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Shawnee Caves Cave Use Study FY 2002 Annual Report

to the Illinois Department of Natural Resources

L. Geoff Schropp

Little Egypt Grotto, Carbondale, Illinois

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Introduction

Cave environments are very unique and delicate and easily disturbed by outside intruders, especially humans. The wildlife living inside the caves is highly adapted and does not respond well to being disturbed. The idea for this study was originally based on the authors curiosity concerning just how much human use these caves are getting, what kind of use, what are the main motivations of people for entering caves, what are the associated impacts, and can the cave wildlife and the caves themselves sustain with elevated human use.

The State of Illinois does not have very many caves compared with some of its neighboring states, specifically Indiana, Kentucky, and Missouri, whose numbers dwarf those of Illinois. Does this mean that a lower number of caves means lower visibility and subsequent lower priority by land managers? Management of cave resources poses many unique issues land managers may not be prepared to address. Hall (1995) states "Because cave protection involves unique species and an environment unfamiliar to many scientists, the problems and challenges of cave protection are often daunting to managers assigned this responsibility" (p. 123). Foster (1989) feels that discussion concerning the management of caves is really concerned with control of the amount of damage that people inflict.

The caves causing the most concern were Ava Cave in Jackson County and Equality Cave (often referred to as Cave Hill Cave) in Saline County, both of which get a great deal of human visitation. These caves have suffered greatly from vandalism, careless use and littering, and impact from the sheer number of people visiting them. Foster (1989) feels that recreational caving has had the most impact on caves. He states:

The damage done by visitors to caves includes both intentional vandalism and accidental damage. Intentional vandalism includes actions such as spraypainting walls, breaking cave formations, killing bats and other animals, removing Indian artifacts, leaving behind garbage, etc. The accidental damage includes such actions as accidental breakage of cave formations, disturbance of sleeping bats, stepping on unseen cave animals, stepping on prehistoric footprints, and the sheer wear and tear on the cave from the hundreds and sometime thousands of cavers over a period of time (Foster, 1989, p. 82).

The intentional vandalism, which really is a dark form of recreation, is especially disturbing in Equality Cave. Atz (1999) describes an incident in which he observed a group of "flashlight cavers" killing hibernating bats in an Indiana cave. He was so upset he contacted the conservation police and was able to have one of the perpetrators prosecuted (he had also removed cave formations), and the man was given jail time, community service, and charged fines. Mr. Atz was later awarded $1000 for his efforts from the NSS (National Speleological Society) Cave Vandalism Deterrence Award. In this situation, the vandals were pretty much caught in the act, and the law enforcement officers cooperated. The prosecution of this vandal was a small victory, but most cave vandalism is not prosecuted or even reported.

While law enforcement may be effective in best-case scenarios like the one above, it is a form of intervention, when what is really needed is prevention. Trash and spray paint are regularly removed from Ava Cave by conscientious cavers and in the long run this may help prevent some intentional vandalism, but this is also a form of intervention and a short-term cure. Caves on federal lands that are granted significant

status are protected under the Federal Cave Resources Protection Act of 1988. What about the caves that are not so significant? D. Buecher (1995) feels the process of granting significant status to caves tends to favor the more spectacular caves or the ones with the rarest features or wildlife, leaving many caves in a more marginal status.

Abused caves like Ava and Equality still have value to the creatures residing in them. as well as for the recreational users. Some experienced cavers still visit them, and put forth quite a bit of effort cleaning them, even though they have been deemed "sacrificial." Rich's Cave and Guthrie Cave, both in Union County, have also been included in this study for comparison. Human impact in them is minimal compared with Ava and Equality Caves, but given enough visitation over time they could become abused caves as well. These caves need good management plans, and to make a good plan one needs to have a good understanding of what is going on in the caves. The findings of this study will hopefully provide land managers a better understanding of the human use and impacts of these caves.

Materials and Methods

The first objective of this study was to gain a somewhat accurate knowledge of the actual amount of human visitation to the four caves concerned. This was accomplished in three ways, with the first being a register installed in the caves. This involved clamping a closeable tube to a structure in the cave with wire rope so it would be harder to steal. Instructions for filling out the register were taped to the outside of the tube and were also on the cover of the register (Appendix A). The registers (Appendix B) were obtained from the Contemporary Cave Use Study (CCUS) of the National Speleological Society (NSS). The NSS is a national non-profit organization of which the author is a member, and it is dedicated to the preservation and conservation of caves worldwide. The CCUS is a long-term study of cave use, and the registers are used to gather information on user demographics, purpose for entering the cave, length of stay, number of people in group, NSS affiliation, personal equipment, first entry to a non-commercial cave, how the cave was found, organizations caving with, and the number of cave trips been on. Register pages that had been filled out were removed on each research visit for data entry. The registers were placed in zip-lock bags with sharpened pencils.

The second method of gaining evidence of human visitation was through the use of "Hobo on/off loggers" light sensing monitors, which were used to detect outside light sources and were provided by the Shawnee National Forest. The light monitors were disguised by putting them in packaging that had been painted flat brown, leaving a small window open for sensing. The l.e.d. (light emitting diodes) lights were covered with tape, and a small laminated card (Appendix C) was placed in each. They were set at the most sensitive setting and installed in the caves. It was necessary to dig small holes and cover

them with mud in a way to avoid cave user detection. This was challenging, as they needed to see without being seen. They were placed in a way that would best detect lights from users moving in a logical pattern within the cave. They were also placed in close proximity to the CCUS registers to try to gain knowledge of cave user compliance with filling out the registers. The monitors were dug up on each research visit to the caves, and the data downloaded to a shuttle for transfer to a personal computer. The monitors were then re-disguised.

The third method of gaining evidence of human visitation was through verbal communication with cave users at the entrance to Equality Cave only. This occurred on only four occasions, and the users were somewhat non-cooperative.

Another objective of the study was to determine if elevated human use affected the temperature of the caves. "Hobo H8 Pro Series" temperature monitors were installed in the caves to measure the cave temperature, and these were also provided by the Shawnee National Forest. Protective boxes were fabricated to orient the monitor in an upside down position to prevent moisture from collecting on a humidity sensor. These were also painted flat brown for disguise, as well as given a laminated card (Appendix C). The temperature monitors were much easier to camouflage, as they were placed in high crevices and were not easily viewable without some climbing. The monitors were set to measure the temperature every eight hours or three times a day. The monitors' data were downloaded on each research visit to a shuttle for transfer to a personal computer. Through testing, one of the monitors was determined to be malfunctioning. It was mailed to the Onset Corporation for repair, resulting in a delay installing it in Guthrie Cave.

Each cave was also briefly visually inspected by the author, primarily looking for amounts of trash, graffiti, vandalism, or other blatant forms of human disturbance or stewardship. A cursory inspection of visible wildlife was also performed.

Results

The results of the data obtained through the cave registers and light monitors are summarized (see Appendix D), and will be addressed in the Discussion Section.

The results of the data obtained through the temperature monitors is summarized below:

Guthrie Cave

Dates: 10/22/01 to 6/16/02

Number of Readings: 713

Average Temperature: 52.58 Degrees F

Median Temperature: 52.73 Degrees F

Mode Temperature: 54.75 Degrees F

Highest Reading: 56.49 Degrees F on 5/13/02

Lowest Reading: 48.02 Degrees F on 1/4/02

Variance: 8.47 Degrees F

Ava Cave

Dates: 8/5/01 to 6/29/02

Number of Readings: 989

Average Temperature: 53.55 Degrees F

Median Temperature: 53.62 Degrees F

Mode Temperature: 53.75 Degrees F

Highest Reading: 54.06 Degrees F on 10/24/01

Lowest Reading: 52.97 Degrees F on 3/25/02

Variance: 1.09 Degrees F

Equality Cave

Dates: 8/23/01 to 6/22/02

	Number of Readings:	913
	Average Temperature:	50.31 Degrees F
	Median Temperature:	51.12 Degrees F
	Mode Temperature:	51.74 Degrees F
	Highest Reading:	52.70 Degrees F on 10/11/02
	Lowest Reading:	47.49 Degrees F on 3/5/02
	Variance:	5.21 Degrees F
Rich's Cave	Dates: 8/21/01 to 6/30/02	
	Number of Readings:	800
	Average Temperature:	52.41 Degrees F
	Median Temperature:	52.75 Degrees F
	Mode Temperature:	53.32 Degrees F
	Highest Reading:	58.52 Degrees F on 9/6/01
	Lowest Reading:	44.69 Degrees F on 1/4/02
	Variance:	13.83 Degrees F

Graphs of the temperatures for the study periods listed can be viewed in Appendix E for Guthrie Cave, Appendix F for Rich's Cave, Appendix G for Ava Cave, and Appendix H for Equality Cave. Please note that the scales on the graphs vary based on the amount of time covered between monitor data retrievals and the amount of variance in temperature readings.

Discussion

The results of the data obtained through the cave registers will be discussed below, addressed by subject.

The Caves: The ease of access to a cave entrance plays a large role in the amount of human visitation the cave will receive. Guthrie Cave is in Union County and requires a hike of almost a mile, with the trail hard to follow and in places overgrown. It had the least amount of visitation and seemed to be the least impacted by visitors. Guthrie Cave is also a State Nature Preserve and requires a permit to enter. The manager informed the author that he was the only person to ever apply for one. It has a large sign at the entrance, which simply says "Guthrie Cave," and is only visible immediately in front of the cave.

Rich's Cave is also in Union County, and is most easily accessed through a private landowner's property. This landowner is a steward for the cave and takes an active interest in discussing it with visitors who park on his property. This probably has a positive effect in keeping out visitors who may otherwise enter the cave for illicit purposes. The hike to the cave is considerably shorter, with a wide, well maintained trail. Rich's Cave is in the Shawnee National Forest, and is designated an Illinois Natural Heritage Landmark. It has a sign to this effect, and also a closure sign for the dates September 1 through April 30 to protect bats. This cave is very well maintained, with a minimum amount of graffiti and trash.

Ava cave is in Jackson County and is also in the Shawnee National Forest. It has three entrances, with the main entrance only about fifty feet from a pullout on a remote

forest road. This ease of access has without a doubt led to high visitation numbers. There are no signs for this cave. It is highly impacted, and gets quite of bit of illicit use, resulting in large amounts of trash and graffiti at times. However, this cave also benefits from quite a bit of stewardship from NSS grotto members and other organized groups, who periodically clean trash and scrub off graffiti.

Equality Cave is in Saline County and is also in the Shawnee National Forest. Access to the entrance is by parking at an abandoned church and hiking about a half mile uphill on a well-defined trail. Continuing on this trail will eventually lead to Glenn O. Jones Lake State Park, where there was (at least a couple of years ago) a small sign pointing the way to the cave. The driveway to the church continues on a short distance to a private landowner's residence. These landowners do not seem to want to have anything to do with the cave. There is a spray painted sign at the driveway entrance that says, "Stay out after dark," and there is another that says, "Cave," pointing the direction to get on the trail so visitors will not continue on the driveway to their residence. Equality Cave is by far the most heavily impacted of the four caves, and receives a high degree of illicit use. It is a maze cave, and extremely easy to get lost in. For this reason, many visitors tie string at the entrance and end up leaving it there when they leave, resulting in literally miles of string in the cave. It is very heavily spray painted with quite a bit of trash. The author and the Little Egypt Grotto of the NSS have held an annual clean up at the cave for the last five years and have been making progress, but it is very saddening to see such reckless and careless use of this cave.

Dates and Time Period Covered: The cave register was installed in Guthrie Cave on January 24, 1998, and the light and temperature monitors were installed October 22, 2001. Therefore, the register covers a period of about 4 years and 6 months, whereas the monitors only cover about 8 months. Final data retrieval for this report was conducted on June 16, 2002.

All equipment was installed in Rich's Cave on August 21, 2001, and final retrieval was conducted on June 30, 2002. This represents about 10 months worth of data.

All equipment was installed in Ava Cave on August 5, 2001, and final retrieval was conducted on June 29, 2002. This represents about 11 months worth of data.

All equipment was installed in Equality Cave on August 23, 2001, and final retrieval was conducted on June 23, 2002. This represents about 10 months worth of data.

Number of Cave Visitors: The number of visitors was determined though register information, light monitor data, and in the case of Equality Cave, verbal communication at the entrance and parking area. "Group visit" will be used to express a separate and distinct group visiting the cave, and this was determined in the same way. The light monitor data only shows distinct group visits, and not the number of distinct visitors. This means that a visit logged on the light monitor, but not in the cave register, could be one person or a very large group. Each light monitor log is counted as only one visitor in this report, unless the log corresponded with entries in the cave register. Compliance refers to the percentage of visits logged on the monitor that registered. Success rate refers to the percentage of visits (which were verifiable through register and light monitor data) that were detected by the light monitor.

Guthrie Cave had 85 visitors representing 28 group visits over a period of almost four and a half years. During the 10-month period covered at the other caves, Guthrie had 16 visitors representing 5 group visits. There were 5 group visits logged on the monitor, 3 of which were registered. This represents a 60% compliance. All 5 of the groups known to visit the cave were logged by the monitor, showing a success rate of 100%.

Rich's Cave had 38 visitors representing 17 group visits. There were 11 group visits logged on the monitor, 6 of which registered, representing a 54.55% compliance. The monitor success rate for detecting visitors' lights was 64.71%.

Ava Cave had 184 visitors representing 39 group visits. There were 26 group visits logged on the monitor, 13 of which were registered, representing a 50% compliance. The monitor success rate for detecting visitors' lights was 66.67%.

Equality Cave had 156 visitors representing 45 group visits. There were 23 group visits logged on the monitor, 12 of which were registered, representing a 52.17% compliance. The monitor success rate for detecting visitors' lights was 51.11%. Unfortunately, the light monitor was found destroyed at the entrance on the last research visit (June 22, 2002). Richard Young and Les Vaughn (personal communication, 25 June, 2002) stated that they had briefly checked and thought the monitor was still in place on a visit to the cave on June 15, 2002. This resulted in a loss of all light monitor data from the previous research visit (April 20, 2002) on. Also, the maze-like passages offer visitors many different ways to go upon entering the cave. The light monitor and register were placed in the most logical passage, but they could both be easily bypassed.

Average Zip Code: This number provides information on how local the cave visitors tend to be. It is of dubious reliability, and would be much more reliable if all of the visitors were from Illinois. The reason for this is out of state zip codes with much lower numbers. All Illinois zip codes are in the 6000's. Tennessee and Kentucky zip codes are in the 4000's and Wisconsin zip codes are in the 5000's. All of these states, as well as Missouri have been represented in the registers.

The Guthrie Cave average zip code was 62927, and the corresponding location was Dowell, which is between Desoto and DuQuoin, and the closest location to the cave by far.

The Rich's Cave average zip code was 61895, and the closest corresponding location was White Heath, which is east of Champaign and about 200 miles away.

The Ava Cave average zip code was 61889, and the closest corresponding location was also White Heath, which is east of Champaign.

The Equality Cave average zip code was 60861, and the closest corresponding location was Riverdale, which is just south of Chicago and about 300 miles away. This is the furthest location from the cave, and is probably due to visitors from Tennessee, Kentucky, and Wisconsin.

Gender: Guthrie Cave had 63 responses to this item, with 63.49% being male, and 36.51% being female.

Rich's Cave had 27 responses to this item, with 85.19% being male, and 14.81% being female.

Ava Cave had 156 responses to this item, with 63.46% being male, and 36.54% being female.

Equality Cave had 92 responses to this item, with 78.26% being male, and 21.74% being female.

Average Age: The average ages of cave visitors are: Guthrie Cave-30.8 years, Rich's-27.7 years, Ava-23.5 years, and Equality-30.8 years. Ava cave's low figure is probably due to the large number of youth group visits.

Reason for Entering Cave: People enter caves for a variety of reasons. Meinhardt (2001) questioned cavers from the Chouteau Grotto in Columbia Missouri, and found that many of the cavers felt that what they were doing was very unique and special. All of the reasons listed below have one thing in common: They all take place in a specific cave environment, which makes it a unique experience to the visitor. The register lists eight reasons for entering the cave, and they are education or training, conservation or clean up, mapping, exploration, photography, recreation or sightseeing, scientific, and other. A visitor can check as many of these areas as they want. Please see Appendix D for the specific numbers and percentages, as they will not all be discussed.

Ava Cave had an exceptionally high number listing education and training (42.05%), and this is probably due to the high numbers of youth groups entering the cave for educational purposes.

Equality Cave had a rather high number listing conservation and clean up (26.40%), which is probably very deceptive due to most grotto cavers visiting the cave

end up picking up trash beyond the annual organized clean up efforts. Also, the visitors doing the vandalism and littering probably do not fill out the register out of fear of being caught.

Cave mapping is a fairly technical process, and any visitors reporting mapping on the registers probably were not. Grotto cavers usually share mapping information with each other, and to the author's awareness, there were no mapping projects in these caves during these time periods. Cave surveyors are very passionate about their hobby, and Dasher (1994) notes that cave mapping can lead to a great feeling of accomplishment and an ultimate appreciation of a cave. The Little Egypt Grotto is presently mapping in Rich's Cave.

Exploration had high numbers in Guthrie Cave (29.2%) and in Rich's Cave (32.5%). Both of these caves require some immersion in cold water, and perhaps this gives visitors more of a feeling that they are exploring.

Photography had fairly low numbers in all of the caves, with those in Guthrie (7.08%) and Rich's (7.5%) being slightly higher. This could be due to these caves being much cleaner and free of major vandalism.

Recreation or sightseeing had high numbers in all of the caves, with Guthrie having 33.63%, Rich's 27.5%, Ava 32.2%, and Equality 29.6%. These figures show the most consistency between the caves.

Scientific reasons for entering a cave scored exceptionally high in Guthrie (17.7%). Guthrie cave is visited periodically by Illinois Department of Natural Resources (IDNR) personnel. The author is also aware of Southern Illinois University at Carbondale (SIUC) students doing cave salamander research there in the past.

Other reasons for entering the cave were fairly low for all of the caves. However, Ava and especially Equality Cave get a great deal of visitation for illicit purposes. Young people frequently use Equality Cave (and to a lesser extent Ava Cave) as a hang out spot and drink, use drugs, and litter and vandalize. These visitors probably do not frequently fill out the registers.

Average Length of Stay in Cave: The average length of stay in the caves was: Guthrie- 1.85 hours, Rich's- 1.34 hours, Ava- 2.33 hours, and Equality- 3.55 hours. The average stay in Equality seems to be a little high compared with the others. However, Equality is the only maze cave of the four, and one could easily spend a great deal of time exploring it. The wet nature of Guthrie and Rich's could lead to visitors spending less time in them as well.

Average Number of Visitors per Group: The average number of visitors per group was: Guthrie- 4.4, Rich's- 4.3, Ava- 11, and Equality- 6.8. The number for Ava seems exceptionally high, but there are a lot of youth groups using the cave. This high number caused the author to reevaluate the method for obtaining this figure. By dividing the total number of visitors by the total number of group visits, a set of more realistic numbers was obtained: Guthrie-3.04, Rich's- 2.24, Ava- 4.72, Equality- 3.47.

National Speleological Society Affiliation: The National Speleological Society (NSS) is a non-profit organization dedicated to preserving and conserving cave environments. Rouse (2001) states "The National Speleological Society (NSS) was established in 1939,

but experienced slow growth until the 1960's" (p. 18). It has nearly 200 local chapters (called grottos) nationwide (Kimmel, 2002), including the Little Egypt Grotto in Carbondale, IL. Grottos from outside the area also visit these caves, and the register shows visits from SEMO Grotto in Cape Girardeau, MO, Stygian Grotto and Meramec Valley Grotto from St. Louis, Near Normal Grotto in Bloomington, IL, Windy City Grotto in Chicago, Sub-Urban Chicago Grotto, and the Nashville (TN) Grotto. The number of NSS visitors to the caves are: Guthrie- 19 (22.35%), Rich's- 5 (13.16%), Ava- 15 (8.15%), and Equality 15 (9.62%).

When joining the NSS, a new member is issued a number, which is theirs for life regardless if they remain a member or not. The average NSS numbers listed in the registers are: Guthrie- 39824, Rich's- 41970, Ava- 41231, and Equality-35008. This number can be used to look at the average time frame the visitor joined the NSS. For instance, the author's NSS number is 40075, and he joined in October, 1994.

Equipment: The equipment items from the cave registers are concerned with a hard hat and lighting systems. NSS standards dictate a helmet mounted light source and at least two additional light sources at a minimum. The helmet mounted light allows a caver to climb and negotiate obstacles while using their hands, making them much safer and protecting their head in the process. Many experienced cavers use two helmet-mounted lights in case the first goes out. A visitor with only one light runs a serious risk of being stranded and lost in a cave if this light should fail. Knutson (1994) states "The extent of safety one wishes to realize is part of what one expects or hopes to experience while caving. Some want a lot of risk, some want little…but everyone should know what the

hazards are" (pp.374). Many visitors have little knowledge of the hazards they face, and put themselves and possibly others at a greater risk by not being properly equipped. In Putnam's (2000) breakdown of caving accident and incident statistics from 1986-1998, the category for incident type "Aid, no injury" had the highest number of entries almost every year. Putnam states that the majority of these incidents were a result of the visitors being under equipped and lacking in experience.

Visitors should check off each piece of equipment they are using. For instance, a visitor who has a helmet mounted carbide lamp and electric back up light, a spare flashlight, and a candle and matches, would check all of the equipment categories. A properly clothed caver with multiple light sources can survive a very long time in the cold, wet environment. The percentages listed in the results were figured by dividing the total for each piece of equipment by the total number of cave visitors. Please see Appendix D for the complete list of data, as not all of the items will be addressed here.

The percentage of visitors listing at least one piece of equipment in the registers was: Guthrie- 88.24%, Rich's- 57.89%, Ava- 72.28%, and Equality- 55.77%.

The use of hard hats was very high in Guthrie (57.65%) and Ava (64.13%), and quite low in Rich's (13.16%). The high number in Ava is probably due to the high numbers of properly equipped youth groups, while the low number of visitors to Rich's were mostly due to shorter trips into a smaller cave with a much larger and easier to find (from inside) entrance.

The use of carbide lamps was high in Guthrie (24.71%) and very low in the other caves. As electric lighting systems have become much more efficient and affordable,

Carbide lamp use has been on the decline. The high number of use in Guthrie is probably due to more visitation by older and more experienced cavers.

The use of electric lights was high in Guthrie (56.47%) and Ava (62.50%), and this is most likely due to the same reasons listed above. The author understands "electric" to mean a helmet mountable battery powered light. There was probably some visitor confusion in this area, most likely leading to flashlight cavers listing electric as well.

The use of a flashlight had typically high numbers in all of the caves, with the exception of Ava Cave (29.35%), which is probably once again due to the youth groups. This makes sense, as flashlights are readily available to the public and can be purchased rather inexpensively.

The flashlight only category showed a high of 36.84% in Rich's and a low of 4.35% in Ava. Caving with only a flashlight is very dangerous, as it could fail with catastrophic results. The author feels that the fairly low number for Equality (14.10%) should be much higher, and this is probably due to visitors not filling out the register or not finding it.

The use of an "other light source" was fairly consistent for all of the caves, ranging from 13.16% in Rich's to 19.02% in Ava. This source is normally considered to be for emergencies, but may be checked off for lanterns, lighters, or any other source not covered by the other categories.

Average Year First Entered a Non-Commercial Cave: Commercial caves are generally considered to be ones that visitors pay to enter, and are generally guided and

often illuminated with electric lighting. The averages are Guthrie- 1990, Rich's- 1989, Ava- 1997, and Equality- 1991.

How the Visitors Found the Caves: Cave locations are quite often guarded with secrecy within the caving community, but not so much with the general public. Word of mouth has often resulted in high impact to some caves. Perez (2002) states the following:

> There are many sources of cave locations in the public domain including books, maps, and even web sites. There are not enough standards or policies for the disclosure of cave locations. There are no rules or sanctions for those who give out locations of sensitive sites. The caves pay the price for our indiscretion (p. 171).

This statement is probably more accurate concerning caves on privately owned lands. However, caves on federal lands which have been identified as being significant are protected under the Federal Cave Resources Protection Act of 1988 (1988), which states:

> Information concerning the specific location of any significant cave may not be made available to the public under section 552 of title 5, United States Code, unless the Secretary determines that disclosure of such information would further the purpose of this Act and would not create a substantial risk of harm, theft, or destruction of such cave (p. 4304).
>
> Additionally, Huppert (1995) notes that Illinois is one of many states that have specific laws to protect caves.

Please consult Appendix D for all of the data, as it all will not be discussed here.

Finding the caves through friends had the highest numbers in this category, with a high of 59.09% in Rich's, to a low of 30.32% in Ava. As friends tell friends, this area has the highest potential to create excessive visitation to the caves.

Finding the caves through books had the lowest numbers in this category by far, with a high in Equality of 2.90% to a low in Rich's of 0%. Books available to the public detailing cave locations are definitely a thing of the past. Most are considered collector's items and their purchase is actively pursued by the caving community to keep them away from the general public.

Finding the caves through clubs had fairly consistent numbers, with a high of 39.13% in Equality, to a low of 24.52% in Ava. The majority of these clubs were NSS grottos, but there were also Christian groups, Scout groups, and Scout camps. There was even listed an illicit "CZR Bong Team."

Other means of finding the caves showed a very high number in Ava Cave (44.52%), and this is probably once again due to the large number of youth groups entering this cave.

Number of Visitors Claiming an Organization or NSS Grotto: The numbers claiming affiliation with an organization was: Guthrie- 50.59% (NSS Grotto- 34.18%), Rich's- 18.42% (NSS Grotto- 13.16%), Ava- 70.11% (NSS Grotto- 11.96%), and Equality- 24.36% (NSS Grotto- 19.23%). Ava cave had by far the most organized group visitation, with 58.15% being groups not affiliated with the NSS. This is once again probably due to the large number of youth groups visiting the cave.

Number of Caving Trips the visitors have been on: This category can help to provide a better understanding of the overall caving experience of the visitors. Please consult, Appendix D. as all of the data will not be discussed here. Visitors were asked to check a category on the registers stating the number of cave trips they have been on, including multiple trips to the same cave. There were eleven categories ranging from 1 to 501 or more. Averages were computed for all categories (Appendix D), as well as an average for visitors who had been on 1-10 cave trips, and 11-501 cave trips, which are addressed below.

The numbers claiming 1-10 cave trips were: Guthrie- 31.82%, Rich's- 70%, Ava- 69.35%, and Equality- 47.62%.

The numbers claiming 11-501 cave trips were: Guthrie- 68.18%, Rich's- 30%, Ava- 30.65%, and Equality- 52.38%.

Guthrie cave is difficult to find and its location is not well known by the general public compared with the other caves. A higher level of experience is expected for the visitors to this cave. Unavoidable passage through cold water probably keeps out some of the less experienced, and the more pristine state of the cave may still hold attraction for experienced cavers.

The main passage of Rich's Cave, which most visitors stay in, is quite short in distance, and it has a large entrance quite visible from a good part of this passage. This probably leads to more casual curiosity-based visitation and not much challenge for the experienced caver. There is however, a great deal of challenge available to the visitor who is willing to crawl through very tight partially water filled passage.

The easy access to Ava Cave coupled with the high number of youth groups has made this an often-used first time experience cave (28.23% first cave visit). More experienced cavers typically use this cave more for training and clean-up efforts than any other reason.

The figures for Equality Cave are a bit harder to evaluate, as it has a much more even distribution of experience. Regular clean-up efforts draw many experienced cavers, and the more experienced cavers seem to be more willing to fill out the registers. Equality is also somewhat geologically unique among southern Illinois caves, which may draw experienced cavers interested in this aspect of caving, despite the "trashed" appearance of the cave. The author also feels that the well-known location of this cave has led to many return trips by visitors who may only know the location of this one cave.

Day of the Week: The day of the week that visitors entered the caves was not asked for on the registers, but was deduced from the date listed, which was requested. Some of the most reliable data came from this area, as the light monitors logged the exact date and time of the visits. The complete data is in Appendix D, and weekend and weekday percentages are listed below.

Guthrie Cave had 63.75% weekend visits and 36.25% weekday visits.

Rich's Cave had 19.44% weekend visits and 80.56% weekday visits.

Ava Cave had 33.7% weekend visits and 66.3% weekday visits.

Equality Cave had 61.54% weekend visits and 38.46% weekday visits.

Caving, along with many other recreational activities, is traditionally done more on weekends than during the week due mostly to work schedules and available free time.

Guthrie and Equality Cave visitations follow this pattern. The reverse was true for Ava with two-thirds of the visits occurring on weekdays, and Rich's with 80.56% on weekdays. The high Ava number is most likely due to the large number of youth group visitations, and the high Rich's number can perhaps be attributed to people visiting the cave while on vacation and/or combining it with other activities. To get to Rich's Cave, one must park on the private landowner's property, and he operates an antique store and bed and breakfast there. It is also located just off the Southern Illinois Wine Trail. Visitation which is spread out more throughout the week may tend to have less impact on the wildlife within the cave. Illinois Caverns in Monroe County has such high visitation on the weekends that the cave has been officially closed on Mondays and Tuesdays, presumably to allow the wildlife a chance to recover. Guthrie and Ava both had no visitors on Tuesdays, Equality only had one on Wednesdays, and Rich's only had one on Thursdays.

Temperature: One of the objectives of this study was to measure the temperature within the caves and try to determine if increased human visitation altered this temperature. This was done by comparing the dates and times of rises in temperature with visits logged in the registers and on the light monitors. Also, the dates of group visits with high numbers of visitors was matched with the temperature data for that particular day, and if possible time. All temperatures used in this report, unless otherwise noted, will be in degrees Fahrenheit. Graphs of the temperatures for the study period are in Appendix E-H.

Ava Cave had the most constant temperature, with a high of 54.06 degrees and a low of 52.97 degrees, varying by only 1.09 degrees. Researcher handling of the monitors raised the temperature reading slightly if it logged it shortly after handling. For instance, on one research visit the temperature was 53.01 degrees at 07:21 in the morning. At 15:21 it registered 54.14 degrees, a rise of 1.13 degrees. The monitor had been handled for data retrieval only five minutes before this reading. This temperature rise due to handling, as well as others, was not included with the high/low temperature data as it was inconsistent with the rest of the data. Ava Cave also had the highest average temperature (53.55) and median temperature (53.62) of the four caves. The largest temperature variations occurred on days (0.44 and 0.13 degrees) when there were no visitors registered or logged. There were a few occasions in which large group visits corresponded with slight rises in temperature (10 visitors/0.05 degree rise, 18 visitors/0.05 degree rise, 16 visitors/0.04 degree rise, and 18 visitors/0.09 degree rise). There was one unregistered visit logged on the light monitor with a rise of 0.05 degrees. On the next research visit the refuse of several tea lights (small candles) was found approximately 20 feet from the temperature monitor, and this may have been the cause of the temperature increase. P. Borsari (personal communication, August 6, 2002) of the Onset Corporation states the accuracy of the temperature monitors as being plus or minus 0.33 degrees at 70 degrees Fahrenheit.

Equality Cave had the lowest average (50.31 degrees), median (51.12 degrees), and mode (51.74 degrees) temperatures. The author feels this cave is a Cold-air-trap cave. R. Buecher (1995) states:

> Cold-air-trap caves selectively capture and hold cold air. Typically these caves have entrances and initial passages which slope downward from the entrance. Usually there is only a single entrance and the cave volume is relatively small. At night or during the winter months, air that is colder or of greater density will flow into the cave, filling the areas lower than the entrance with cold air. During the warmer months of the year, a pool of colder dense air remains. The volume of cold air stored must be large enough to keep the area cool for several months (p. 43).

The temperature in Equality Cave dropped below 50 degrees on 12/27/01 and did not rise above 50 degrees until 5/6/02. Dunlap (1995), from his research in caves of southern Indiana, states that the endangered Indiana Bat (Myotis sodalis) prefers colder temperatures for its hibernation areas, typically between 5-10 degrees Celsius (41-50 degrees Fahrenheit). Harvey (1992) notes a slightly lower temperature of 38-43 degrees Fahrenheit. Dunlap also states (as cited in Brack, Tyrell, & Dunlap, 1995) that these bats are very selective and "While there are tens of thousands of caves in this species' known hibernation range, only about 135 caves have been documented as being used by these bats with only a dozen or so caves containing substantial populations" (Dunlap, 1995, p. 76-77). Equality Cave could have the potential to be an Indiana Bat hibernaculum temperature-wise, but the author feels the high degree of visitation and impact to the cave may prove to be a deterrent for the sensitive creatures. There were eight occasions when visits corresponded with slight temperature rises ranging from 0.04 to 0.09 degrees, and one light monitor log with a rise of 0.31 degrees. A visit research on March 19, 2002, found Equality Cave partially flooded, and very cold water had pooled in the bottom of

the cave. This water was waste deep near the temperature monitor, and was draining to lower levels, but not fast enough to keep it from pooling. The author had never seen more than a trickle of water in this cave. Some of the coldest temperatures correspond with times of extremely heavy surface precipitation. Perhaps large amounts of very cold water may cause a lowering of temperature in this type of cave.

Guthrie, and especially Rich's Cave, had the highest variations of temperature, with the highs and lows being somewhat consistent with surface temperature. For this reason, the author feels these caves fall into the chimney cave classification. R. Buecher (1995) states:

> Chimney caves are caves with two or more entrances which lie at different elevations. During the year two patterns of steady airflow can develop due to the differences in air density between the two entrances and the air in the cave. The greater the elevation difference the more pronounced the air flow will be.
>
> During the winter, cool air entering the lower entrance is warmed and rises to the top of the cave and exits as a plume of warm air at the upper entrance. During the summer, the air inside the cave is cooler and more dense than outside air and it flows out the lower entrance (p. 43).

Rich's Cave has two entrances at higher elevations than the large main entrance, and Guthrie Cave is rumored to have a second entrance.

Rich's Cave had no temperature changes that could be attributed to visitation. Guthrie Cave had three rises in temperature (1.05, 0.04, and 0.17 degrees) corresponding with light monitor logs. The last rise corresponded with a research visit and was logged three minutes before the temperature monitor data was downloaded. There were six

visitors in close proximity to the monitor. A very big rise and fall of temperature recorded in Rich's Cave on October 7-8, 2001, was due to the temperature monitor being removed for replacement, and the changes during this time period were actually outside surface temperature readings.

Summary

A great deal of information has been gathered through this study. Ava and Equality Caves have had excessive amounts of visitation and show it. Due to fiscal year restraints, data is missing from this research for some summer months. Summer is traditionally a time of increased recreation, and one has to believe that this would mean increased visitation to the caves. It would not be unreasonable to estimate 300 or more visitations to Ava Cave, and 400 or more visits to Equality Cave annually. Guthrie and Rich's Caves probably experience more visitation as well, but at much lower numbers.

The state of abuse to Equality Cave requires serious attention. Its reputation as a "party cave" in the local community has led to serious damage and degradation. Many people write this cave off as a lost cause, but many others do not feel this way. Clean-up efforts have made great progress, but something needs to be done to mitigate future illicit use of and damage to this cave. Taylor and Webb (1998) state "The public knows very little about caves and the organisms that inhibit them" (pp. 3). Perhaps an educational effort could be effective in helping to prevent future damage. Foster (1989) feels that making the public aware of the need to protect caves will help on a long-term basis. Perhaps a small sturdy sign inside the cave entrance could help to make vandals aware that they are breaking the law, and could also provide conservation information as well. A sign outside this cave would probably be very short-lived. A law enforcement effort leading to prosecution may have a strong mitigation effect as well. Gating the cave and restricting use may be the most effective solution.

The state of abuse in Ava Cave is much less, and over the years clean-up efforts have helped to reduce the amount of vandalism a great deal. People spray painting arrows

to find their way does seem to be a recurring problem, as these arrows are periodically scrubbed off and then reappear. Tom Clifton of the Meremac Valley Grotto (personal communication, July 2001) has spearheaded clean-up efforts at Ava Cave, and he suggested mounting small reflective arrows in strategic locations to help with this problem and even provided a prototype. Accidental damage seems to be the biggest problem in this cave due to the large numbers of visitors. Trout (1998) suggests impact mapping as a way to keep track of cave damage. Setting up a permitting system in this cave may be the best solution for limiting use. Anita Arends of the Shawnee National Forest (SNF) (personal communication, March 2002) states that they are in the process of establishing guidelines for permits for guided cave visitation for the Forest, as it is not covered under their recent Decision Memo concerning Commercial Outfitting and Guide Services (Foot Travel). The main entrance of Ava Cave's close proximity to the road would make an outside sign prohibitive, as it would attract even more visitors. A small sturdy sign just inside the cave entrance would probably be helpful.

Guthrie and Rich's caves simply do not have the abuse problems suffered by the other caves. Their somewhat remote locations are probably the main reason for this. Keeping public knowledge of their locations to an absolute minimum should be priority to help keep them from becoming abused. The sign in front of Rich's Cave has been pretty effective in keeping people out during the bat closure time period. Seven of the seventeen cave visits occurred during the closure, but there were no visits between October 11, 2001, and March 27, 2002, a really critical time period when the bats should not be disturbed. Guthrie Cave has a large sign, and it would be helpful to provide information on this sign addressing conservation, information on safe caving techniques

and equipment, and maybe even State legal information concerning caves and Nature Preserves. Guthrie Cave has a sizeable bat population, and may benefit from a seasonal bat closure. An inventory of wildlife would be helpful in determining the need for this.

One of the most beneficial findings of this study concerned the effectiveness of the light monitors for measuring visitation. Properly placed, they worked quite well for detecting group visits, but were not accurate in determining group size. The brighter the light, the better they worked. Some large groups using l.e.d. lights did not log at all, due to the soft nature of these lights. Proper positioning and camouflage were critical with these monitors. Placing more than one in a cave could increase the accuracy of visitation measurement, and their relatively low cost ($ 59.95) is not prohibitive.

Most of the temperature changes possibly attributable to human visitation were so negligible and few that it is probably safe to say that there was no noticeable effect on temperature due to normal human cave visitation. The accuracy of the monitors compared with the small temperature changes also lead to the same conclusion. No data was available for some of the summer months, and this probably resulted in lower temperature averages for all of the caves. The collection of the data will still be beneficial though, as it will be continued, and as Dunlap (1995) states, temperature data covering many years will no doubt be beneficial to future research.

Acknowledgement

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CAVE REGISTER
and
QUESTIONNAIRE

Cave _____

County _____ State _____

This register is maintained by the _____

Date register placed in cave _____ Date register removed from cave _____

INSTRUCTIONS and HOW TO SAVE TIME

1. Every person in each group should fill out a questionnaire on each trip into the cave.

2. Please assist in advancing the understanding of caves and caving by filling out the next available questionnaire in this cave register book. Most questions are self explanatory and designed to be answered quickly. You do not need to spend time recalling your past caving to obtain exact answers.

3. If there are two or more register books available, you may save time by having some of your group fill out questionnaires in one book while other group members fill out questionnaires in another book at the same time.

4. If you have filled out a cave register questionnaire like this one in the last 6 months, you may save time by skipping the personal data questions that have not changed. Every entry should at least have name, zip code, trip date, NSS number (if one), trip purpose, length of trip and size of group. Also please answer those questions in which your answers have changed. Cavers who often fill out registers should completely answer a questionnaire at least once a year as some registers are not returned.

5. Please do not over tighten the lid of the register container. It is not intended to be watertight.

SPONSORS:

Cave Conservation and Management Section (NSS), Middle Ozark Lower Earth Society (NSS), The Robertson Association (OTR), Southern California Grotto (NSS), The Virginia Region (NSS), Toronto Caving Group, Vertical Section (NSS).

Published: November 1990, Version 5.10 Code: NoDRD ____, NoMS ____.

Name_____ Age_____ Male_____ Female_____

Address_____ Today's date_____

City_____ State_____ Zip_____

Main purposes of this cave trip: Education or training___, Conservation or cleanup___,Mapping___, Exploration_____, Photography____, Recreation/sightseeing____, Scientific_____, Other_____.

How long do you plan to stay in the cave, in hours?_____. # of people in your group on this trip?_____. Are you an NSS member? Yes____No____, Number_____.

Check types of equipment you are using: Hardhat_____, Carbidelamp____,Electric____,Flashlight____,Other light source____. Year you first entered a non-commercial cave:____.

How did you find this cave? Friends___ Book/periodical____,Club____,Other____. Name the organizations, clubs or grottos you usually cave with:_____.

Circle approximate number of cave trips you have been on. (Count multiple trips into the same cave separately.) 1 2 3 4 5-10 11-25 26-50 51-100 101-250 251-500 501 or more

Comments_____

Name_____ Age_____ Male_____ Female_____

Address_____ Today's date_____

City_____ State_____ Zip_____

Main purposes of this cave trip: Education or training___, Conservation or cleanup___,Mapping___, Exploration_____, Photography____, Recreation/sightseeing____, Scientific_____, Other_____.

How long do you plan to stay in the cave, in hours?_____. # of people in your group on this trip?_____. Are you an NSS member? Yes____No____, Number_____.

Check types of equipment you are using: Hardhat_____, Carbidelamp____,Electric____,Flashlight____,Other light source____. Year you first entered a non-commercial cave:____.

How did you find this cave? Friends___ Book/periodical____,Club____,Other____. Name the organizations, clubs or grottos you usually cave with:_____.

Circle approximate number of cave trips you have been on. (Count multiple trips into the same cave separately.) 1 2 3 4 5-10 11-25 26-50 51-100 101-250 251-500 501 or more

Comments_____

Name_____ Age_____ Male_____ Female_____

Address_____ Today's date_____

City_____ State_____ Zip_____

Main purposes of this cave trip: Education or training___, Conservation or cleanup___,Mapping___, Exploration_____, Photography____, Recreation/sightseeing____, Scientific_____, Other_____.

How long do you plan to stay in the cave, in hours?_____. # of people in your group on this trip?_____. Are you an NSS member? Yes____No____, Number_____.

Check types of equipment you are using: Hardhat_____, Carbidelamp____,Electric____,Flashlight____,Other light source____. Year you first entered a non-commercial cave:____.

How did you find this cave? Friends___ Book/periodical____,Club____,Other____. Name the organizations, clubs or grottos you usually cave with:_____.

Circle approximate number of cave trips you have been on. (Count multiple trips into the same cave separately.) 1 2 3 4 5-10 11-25 26-50 51-100 101-250 251-500 501 or more

Comments_____

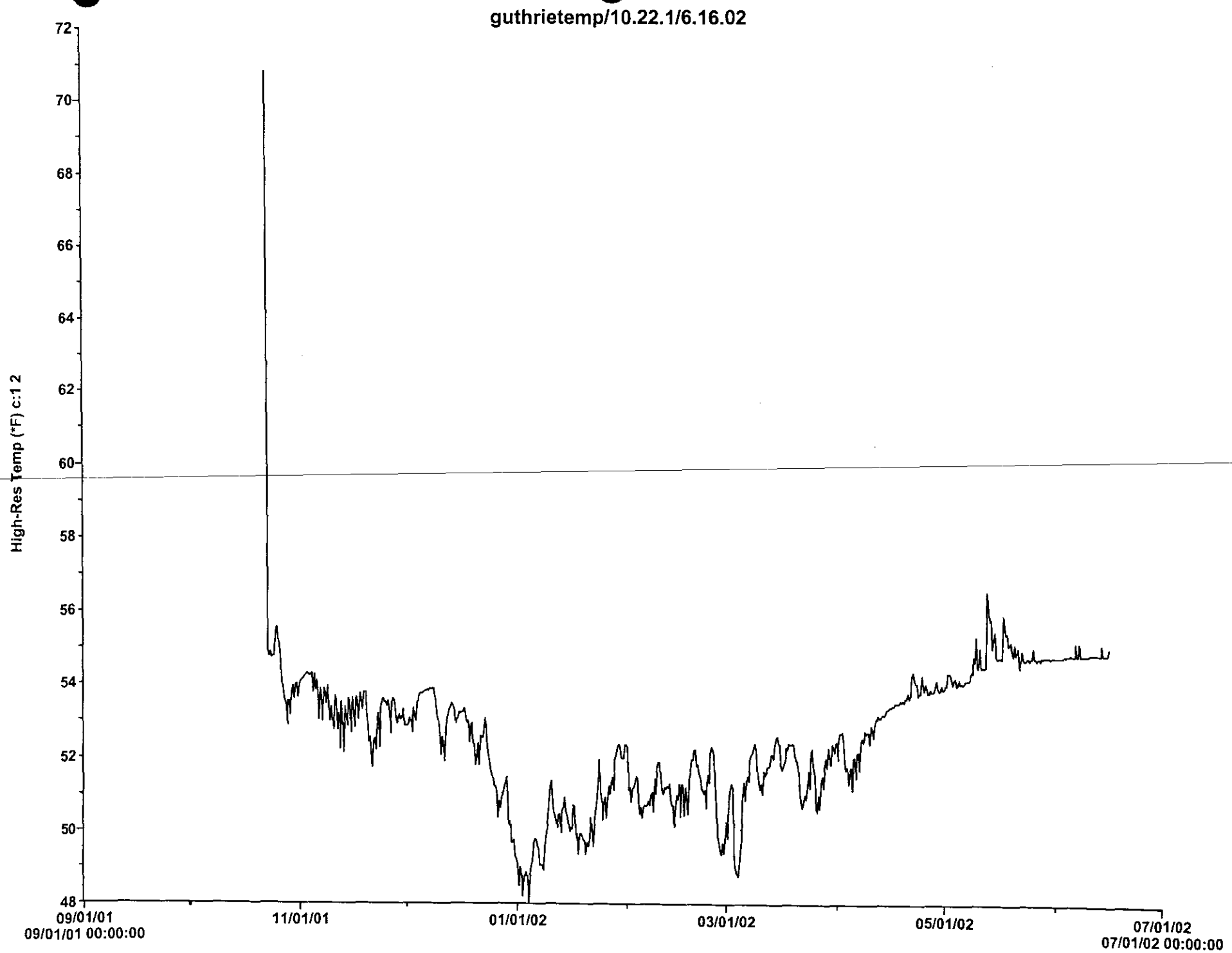
SHAWNEE CAVES CAVE USE STUDY
CAVE MONITORING EQUIPMENT

This equipment is meant to be concealed. Please do not move or tamper with it. If it has been moved or affected in any way, please call (618) 453-1121 ext. 239 and leave a message stating the name of cave and the problem encountered. Thank you for your assistance with this very important research project.

Cave	Guthrie	Ava	Equality	Rich's
Dates	1/24/98-6/16/02	8/5/01-6/29/02	8/23/01-6/22/02	8/21/01-6/30/02
Length of Time Covered	4 Yrs. 6 Mos.	11 months	10 months	10 months
Number of Cave Visitors *1	85	184	156	38
Average Zip Code	62927	61889	60861	61895
Gender	63 Responses	156 Responses	92 Responses	27 Responses
Male Visitors	40 or 63.49%	99 or 63.46%	72 or 78.26%	23 or 85.19%
Female Visitors	23 or 36.51%	57 or 36.54%	20 or 21.74%	4 or 14.81%
Average Age	30.8	23.5	30.8	27.7
Reason for Entering Cave:	113 Responses	264 Responses	125 Responses	40 Responses
Education or Training	4 or 3.54%	111 or 42.05%	13 or 10.40%	6 or 15%
Conservation or Clean-up	4 or 3.54%	14 or 5.30 %	33 or 26.40%	0 or 0%
Mapping	0 or 0%	2 or 0.76%	6 or 4.80%	2 or 5%
Exploration	33 or 29.2%	21 or 7.95%	17 or 13.60%	13 or 32.5 %
Photography	8 or 7.08%	7 or 2.65%	4 or 3.20%	3 or 7.5%
Recreation or Sightseeing	38 or 33.63%	85 or 32.20%	37 or 29.60%	11 or 27.5%
Scientific	20 or 17.7%	10 or 3.79%	13 or 10.40%	5 or 12.5%
Other	6 or 5.31%	14 or 5.30 %	2 or 1.60%	0 or 0%
Average Stay in Hours	1.845	2.33	3.552	1.341
Average Number in Group	4.4	11	6.8	4.3
Number of NSS Visitors	19 or 22.35%	15 or 8.15%	15 or 9.62%	5 or 13.16%
Average NSS Number	39824	41231	35008	41970
Equipment: % Based on total visits	85	184	156	38
Number Claiming at Least 1 piece of equipment	75 or 88.24%	133 or 72.28%	87 or 55.77%	22 or 57.89%
Hard Hat	49 or 57.65%	118 or 64.13%	49 or 31.41%	5 or 13.16%
Carbide Lamp	21 or 24.71%	5 or 2.72%	10 or 6.41%	1 or 2.63%
Electric Light	48 or 56.47%	115 or 62.50%	46 or 29.49%	8 or 21.05%
Flashlight	70 or 82.35%	54 or 29.35%	65 or 41.67%	20 or 52.63%
Flashlight Only	19 or 22.35%	8 or 4.35%	22 or 14.10%	14 or 36.84%
Other Light Source	16 or 18.82%	35 or 19.02%	27 or 17.31%	5 or 13.16%
Avrg. Year 1st Entered non-commercial cave	1990	1997	1991	1989
How they found Cave:	71 Responses	155 Responses	69 Responses	22 Responses
Friends	32 or 45.07%	47 or 30.32%	28 or 40.58%	13 or 59.09%
Book	1 or 1.18%	1 or 0.65%	2 or 2.90%	0 or 0%
Club	26 or 30.59%	38 or 24.52%	27 or 39.13%	7 or 31.82%
Other	12 or 14.12%	69 or 44.52%	12 or 17.39%	2 or 9.09%

Number claiming organization	43 or 50.59%	129 or 70.11%	38 or 24.36%	7 or 18.42%
Number claiming NSS grotto	29 or 34.18%	22 or 11.96%	30 or 19.23%	5 or 13.16%
Number of Caving Trips:	66 Responses	124 Responses	63 Responses	20 Responses
One	1 or 1.52%	35 or 28.23%	5 or 7.94%	3 or 15%
Two	1 or 1.52%	10 or 8.06%	7 or 11.11%	2 or 10%
Three	3 or 4.55%	11 or 8.87%	7 or 11.11%	4 or 20%
Four	2 or 3.03%	7 or 5.65%	1 or 1.59%	1 or 5%
Five-Ten	14 or 21.21 %	23 or 18.55%	10 or 15.87%	3 or 15%
Eleven-Twenty-five	9 or 13.64%	17 or 13.71%	11or 17.46%	1or 5%
Twenty-six-Fifty	8 or 12.12 %	9 or 7.26%	6 or 9.52%	0 or 0%
51-100	16 or 24.24%	2 or 1.61%	2 or 3.17%	2 or 10%
101-250	10 or 15.15%	8 or 6.45%	10 or 15.87%	4 or 20%
251-500	1 or 1.52%	0 or 0%	1 or 1.59%	0 or 0%
501 or More	1 or 1.52%	2 or 1.61%	3 or 4.76%	0 or 0%
Day of Week	80 Responses	184 Responses	156 Responses	36 Responses
Sunday	21 or 26.25%	24 or 13.04%	29 or 18.59%	5 or 13.89%
Monday	5 or 6.25%	22 or 11.96%	17 or 10.90%	13 or 36.11 %
Tuesday	0 or 0%	0 or 0%	20 or 12.82%	4 or 11.11%
Wedensday	4 or 5%	25 or 13.59%	1 or 0.64%	8 or 22.22%
Thursday	20 or 25%	32 or 17.39%	12 or 7.69%	1 or 2.78%
Friday	0 or 0%	43 or 23.37%	10 or 6.41%	3 or 8.3%
Saturday	30 or 37.50%	38 or 20.65%	67 or 42.95%	2 or 5.56%
Weekend Visits	51 or 63.75%	62 or 33.70%	96 or 61.54%	7 or 19.44%
Weekday Visits	29 or 36.25%	122 or 66.30%	60 or 38.46%	29 or 80.56%
Number of Separate Group Visits to Cave	*28	39	45	17
Number of Light Monitor Hits	*5	26	23	11
Light monitor Hits Logged in (Compliance)	*3 or 60%	13 or 50%	12 or 52.17%	6 or 54.55%
Light monitor Hits Not Logged in (Non-compliance	*2 or 40%	13 or 50%	11 or 47.83%	5 or 45.45%
Percentage of Visits w/light mon. hits (Success)	100%	66.67%	51.11%	64.71%
Average Group Size	3.04	4.72	3.47	2.24
Average Time of Day in Cave	15:01 or 3:01 p.m.	14:16 or 2:16 p.m.	13:28 or 1:28 p.m.	15:54 or 3:54 p.m.

Lt. Mon. installed
10/22/01 *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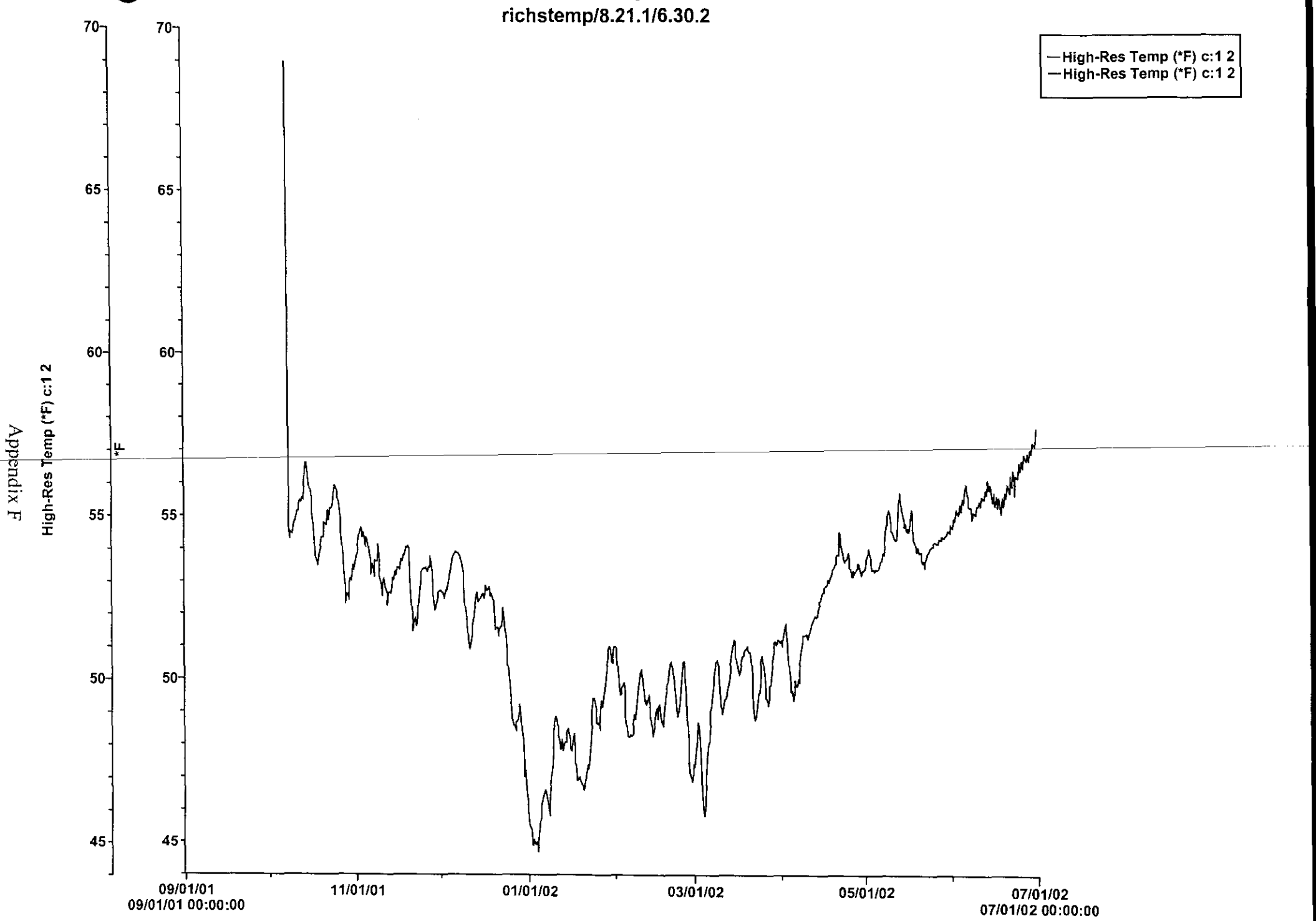
Appendix E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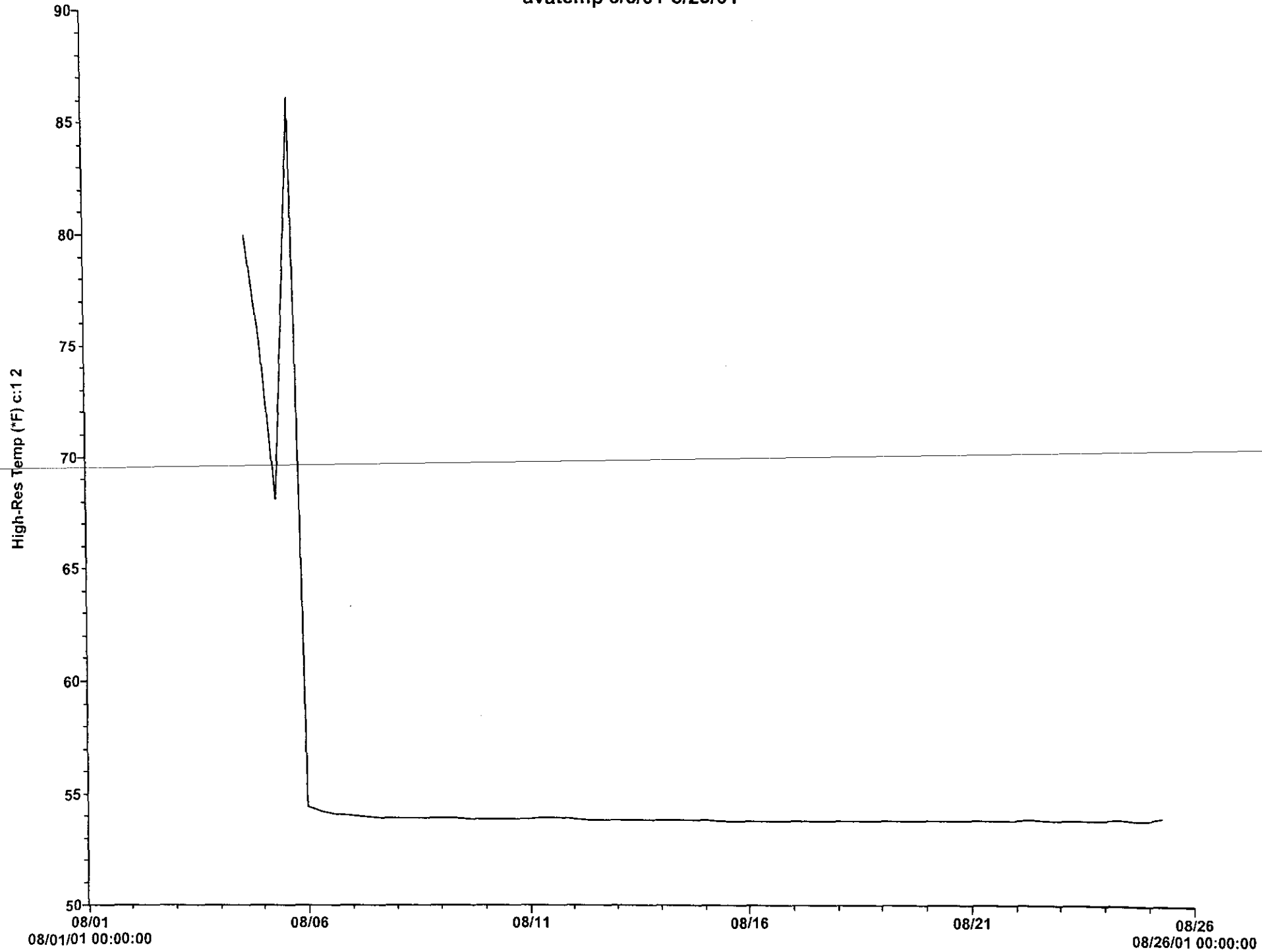
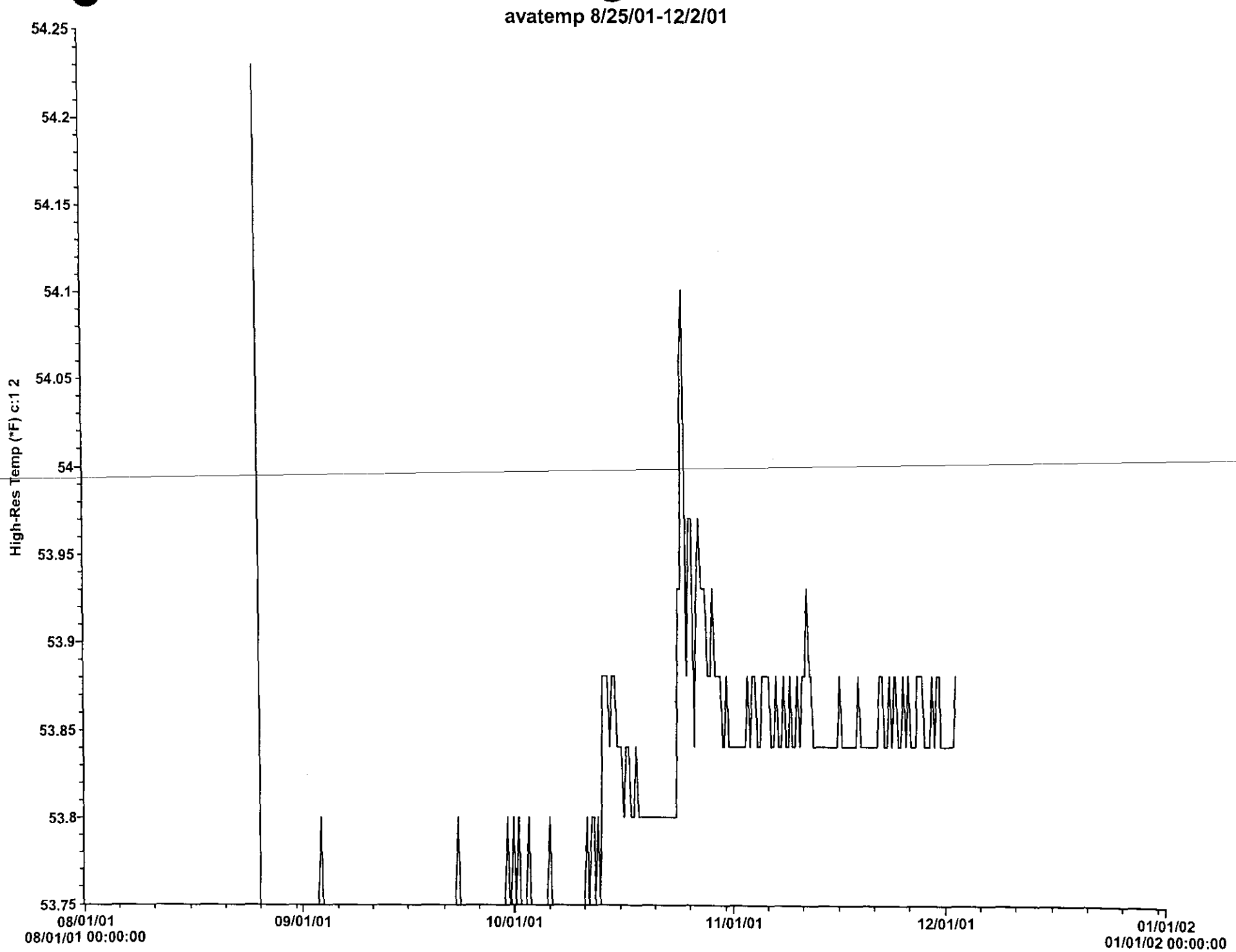
Appendix F

avatemp 8/5/01-8/25/01



Appendix G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54
53.95
53.9
53.85
53.8
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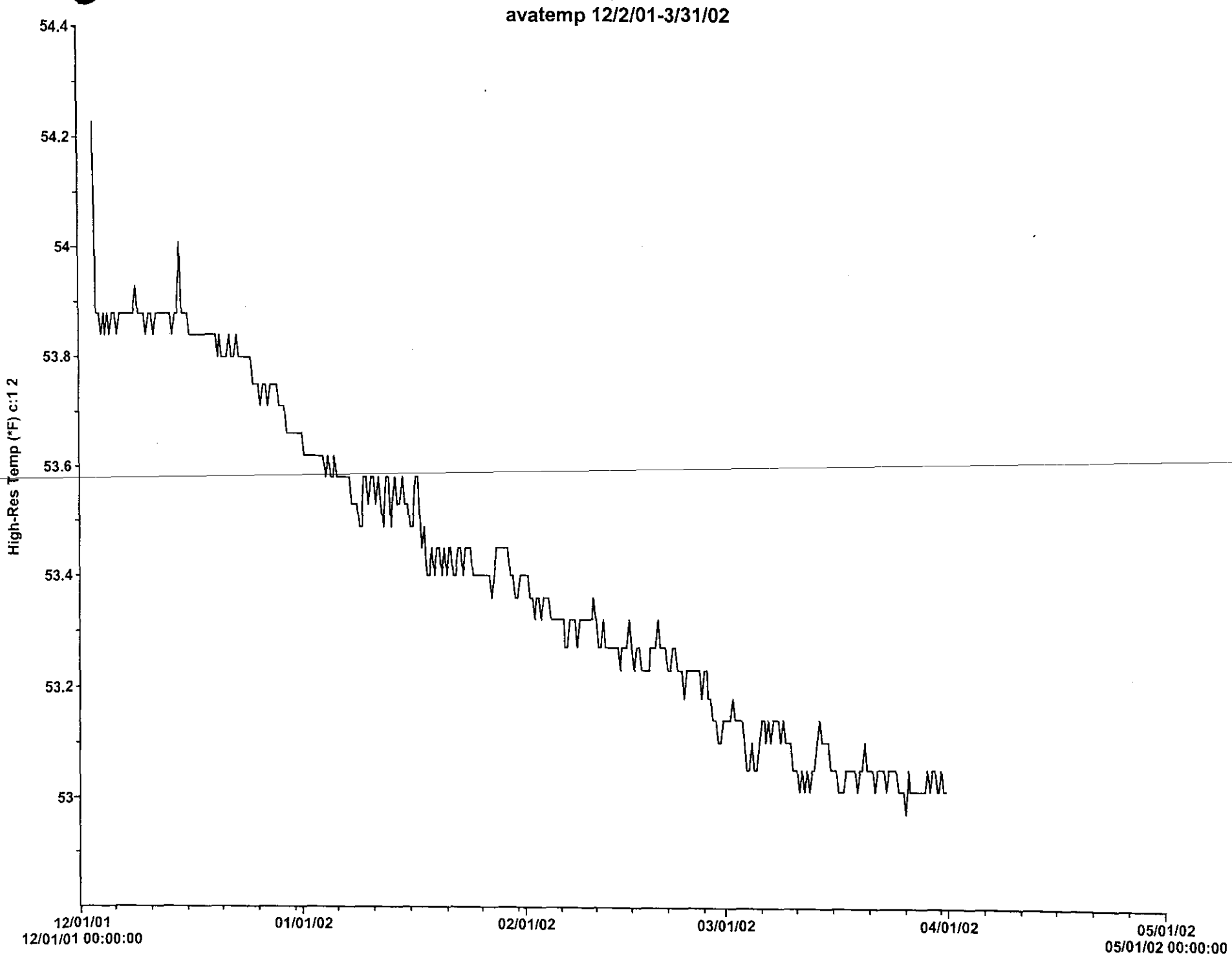
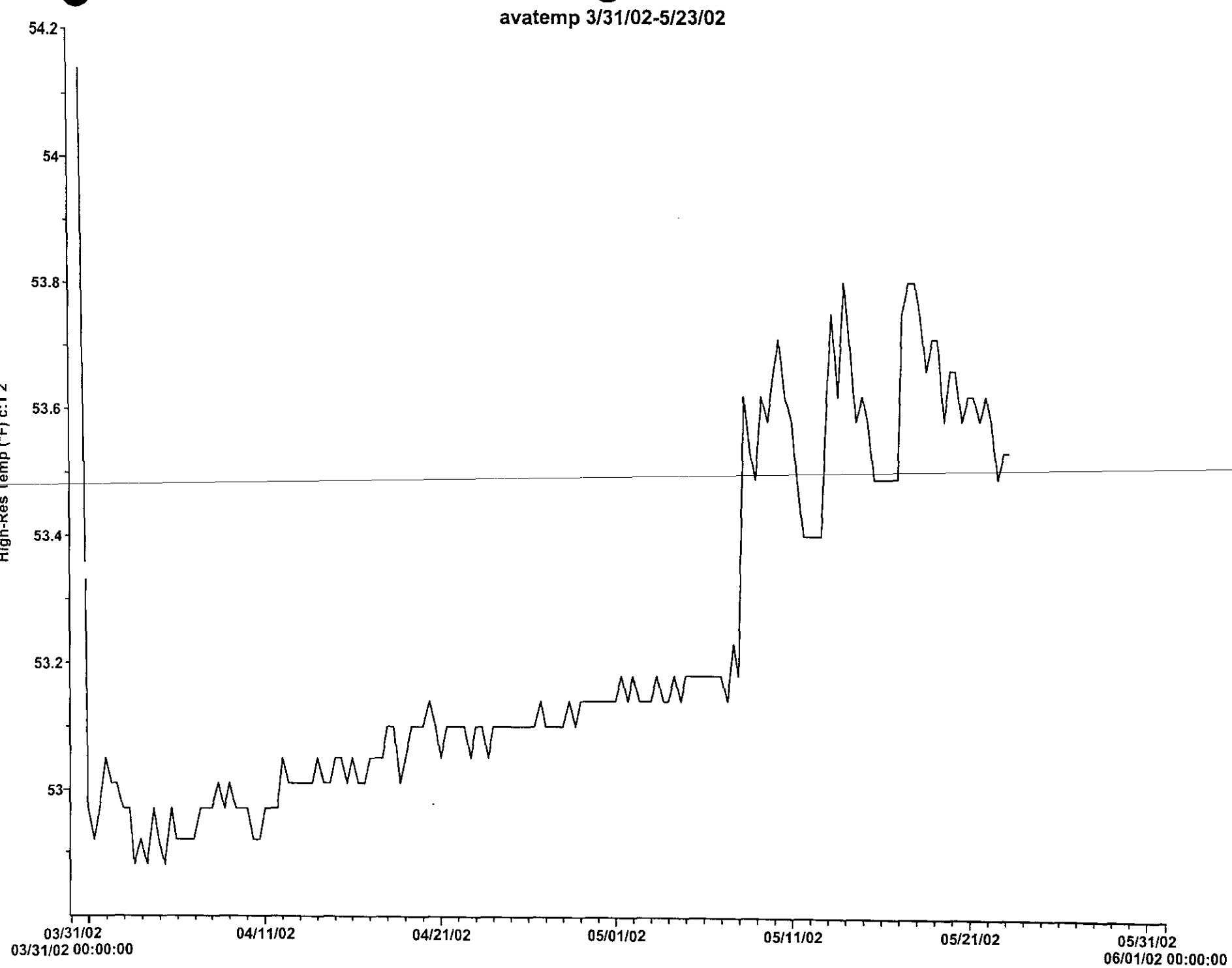
08/01/01
08/01/01 00:00:00
09/01/01
10/01/01
11/01/01
12/01/01
01/01/02
01/01/02 00:00:00

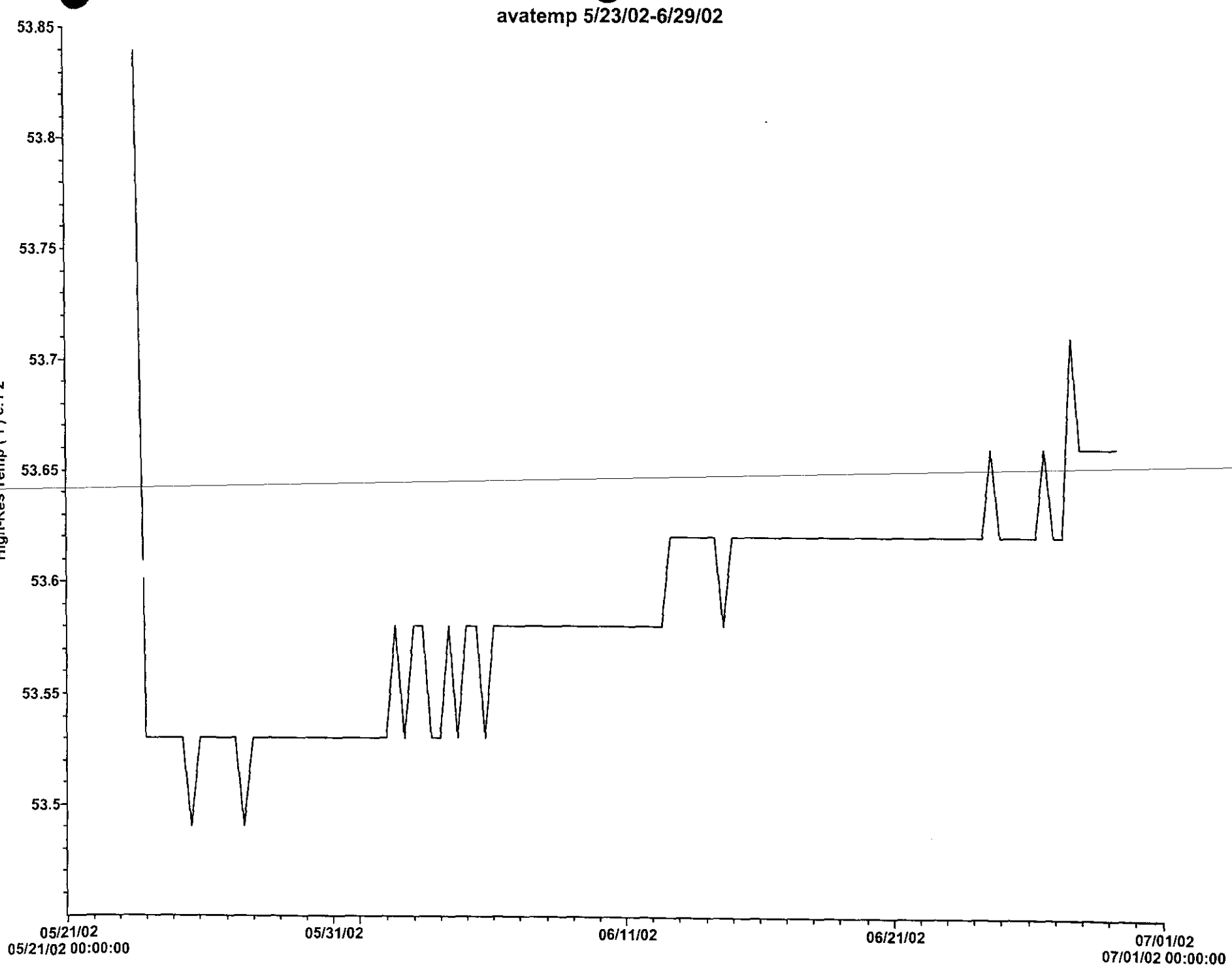
Appendix G

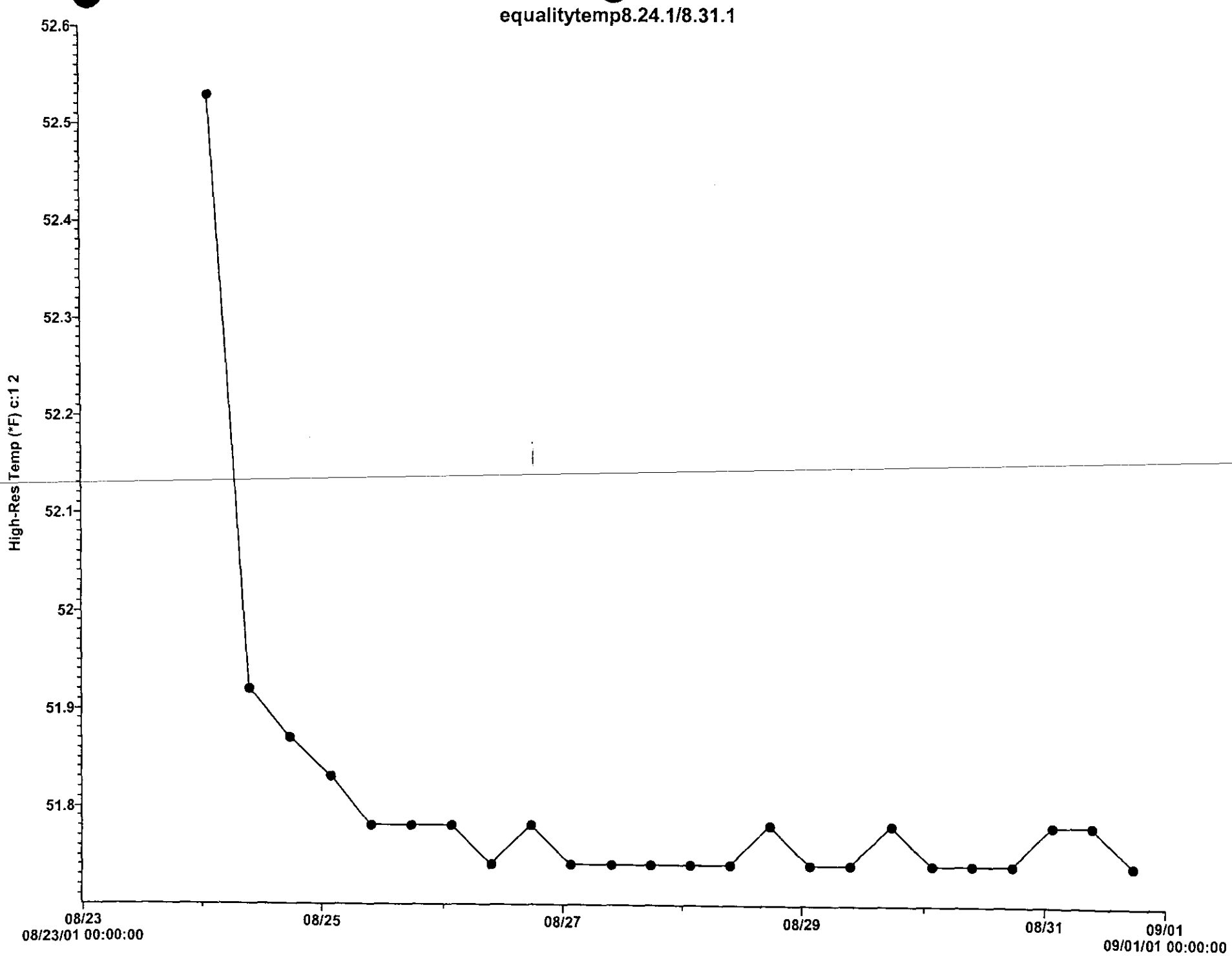

avatemp 12/2/01-3/31/02
High-Res Temp (*F) c:1 2
54.4
54.2
54
53.8
53.6
53.4
53.2
53
12/01/01
12/01/01 00:00:00
01/01/02
02/01/02
03/01/02
04/01/02
05/01/02
05/01/02 00:00:00

Appendix G

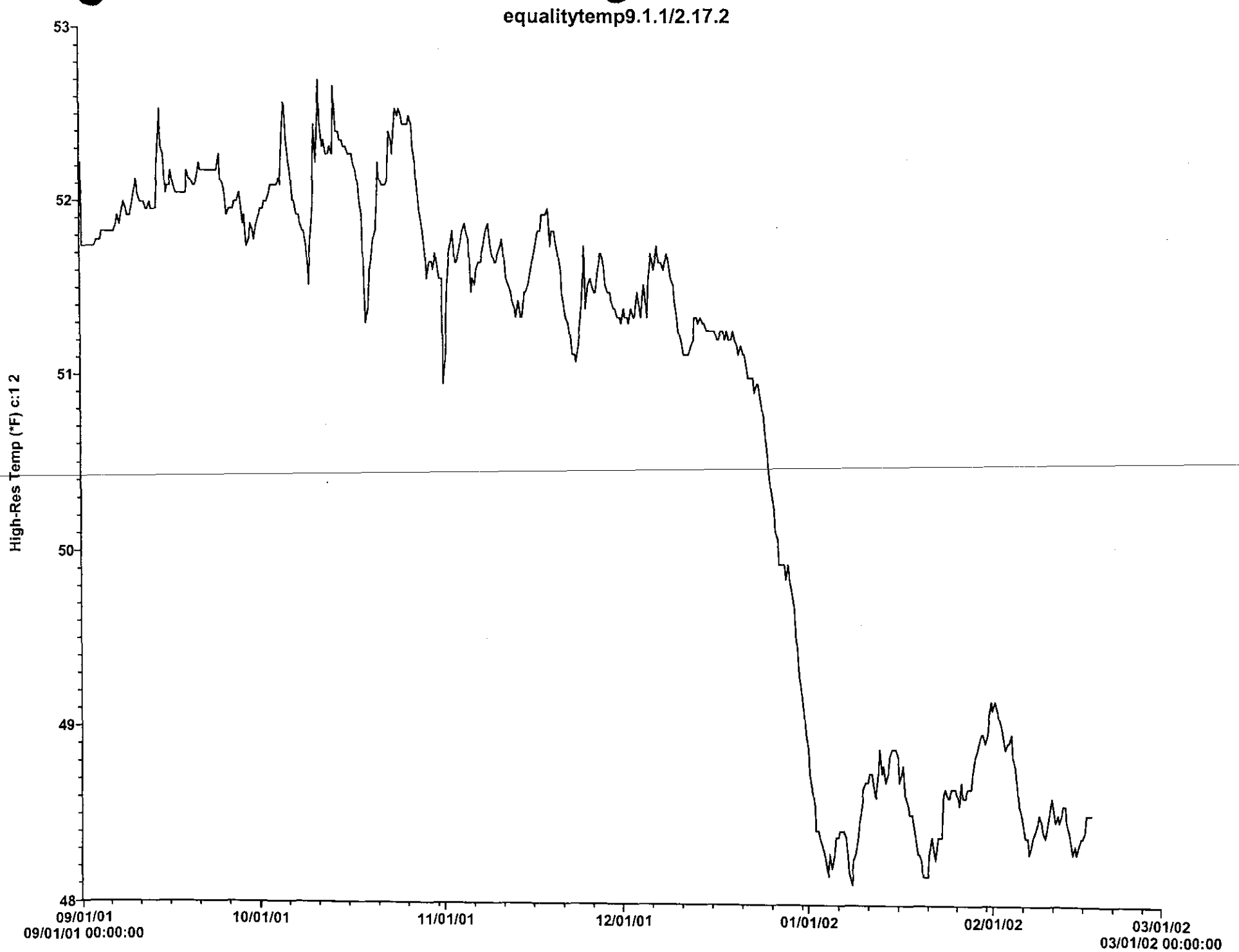

avatemp 3/31/02-5/23/02
High-Res Temp (°F) c:1 2
54.2
54
53.8
53.6
53.4
53.2
53
03/31/02
03/31/02 00:00:00
04/11/02
04/21/02
05/01/02
05/11/02
05/21/02
05/31/02
06/01/02 00:00:00

Appendix G

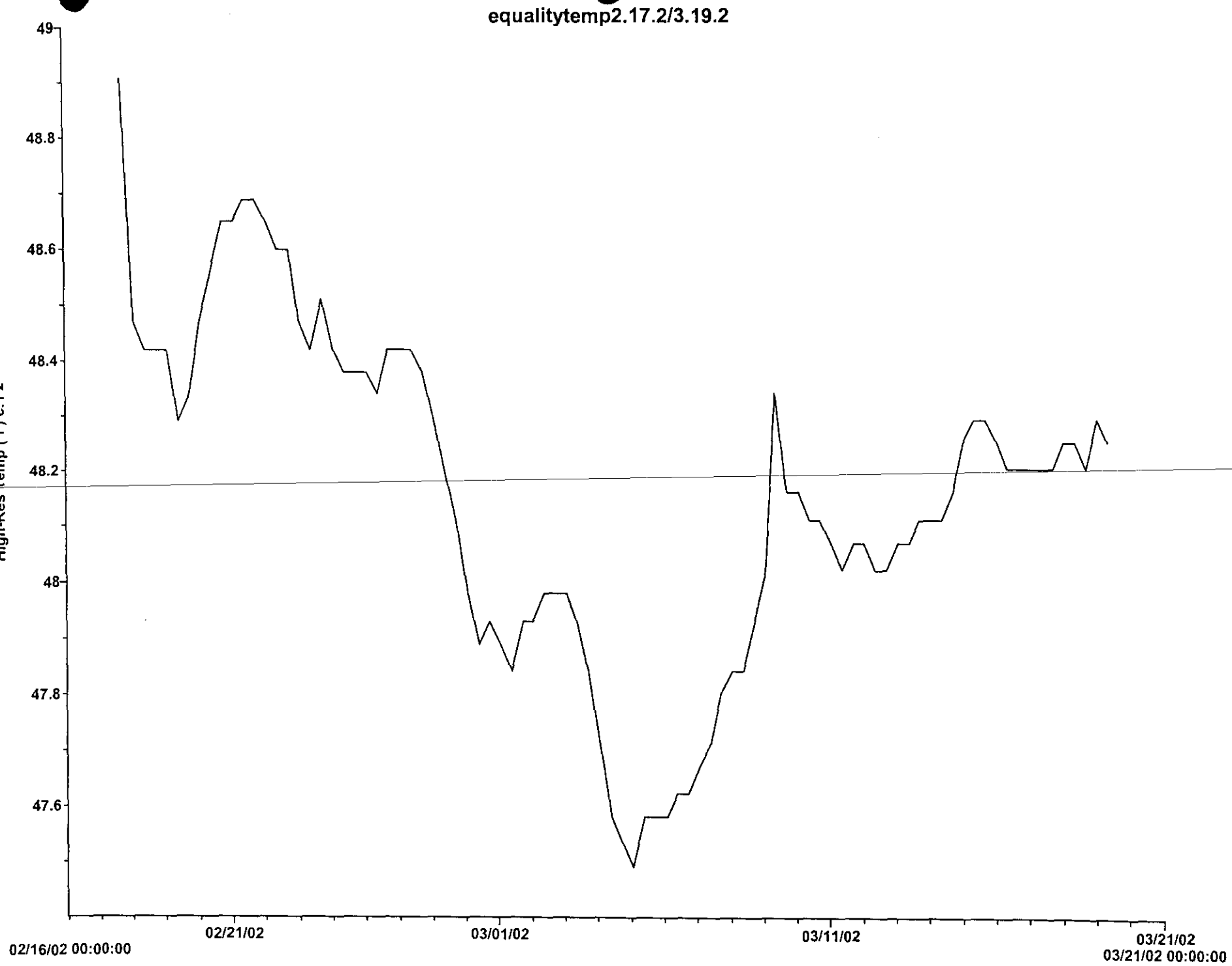

avatemp 5/23/02-6/29/02
High-Res Temp (°F) c:1 2
53.85
53.8
53.75
53.7
53.65
53.6
53.55
53.5
05/21/02
05/21/02 00:00:00
05/31/02
06/11/02
06/21/02
07/01/02
07/01/02 00:00:00


equalitytemp8.24.1/8.31.1
High-Res Temp (°F) c:1 2
52.6
52.5
52.4
52.3
52.2
52.1
52
51.9
51.8
08/23
08/23/01 00:00:00
08/25
08/27
08/29
08/31
09/01
09/01/01 00:00:00

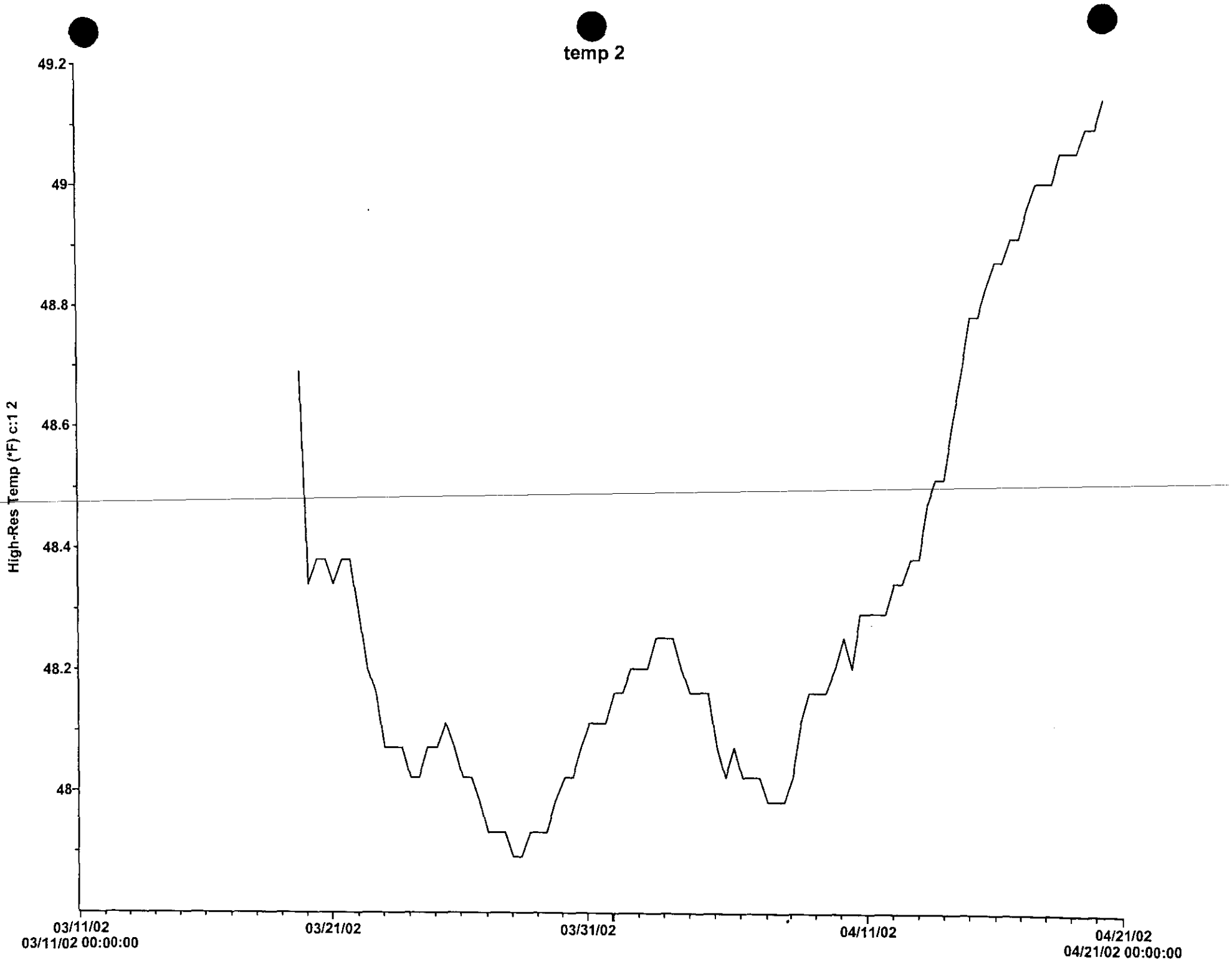
Appendix H


equalitytemp9.1.1/2.17.2
High-Res Temp (*F) c:1 2
53
52
51
50
49
48
09/01/01
09/01/01 00:00:00
10/01/01
11/01/01
12/01/01
01/01/02
02/01/02
03/01/02
03/01/02 00:00:00

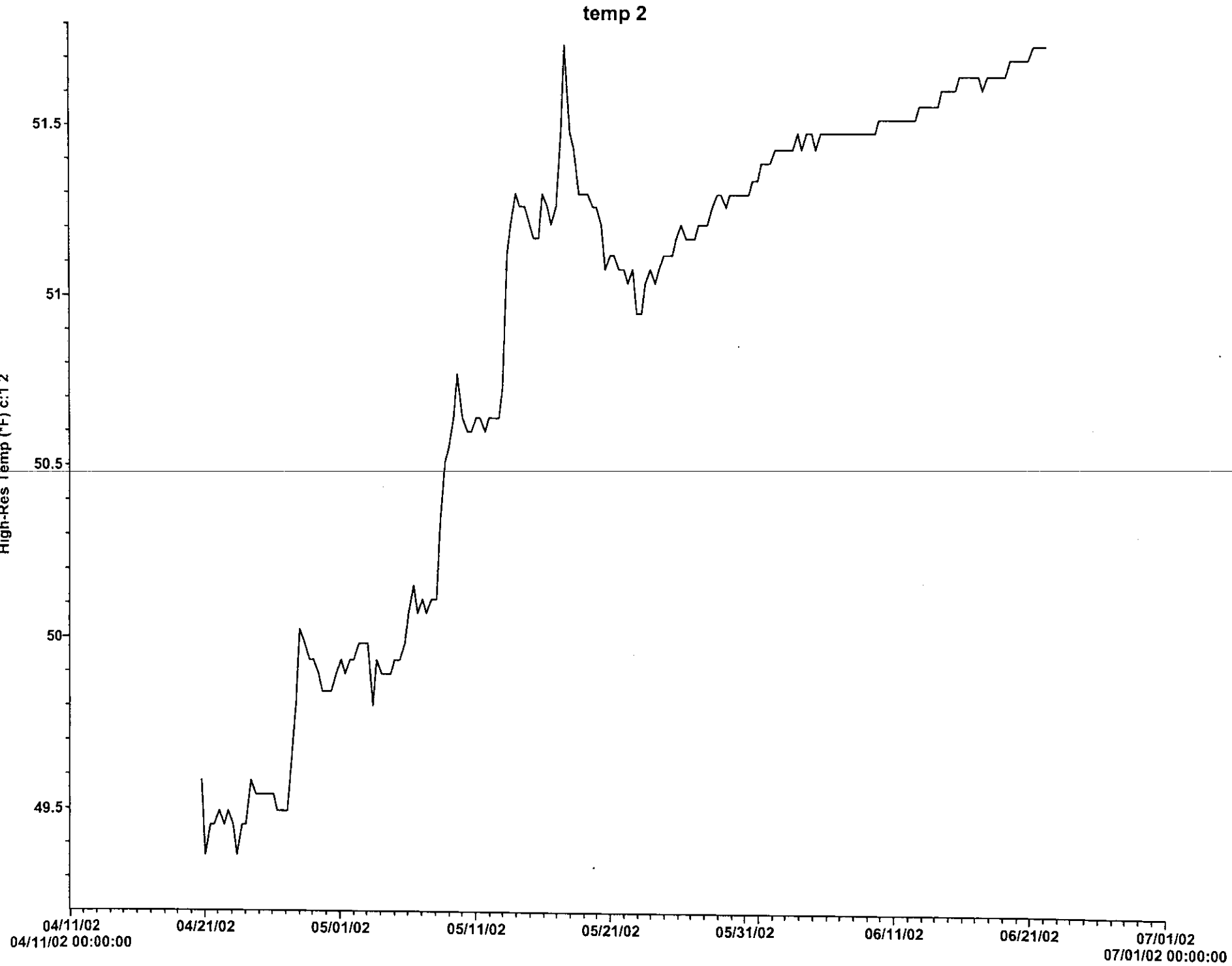
Appendix H


equalitytemp2.17.2/3.19.2
High-Res Temp (*F) c:1 2
49
48.8
48.6
48.4
48.2
48
47.8
47.6
02/16/02 00:00:00
02/21/02
03/01/02
03/11/02
03/21/02
03/21/02 00:00:00

Appendix H


temp 2
High-Res Temp (*F) c:1 2
49.2
49
48.8
48.6
48.4
48.2
48
03/11/02
03/11/02 00:00:00
03/21/02
03/31/02
04/11/02
04/21/02
04/21/02 00:00:00

Appendix H


temp 2
High-Res Temp (*F) c:1 2
51.5
51
50.5
50
49.5
04/11/02
04/11/02 00:00:00
04/21/02
05/01/02
05/11/02
05/21/02
05/31/02
06/11/02
06/21/02
07/01/02
07/01/02 00:00:00