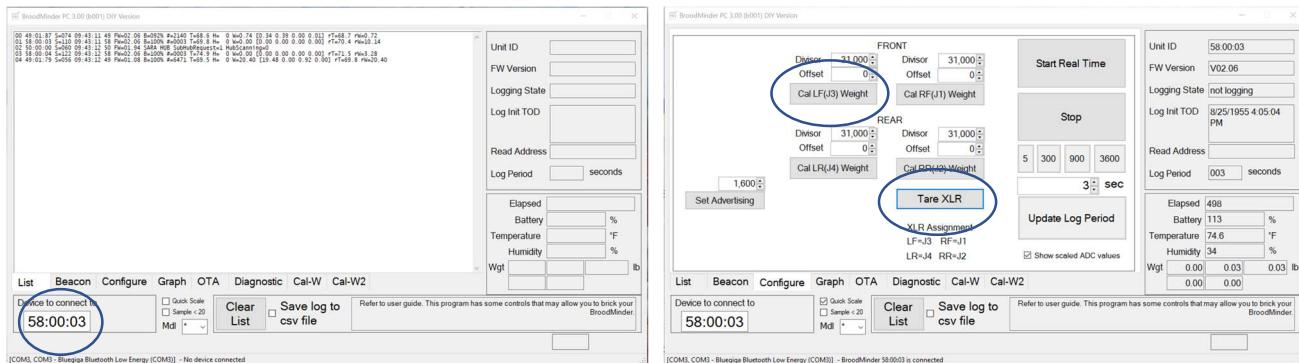
Note: if you are not using a channel, set the divisor to 0 and it will always read 0 weight.

Notes: The divisors are the values that convert the raw readings of the ADC to weight. 31,000 is a good starting place for the small load cells. The large one is more like 11,000. The readings that you see in this program are in pounds (with apologies to the MKS crowd). It is a simple matter to set the divisor to a value, then do a test weight. And then adjust the divisor appropriately. For example:

Real Weight = 30.0 pounds, Divisor = 31,000, BRM-58 readout is 20.0 pounds

Change the divisor to $31000 * 20.0 / 30.0 = 20,666$ and the weight should correctly read 30.0

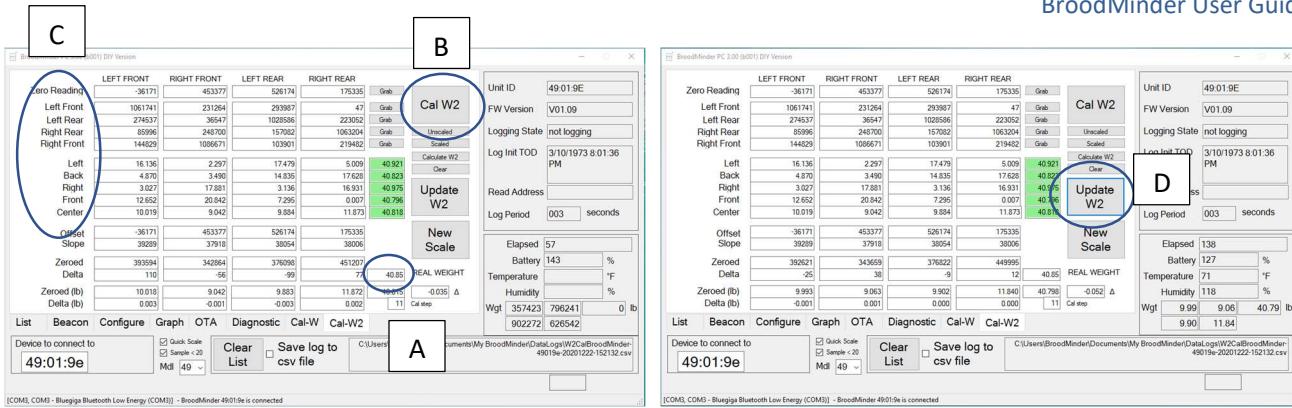
All offsets should remain 0 for BRM-58



There are many other controls and features that we will not go into here. Feel free to explore.

That's it, you are done unless you are using 4 50KG sensors in one scale. For that we have to get a bit more exotic.

If you are using 4 sensors together, then you should use the Cal-W2 tab as explained next.



- Enter the true weight that you will use for calibration. Note: If you are calibrating a BroodMinder-W2 you need to add 1.7 pounds for the weight of the top half of the scale.
- Remove all the weight from the load cells and press Cal W2. The first thing it will do is zero the system. You will see the raw ADC values show up in the zeroed row. After this step, you will see approximate weights shown in (lb) rows. This is based on the slope in the slope row. We use a default value for the -W2 sensors. You can play around with this to get close for your sensors.
- Next you should move the calibration weight as directed on region C above. The program automatically advances when it sees a weight > 5 pounds on the appropriate sensor. After the 4 corners are complete, the program calculates the slope for each sensor and updates the Slope line. The next 5 positions are used to verify the scale. If the value is within 0.5 the box lights up Green.
- After you are satisfied with the calibration, press “Update W2” and it will write the values to the circuit board. You know it is complete when the Weight (Wgt) values switch back to pounds.

Basically what is happening here is we are using linear algebra to solve the simultaneous equations generated by the first 5 positions. After zeroing the sensors, there 4 weights and 4 variables (slopes). Through the magic of mathematics, we get the answers.

- You may want to use this board to run 4 hives, that is fine with us. If you use connectors, but certain that they are really good and weather resistant. They usually are the point of failure.
- Try to avoid anything that will result in friction or stiction. It is remarkable how a tiny rub will have a big impact. Do not use hinges, they are awful. Even ball bearings will result in significant errors. Pivots are good.

This is a very brief outline of how to proceed, I hope it is enough. If you need some more help or have additions we should add to this manual for the next user, contact Rich at Rich@BroodMinder.com.

TROUBLESHOOTING

More often than not, the problem is simply wiring. Start by measuring between the load cell leads. You should see hundreds of ohms, not 0 and not infinity. Also be aware that we use plated through holes. If you drill them out (like Lorenzo did), the pads will no longer conduct from the top of the board to the bottom. You can solve this by solder jumper wires with the schematic as a guide.

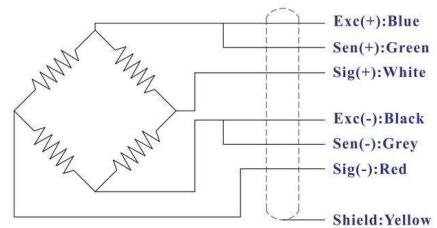
12.3 Converting a broken hive scale using DIY

It is easy to take an old broken hive scale and convert it to a BroodMinder enable scale. Here is an example.

- 1) Cut the load cell wire to length
- 2) Carefully tin the leads. Old wire may be difficult to tin, use plenty of flux if this is the case.
- 3) Determine the wiring. In our example, this is the wiring of the load cell
- 4) Connect to the board. In our case, from the top
 - a. Green – Exc - J1(1)
 - b. Red – Sig(-) – J1(2)
 - c. White – Sig(+) – J1(3)
 - d. Black + Shield – Gnd – J1(4) or J2(4)
- 5) Connect pins 1,2 & 3 of the unused channels (Gnd)
- 6) I do not recommend using a connector. I tried and the corrosion was a big problem. It worked for a while and then the calibration was way off.
- 7) Stabilize the wire with a tie wrap and cut a hole in the case (Bud Industries PN-1322-CMB \$11.20 or Hammond 1591CSFLBK \$5.50)
- 8) Ensure the box is sealed, silicone caulk works well if you use the cheaper Hammond box.
- 9) If the box is tucked up in good spot, you might be able to get away with mounting without sealing the cable entry. Be certain to have a drip loop so that rain doesn't drip inside.
- 10) The BLE chip will work better if it is oriented so the circuit board is away from the metal frame.

Good luck, let us know how it goes.

Wiring Diagram



13 Appendices

13.1 Appendix A - BroodMinder-W physics

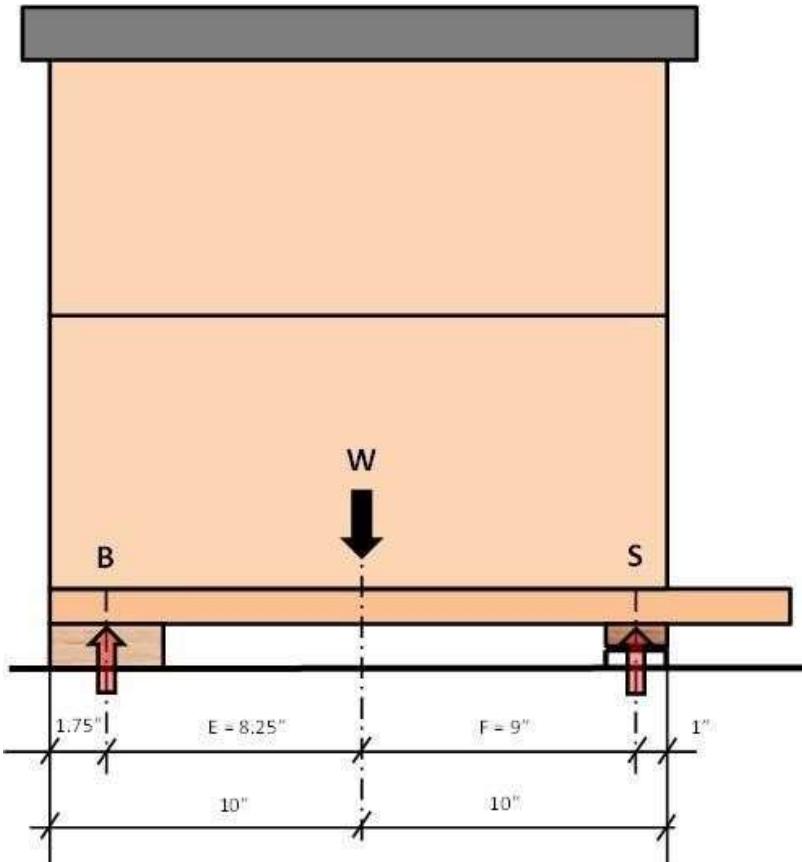
There are many ways the BroodMinder hive scale can be used and since it only measures a fraction of the total hive weight, the design and placement of the auxiliary support and the BroodMinder scale positioning becomes an integral part of the total hive weight measuring system. Generally, the more effort is put into this, the better the results will be. The hive support systems shown below start from the easiest to the most sophisticated with highest uncertainty to lowest. It is up the individual user to decide what to implement.

NOTE: the most typical error source is inadequate support under the scale. This can result in strange behavior as the hive flexes as it expands and contracts due to sun, rain, temperature, etc. Providing a flat support will improve results. An easy fix is to place a ¾" plywood sheet (or equivalent) under the scales.

ADDITIONAL NOTE: If all you want to see is honey flow, good support is not required. You will just have to ignore the daily fluctuations. You will still be able to observe the overall change in weight.

a) Default Arrangement

This is the default arrangement with the scale at the front of the hive and a 2x4 as an auxiliary support (fulcrum) at the back:



Here are some calculations surrounding the setup:

Assumptions

The hive weight W is distributed evenly and the center of gravity is in the middle of the hive. For simplicity, the front overhang of the bottom board is not considered. Hive weight is assumed to be 100%.

Calculations

$$\text{Scale Loading } S = \frac{W \times E}{E+F} = \frac{100\% \times 8.25"}{17.25"} = 47.83\%$$

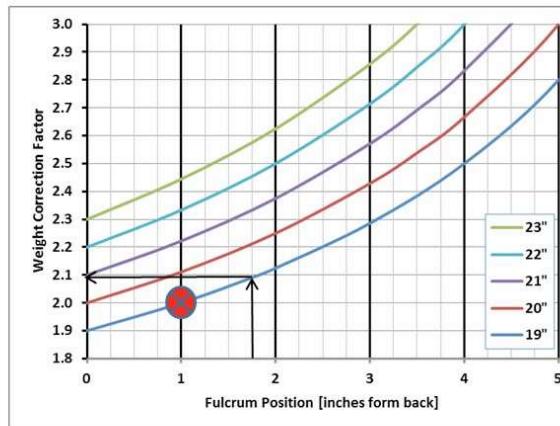
$$\text{Back Support Loading } B = \frac{W \times F}{E+F} = \frac{100\% \times 9"}{17.25"} = 52.17\%$$

When using standard 2×4 lumber as a back support and aligning it with the back of the hive, the total hive weight W can be calculated from the weight on the scale S as:

$$W = S \times \frac{(E+F)}{E} = S \times \frac{17.25}{8.25} = S \times 2.091$$

Therefore, use 2.09 as the default hive scale factor in the app if you are using this setup. This of course can be fine tuned once some weight measurement are available.

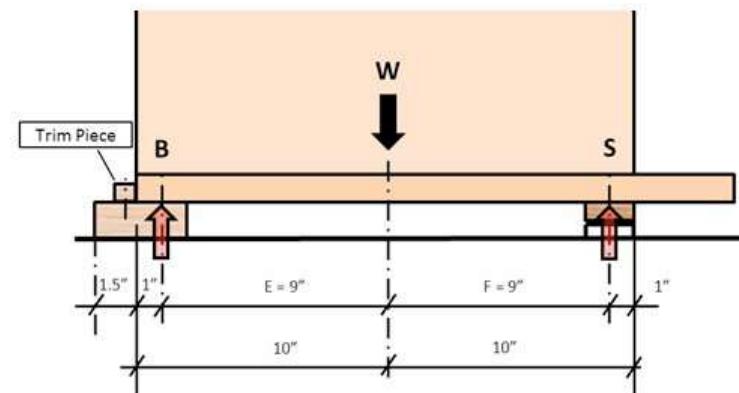
The chart below shows the scale correction factor for different scale and fulcrum arrangements. The X-Axis is the position of the fulcrum point in inches from the back of the hive. The different lines represent the scale centerline position in inches from the back of the hive. Arrows show the example above.



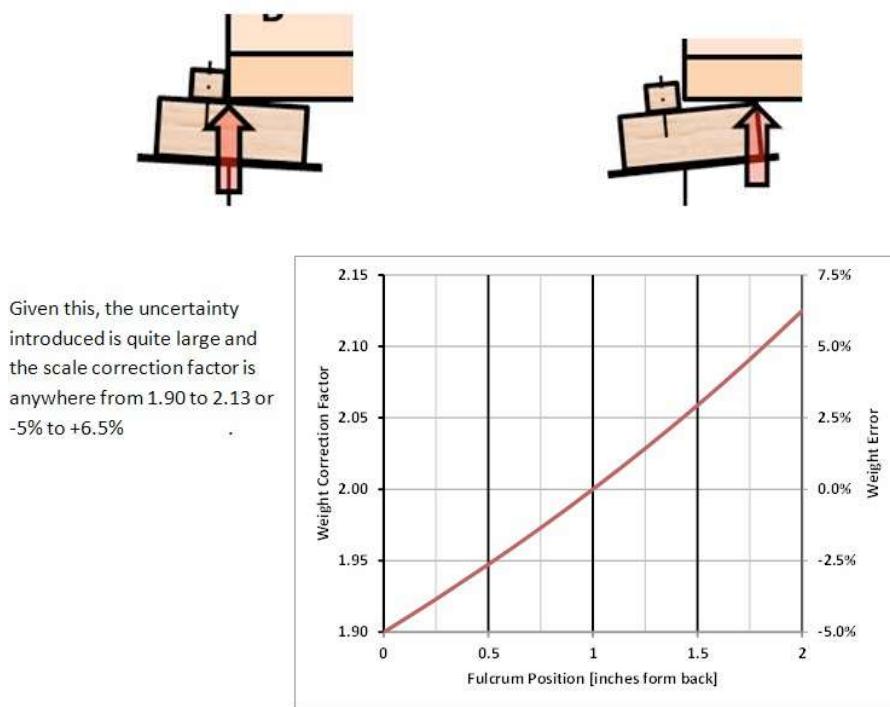
This depicts the ideal fulcrum and scale position resulting in a scale correction factor of 2.0.

b) Alternate Arrangement 1

Based on the above, the auxiliary support should be placed 1" from the back of the hive. It is recommended to attach a trim piece on top of the 2×4. This will help for accurate positioning of the auxiliary support.



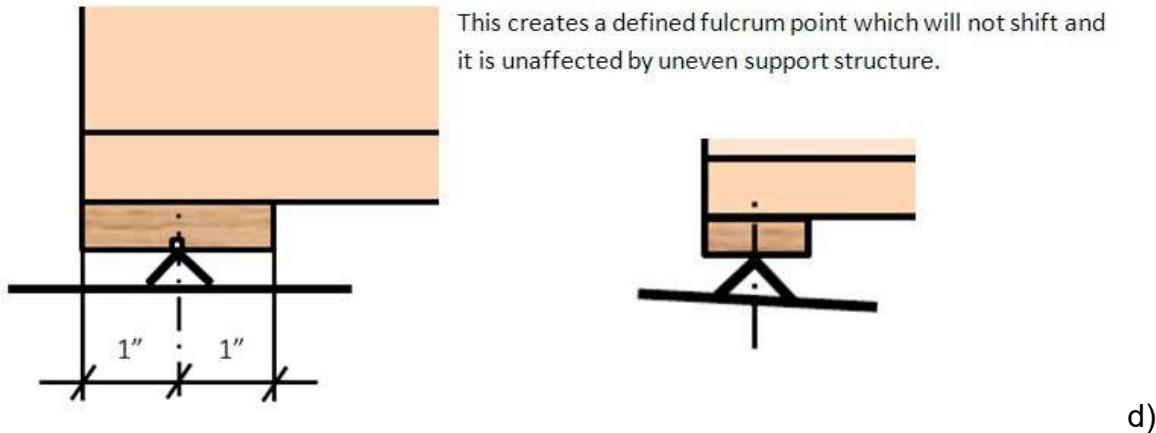
Now we have equal moment arms E and F and the hive scale correction factor becomes 2.0 which is the default in the mobile app. There are however some other influence factors which should not be overlooked. The real fulcrum point of the auxiliary support is anywhere between the back of the hive and the front of the aux support due to variations of the support system levelness and potential warpage of the 2x4 itself.



c) Alternate Arrangement 2

A different support system can be used which has a defined fulcrum point and is not affected by the alignment of the support structure:

Take a piece of pine or oak, about $\frac{3}{4}$ " thick and 2" wide. Length needs to be the width of the hive. Cut a small kerf into it. The kerf needs to be as deep as the width of the saw blade. Attach this piece to the underside of the bottom board of the hive. Align it flush with the back. Then place a piece of 1" by $\frac{1}{8}$ " 6061 or 6063 aluminum angle, same length as the wood strip, under it to support the hive. The corner of the aluminum angle rests in the kerf. The total height of the aluminum angle and the wood needs to be equal or slightly bigger than the scale height to ensure the hive is level or even slightly tilted forward to ensure water drainage away from the hive entrance.



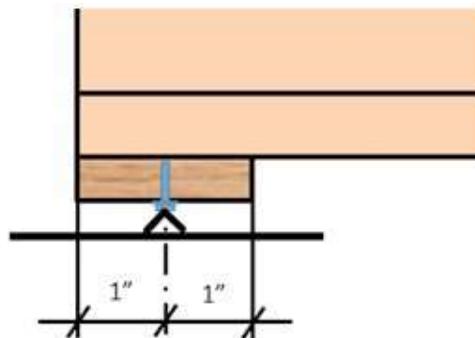
Lateral Balancing

All of the above support systems are affected by undefined lateral weight shift since the hive is resting on more than three points. There are two points at the front inside the hive scale and a linear support at the back of the hive. This could lead to overload on one of the load cells in the scale and therefore, lateral balancing is typically required if the support system under the hive is not one continuous platform, i.e. separate cinder blocks for the front and the back of the hive.

Read the weight from each load cell individually by switching to the real time display with the app. In this mode, the weight on the scale is shown as %Left, % Right. The right hand side of the scale is the side with the device identification sticker. No further action is required if the L/R difference is less than 10%.

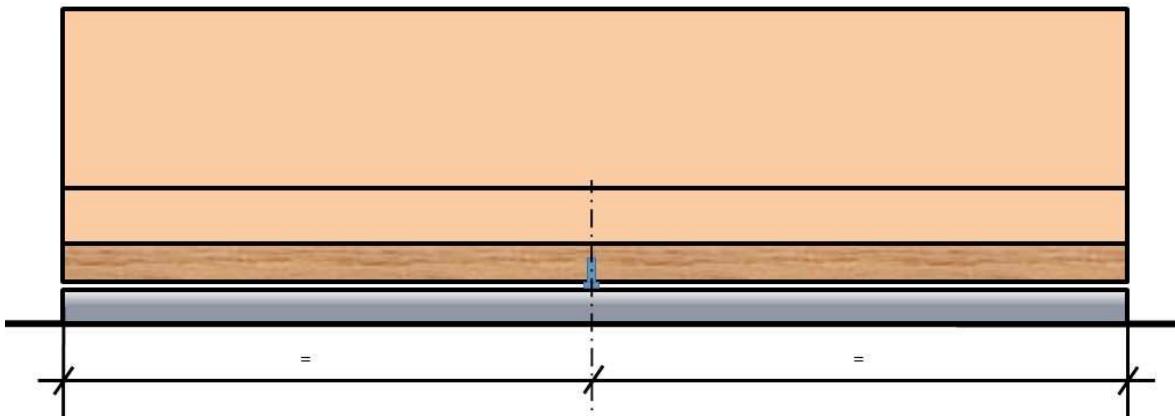
If not then shim the scale on the side with the lower weight reading until the weight readings match. Alternatively, shimming can also be done under the back support on the opposite side of the low weight reading.

e) 3-Point Hive Support



There is a way to alleviate the need for lateral balancing by introducing a true 3-point support system. The parts are similar to the ones used in arrangement 2 but instead of

using a 1" angle, for this arrangement you will need a $\frac{3}{4}$ " angle. A 7/32" hole is drilled in the middle of the board instead of cutting a kerf. A $\frac{1}{4}$ " x 0.5" slotted machine screw is used as center support. The screw will cut its own threads into the board. The slot in the screw head is aligned so that it can rest on the edge of the aluminum angle in a single point without sliding off.

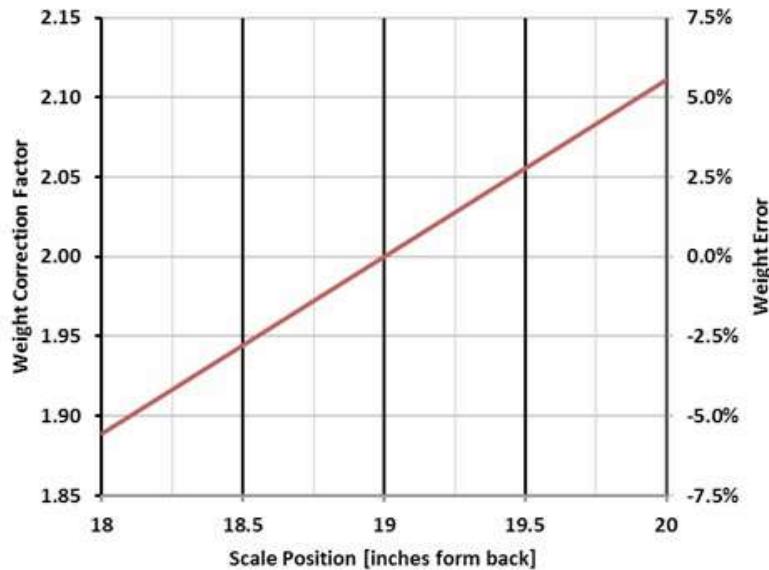


There is a small gap between the aluminum angle and the wood board. It has to be ensured that this gap is even width across the hive. The screw in the middle should be the only contact point. This will ensure that the correct weight is measured and at the same time it is the "safety net" against the hive falling over if excessive uneven loading is taking place, i.e during hive inspections.

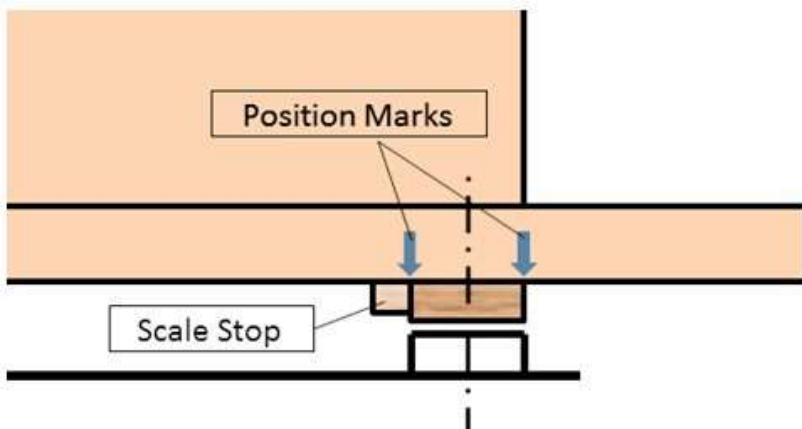
f) BroodMinder Scale Positioning

Most of the above has been dealing with the auxiliary support. Let's focus now on the scale positioning.

As shown in the previous sections, it is desirable to have the front face of the scale placed in line with the front face of the hive body. Moving it further in would improve accuracy at the expense of hive stability and moving it further out would reduce accuracy with little improved hive stability.



This chart shows the influence of scale placement on the scale correction factor and scale error introduced due to inaccurate positioning of the scale. The influence is 5.6% per inch



It is advisable to mark the scale position on the bottom board of the hive or to attach a mechanical stop. This will help to put the scale back into the same location after it has been pulled for a battery change or some other reason.

13.2 Appendix B – BLE advertising protocol

Note: If you have suggestions for improving the explanation, then us the details.

For those brave souls with the gumption to create their own data harvesting equipment, we provide information on the BLE advertising protocol that BroodMinder uses. Indeed our own BroodMinder-CELL, WiFi, and -SubHub uses the advertising to eavesdrop on the devices and then forward the data directly to MyBroodMinder.com.

There are several nice BLE Explorer programs available. Our favorites are:

- Android & iOS – nrfConnect by Nordic Semiconductor. The Android version is best, but we use both all of the time. It has a nice signal level graphing feature.
- PC – Bluetooth LE Explorer by Microsoft. Unfortunately, this program doesn't show the advertising data.
- Mac – BlueSee – This app seems to work nicely and it does show the manufacturers data in the advertising packet.

You will likely notice that the first 3 bytes of the device ID are always 06:09:16 then follows the particular device ID which is always Model:ID:ID. Some devices (iOS & Mac) hide the true ID, so we also include that in the name field in the extended advertising packet.

Advertising Packet Makeup for BroodMinder

When you read advertising packets from BLE, you can identify BroodMinder products by looking at the following.

The data will look something like this. – this example is from device 43:30:07

```
GAP Scan Response Event -----
ble_evt_gap_scan_response: rssi=-77, packet_type=0, sender=[ 07 30 43 80 07 00 ], address_type=0, bond=255,
data=[ 02 01 06 02 0a 03 18 ff 8d 02 2b 15 02 00 02 21 00 d0 62 00 ff 7f 05 80 37 07 30 43 00 00 00 ]
```

Note: Values are in decimal unless preceded with 0x

- 1) Check for "Manufacturer Specific Data" flag
Bytes 6,7 = 0x18, 0xff

- 2) Check for IF, LLC as the manufacturer
Bytes 8,9 = 0x8d, 0x02

Bytes 10-29 are the data from the BroodMinder as outlined below.

DeviceModelIFIc_1 = 0x2b (43d = scale)

DeviceVersionMinor_1 = 0x15 (21d)

DeviceVersionMajor_1 = 0x02 (FW 2.21)

Elapsed_2V2 = 0x21 (33d)

Temperature_2V2 = 0x62d0

WeightL_2V2 = 0x7FFF

WeightR_2V2 = 0x8005

The mapping for all models is on the next page

PRIMARY			
Byte	Type	Value	Parameter
0	Ad field Length	02	
1	Field Type	01	Connectible
2	Value	06	LE General Discovery, Connectible, Single Mode Device
3	Ad field Length	02	
4	Field Type	0A	Xmit Power
5	Value	03	Power in DB
6	Ad field Length	24	
7	Field Type	FF	Manufacturer data
8	Value	8d	IF, LLC = 0x028d, 653
9	Value	02	IF, LLC = 0x028d, 653
10	Value		Model
11	Value		Version Minor
12	Value		Version Major
13	Value	Realtime Temp1	47/49/56/57/58 (SM&XLR)
14	Value	Battery	
15	Value	Elapsed	
16	Value	Elapsed	
17	Value	Temperature	47 & above is centicenigrade + 5000
18	Value	Temperature	
19	Value	Realtime Temp2	47/49/56/57/58 (SM&XLR)
20	Value	WeightL	
21	Value	WeightL	
22	Value	WeightR	
23	Value	WeightR	
24	Value	Humidity	will be 0 for 41/47/49/52
25	Value	WeightL2/SM_Time0	49/57/58 (XLR)
26	Value	WeightL2/SM_Time1	49/57/58 (XLR)
27	Value	WeightR2/SM_Time2	49/57/58 (XLR)
28	Value	WeightR2/SM_Time3	49/57/58 (XLR)
29	Value	Realtime total weight / Swarm State	47/49/56/57/58 (SM&XLR)
30	Value	Realtime total weight	47/49/56/57/58 (SM&XLR)
SECONDARY			
Byte	Type	Value	Parameter
0	Ad field Length	09	
1	Type	09	Complete Local Name
2		4'	ascii name
3		2'	
4		:	
5		0'	
6		0'	
7		:	
8		0'	
9		0'	

Note: BRM52 BroodMinder-SubHub is different as explained below.

Here are the equations

```

if (ModelNumber == 41 | ModelNumber == 42 | ModelNumber == 43)
{
    temperatureDegreesF = e.data[byteNumAdvTemperature_2V2] + (e.data[byteNumAdvTemperature_2V2 + 1] << 8);
    temperatureDegreesF = (temperatureDegreesF / Math.Pow(2, 16) * 165 - 40) * 9 / 5 + 32;
}
else
{
    double temperatureDegreesC = e.data[byteNumAdvTemperature_2V2] + (e.data[byteNumAdvTemperature_2V2 + 1] << 8);
    temperatureDegreesC = (temperatureDegreesC - 5000) / 100;
    temperatureDegreesF = temperatureDegreesC * 9 / 5 + 32;
}

humidityPercent = e.data[byteNumAdvHumidity_1V2];

if (ModelNumber == 43)
{
    weightL = e.data[byteNumAdvWeightL_2V2 + 1] * 256 + e.data[byteNumAdvWeightL_2V2 + 0] - 32767;
    weightScaledL = weightL / 100;

    weightR = e.data[byteNumAdvWeightR_2V2 + 1] * 256 + e.data[byteNumAdvWeightR_2V2 + 0] - 32767;
    weightScaledR = weightR / 100;
}
else if (ModelNumber == 49 | ModelNumber == 57 | ModelNumber == 58)
{
    weightR = e.data[byteNumAdvWeightL_2V2 + 1] * 256 + e.data[byteNumAdvWeightL_2V2 + 0] - 32767;
    weightScaledR = weightR / 100;

    weightL = e.data[byteNumAdvWeightR_2V2 + 1] * 256 + e.data[byteNumAdvWeightR_2V2 + 0] - 32767;
    weightScaledL = weightL / 100;

    weightR2 = e.data[byteNumAdvWeightL2_2V2 + 1] * 256 + e.data[byteNumAdvWeightL2_2V2 + 0] - 32767;
    weightScaledR2 = weightR2 / 100;

    weightL2 = e.data[byteNumAdvWeightR2_2V2 + 1] * 256 + e.data[byteNumAdvWeightR2_2V2 + 0] - 32767;
    weightScaledL2 = weightL2 / 100;
}

realTimeTemperature = ((float)(e.data[byteNumAdvRealTimeTemperature2] * 256 + e.data[byteNumAdvRealTimeTemperature1] - 5000) / 100) * 9 / 5 + 32;

realTimeWeight = (float)(e.data[byteNumAdvRealTimeWeight2] * 256 + e.data[byteNumAdvRealTimeWeight1] - 32767) / 100 ;

```

SM_Time is the unix time of last temperature event. Time0 = LSB, Time3 = MSB, it will be time since boot if time has not been set in the device by a device sync.

BRM-52 BroodMinder-SubHub

The -SubHub does some tricky advertising. The advertising changes every 5 seconds to send out a different device. It will roll through all devices (including itself) and then repeat. We call these Mock Advertisements. Depending on what operating system is being used, you may or may not (e.g. iOS) be able to see the true device ID (e.g. 06:09:16:52:01:23). That is why we place the device ID in the extended advertising byte. Also note that it is difficult to read the extended advertising for some devices, however for those, you typically *can* read the true device ID.

The Mock ID resides in byte 13, 19, and 30. That makes the process as follows:

1. Establish if this is a -SubHub by the ID (either the true ID or the ID in the extended advertising). It will always be 52:xx:xx.
2. If it is a "52" device, then parse bytes 13/19/30. E.g. 43/01/23 will be 43:01:23
3. Parse the rest of the advertising packet according to the device type based on the model byte (byte 10)

Easy Peasy 😊

13.3 Appendix C – Repair Guide

We want these sensors to last forever. However, installing them outside or inside a beehive puts special stress on the circuit boards. We encourage everyone to repair their own if they are capable, or to contact Support@BroodMinder.com where we will offer you ‘Refresh’ or ‘Refurb’ services.

Refresh – We will replace the plastic housings, test/update the sensor, install new batteries.

Refurb – We will repair/replace any broken parts or if a total loss, we will send a different refurbished unit.

Here is a brief list of the most typical problems (we don’t see many):

- Most issues are software issues. In general, they get solved in the app or on MyBroodMinder.
- **Fast battery drain.** This is the most typical problem. Sensor batteries are all designed to last > 12 months. The cause is usually excessive moisture. 75% of the time it is repairable.
- **Weight errors.** Most are caused by installation errors. Next most prevalent caused by water infiltration due to broken housings.
- **CELL/WIFI problems.** If the unit was working and quit, then almost always due to water infiltration and the gasket being installed wrong. The second most common problem is lack of sunlight, particularly in the Pacific Northwest in the winter. You can get replacement batteries from Voltaicsystems.com. The V25 has replaced the V15. Once or twice we have seen problem with the modem connector to the circuit board. There are a lot of debugging features in the Cell App.
- **Battery holder breakage.** In devices with plastic battery holders the replacement part is MPD p/n BU2032SM-BT-GTR
(<https://www.digikey.com/en/products/detail/mpd-memory-protection-devices/BU2032SM-BT-GTR/2439521>)
- **Battery no connect.** We don’t see this often, but the battery holder can get gunk from the bees on it. You can clean the battery connectors with isopropyl alcohol.

General Notes:

- You can clean any components using 90% or greater isopropyl or ethanol alcohol. Warm it after aggressively cleaning to evaporate all moisture. This is a decent way to dry out a board since the alcohol will ‘pick up’ the extra moisture.
- Keep things dry. Cracked housings are the leading cause of scale problems. If you don’t want to purchase new housings, then just tape the old one. There are lots of good tapes out there. Clear Gorilla tape is one of our favorites.
- I refer to Digikey a lot, but many supply houses have these parts.

REPAIR - Fast Battery Drain – TH and W

The typical cause for fast battery drain is a partially shorted decoupling capacitor. They are used to add a bit of life to the battery (ironic huh?) and to ensure stable supply voltage. As time has gone on, we have become more aggressive with conformal coating. I have been told by companies making solder, that the new, more environmentally friendly formulations for flux are the root cause. In particular, moisture can get trapped underneath capacitors and create a current path between pads. (This has also led us to use larger components in more recent designs.)

This is easy to measure if you have a DVM (current meter) that reads into the uA range. A non-auto ranging meter is much easier to use because the circuit puts out advertising pulses every 1 or 5 seconds and that messes with the auto ranging. A good board requires < 5 uA at idle, however it will bounce between that and a few mA. Below is the setup that we use.

Note that the power may be applied on the connector as shown. Pin 1 (the square pad) is ground, pin 2 is 3.0 volts.



In this picture I have circled the typical capacitors which cause problems. Both may be removed with almost no change in performance. If you do want to replace them, here is the info. Start with the 100uF one on the left.

Large 100 uF Digikey: 478-8155-2-ND or equivalent
Small 0.1 uF Digikey: 399-5784-2-ND or equivalent

Sometimes it is a component on the BLE module (blue) that is not replaceable. Then the board is pretty much scrap.

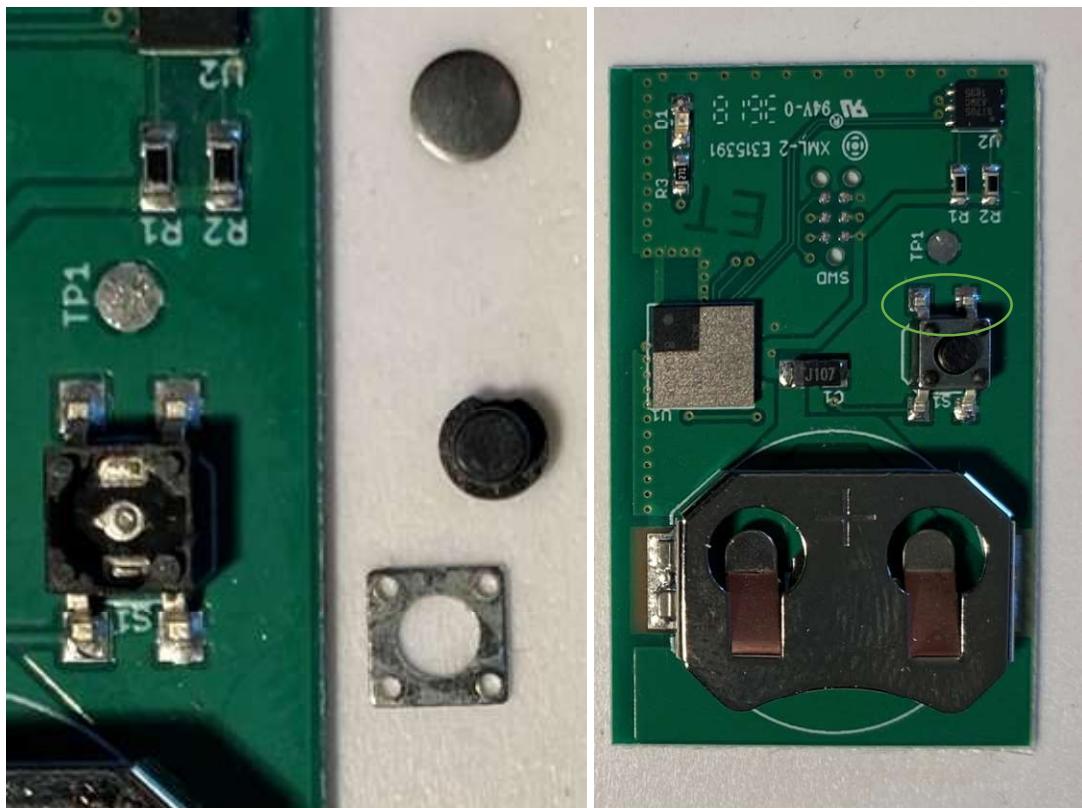
It is a good idea to coat the components after replacing. You can use nail polish for this if you don't have conformal coating material. In general, I don't recommend paint or varnish unless you know it is OK via some other source.

More info on "Tin Whiskers" - <https://nepg.nasa.gov/whisker/background/index.htm> & <https://www.eevblog.com/forum/projects/removing-tin-whiskers/>

REPAIR – Will not respond– T2 (and T2SM)

We try to get the best parts possible, but sometimes it doesn't work out. We have seen instances where it seems the T2 is dead and the only thing dead is the push button. It seems like the interior of the button may have developed a thin film on the connection disk (but we aren't certain). There are a couple of ways to deal with this.

- 1) Replace the button (E-Switch TL3305AF160QG Digikey EG5350CT-ND)
- 2) We have had good luck with restoring operation by pressing the button repeatedly. As soon as you see the LED flash you know you're on the right track. Push it quickly (3-4 times per second) for 30 seconds or so. We have seen most buttons work after this process.
- 3) Ignore the problem and use a knife to short across the switch terminals thus actuating the switch.



You can see the switch guts on the board to the left. It is a "snap dome" switch which should be super reliable. Our best guess is that the dome was contaminated, and a thin film formed preventing contact. Aggressive repeated pressing seems to break through. YMMV.

REPAIR – Scale weight problems BRM-43, original BroodMinder-W

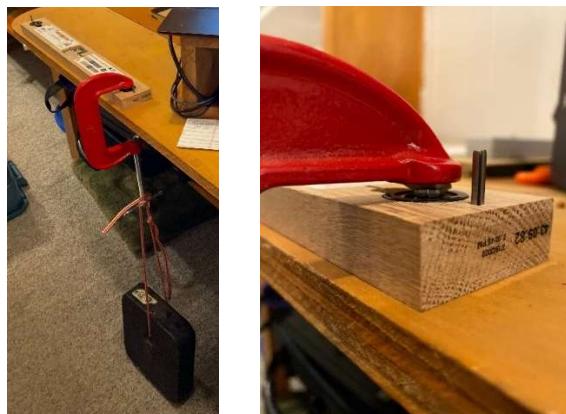
The scales have also been reliable unless exposed to environmental problems, typically because the housing become cracked and rain enters. Usually, a good cleanup helps. I have not seen the ADC1234 fail. Typically, it is a capacitor (as discussed above) or the battery holder (MPD p/n BU2032SM-BT-GTR). The weight sensors are also available at Digikey, FX1901-0001-0100-L by TE Connectivity Measurement Specialties.

If you are going to do much with scale repair, it is a good idea to get the PC app and a Silicon labs BLED112 dongle (available at Digikey).

Once you repair the scale and need to recalibrate it, we suggest using the PC app and to adjust the divisor and offset for each channel by trial and error. See the DIY section above for a bit more info on the PC App (available at

https://www.dropbox.com/sh/vj621467gak5bd7/AAAitrlE_vKsw07AGnlgoxha?dl=0 in directory PCApp).

- Note the divisor and offset values the appear when you connect. Write them down.
- Set the scale wooden side down with the aluminum and housings removed.
- Set the log period to 5 seconds (this is the fast it will go) press “Update Log Period” and press ‘Start Real Time’
- With no load on the scale, adjust the Offset for left and right (front only for BroodMinder-W). The value can vary widely. + or -15,000 is not unusual.
- Apply a known weight. We suggest using a large c-clamp with a weight dangling. It should not touch the table or any part of the scale. Taping a small nut to the c-clamp will keep it situated on the sensor.
- Adjust the Divisor to read correctly. Generally, the Divisor value should be between 1,200 and 1,400.
- After values are set, you must press “Cal LF Weight” and Cal RF Weight” to store the values in the scale.
- Test using the BroodMinder-Lite app in “real-time” mode to ensure that the values are stored.



REPAIR – BroodMinder-W2

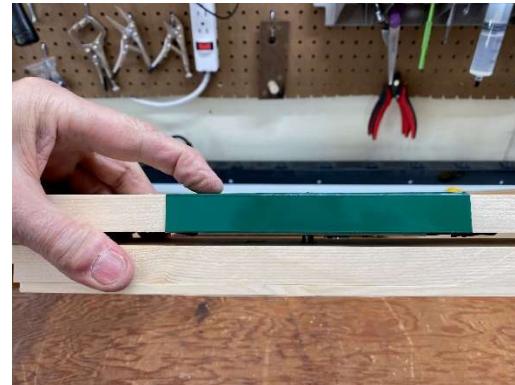
The W2 is pretty new, so we don't know all of the failure modes yet. We will show you how to disassemble without destroying it.

This is what it looks like inside. It is pretty simple. The hard part is keeping bees inside and weather outside.

Battery Shield

An upgrade we recommend for all of the original -W2 scales is to add a plastic water shield above the battery compartment. It turns out that moisture may drip down the inside of the hive and end up here. Sandwiching a shield between directly above the batteries and below the screwed on cover prevents this from happening.

- Remove the battery cover
- Place the shield centered above the battery area
- Replace the battery cover
- Tape the corners to make watertight



W2 Disassembly

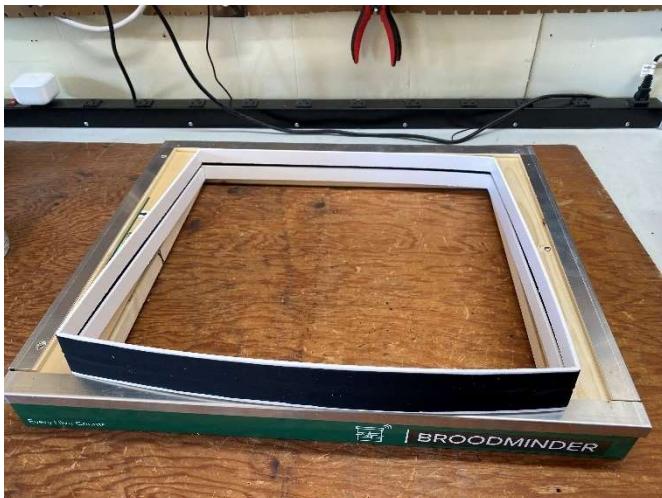
- 1) Remove the inner seal that is stapled in place. (be gentle)
- 2) Take off the two nuts holding the halves together.





After removing the slatted rack, start by carefully prying loose the staples holding the inner seal in. Use a small putty knife if possible.

The inner seal is spandex mounted on expanded PVC. It is very flexible, but easy to poke a hole in with a knife.



Remove the inner seal assembly.

Note that when you reassemble, don't stretch the spandex, that will put force on the scale.



Remove the two nuts holding the top to the bottom frame.

Now you can separate the halves.





If you are replacing the housing, first lay down the double stick tape. We suggest making the short pieces run to the edge in order to bridge the two housing pieces and help to seal out water.



Installing the housing is all about making certain that it does not rub.

Install the long pieces first. Be certain that the housing is centered in the metal drip ledge. If it rubs on this aluminum part, it will affect the weight reading.



When installing the short pieces, be certain to pull the long piece towards the middle so that it is tight against the frame. Leave part of the housing double stick tape covered as shown. Carefully peel it off after get the housing situated on the frame.



It can be tricky to get the housing back in after you separate the halves.
Patiently use a putty knife to do this.



We recommend a little blue locktite to secure the nuts.

13.3 Appendix D – Battery Power

In the winter of 2020/21, we worked to extend battery greater than 5 years. The following section provides measurement data for those interested in such matters.

In order to avoid connectors and wires, we have chosen the battery route. Our goal has always been to have batteries last between one and two years. In the absence of failures due to tin whiskers noted above, we have met that goal.

The major energy cost to BroodMinder devices is Bluetooth Low Energy (BLE) advertising. The advertisements, which contain current measurement values, are emitted once every 5 seconds (once every second for -W2). While the current draw is very short, it still adds up over the span of a year.

In early 2020, we decided to design and offer the BroodMinder-SubHub. Based on the same circuit as the BroodMinder-W2, the board can be outfitted with 4, AA batteries giving it a much larger power base to work with. With the -SubHub gathering data once every 10 minutes, it made possible to cut advertising time for the hive devices from 60 minutes to 10 minutes, cutting power consumption by nearly 75% and extending battery life to over 5 years.

Battery Energy CR2032 = 225 mAh AA (L91) = 3500 mAh AAA (L92) = 1200 mAh

Model Number	Model	Idle energy / 24h (uAh)	Advertising energy per adv. (uAh)	Adv energy per adv w/listener (uAh)	Sampling energy per sample (uAh)	Connection energy per sec (uAh)	Adv period (sec)	Sample Period (sec)	Advert energy (mAh)	Sampling Energy (mAh)	Connect Energy (mAh)	Total Energy (mAh)	Battery Energy	Battery Life (years)
BRM-42	BroodMinder-TH	0.033	0.016	0.018	0.021	0.917	5	3600	103	0.2	5.7	109	225	2.1
BRM-43	BroodMinder-W	0.048	0.014	0.016	0.388	0.9	5	3600	87	3.4	5.6	96	225	2.3
BRM-47	BroodMinder-T2SM	0.06	0.017	0.02	0	0.327	5	3600	107	0	2	109	225	2.1
BRM-49	BroodMinder-W2	0.06	0.018	0.02	0.307	0.508	1	3600	568	2.7	3.2	574	3500	6.1
BRM-56	BroodMinder-TH2	0.06	0.018	0.02	0	0.327	5	3600	114	0	2	116	225	1.9
BRM-57	BroodMinder-W+	0.06	0.019	0.02	0.217	0.513	1	3600	600	1.9	3.2	605	1200	2
BATTERY SAVER MODE - 10 minutes advertising per hour														
BRM-47	BroodMinder-T2SM	0.06	0.017	0.02	0.042	0.327	5	3600	21	22.1	0	43	225	5.2
BRM-49	BroodMinder-W2	0.06	0.018	0.02	0.307	0.508	2	3600	316	2.7	0.1	318	3500	11
BRM-56	BroodMinder-TH2	0.06	0.017	0.02	0.042	0.327	5	3600	21	22.1	0	43	225	5.2
BRM-57	BroodMinder-W+	0.06	0.019	0.02	0.217	0.513	5	3600	126	1.9	0.1	128	1200	9.4
Model Number	Model	energy / 24h (uAh)	Advertising energy per adv. (uAh)	per adv w/listener (uAh)	energy per second (uAh)	energy no sample per sec (uAh)	Adv period (sec)	Listening period	Advert energy (mAh)	Sampling Energy (mAh)	Connect Energy (mAh)	Total Energy (mAh)	Battery Energy	Battery Life (years)
BRM-52	BroodMinder-SubHub	0.06	0.033	0.035	3.233	0.506	1	600	1034	3401.2	0.1	4435	7000	1.6

Note: Validation measurements were performed utilizing a new (wonderful) instrument. The crowdfunded Joulescope, DC Energy Analyzer was designed to make these types of low power DC measurements.

13.3 Appendix E – Swarm Minder Details

In this appendix we will share a bit more about how the swarm minder (-SM) works.

The -SM is reading temperature once every minute. Then it compares current and prior values looking for specific changes.

It watches for a minimum temperature to be obtained. Once obtained, it watches for a temperature increase of at least 1C from 30 minutes prior. That increase must continue for between 2 and 20 minutes and be followed by a temperature decrease.

Version 5.26 is sensitive to false positives in order that we don't miss any. This will be reduced in future versions by more carefully verifying presence of brood as indicated by the Brood Zone™.

SwarmMinder State Codes (T2-SM Models 47, 56)

The following numeric codes (base 10) will be displayed in the Sample State value for the -T2SM & -TH2SM devices

SWM_STATE_STOPPED	
00	SM Stopped
01	Initialization complete - stopped
02	Stopped: by STOP request

SWM_STATE_CHECKING	
20	Start checking for swarm event
21	Buffering temperature data
22	Temperature < Hive Base Temp (32.5C, 90.5F)
25	Buffered Hive Temp < Hive Base Temp
29	SWARM EVENT DETECTED

SWM_STATE_LOGGING	
40	Swarm Event Detected - start logging
41	Still logging swarm data

SWM_STATE_WAITING	
60	Swarm Event logging complete- start waiting - swarm detection interval
61	Swarm Event logging complete- still waiting