Denali National Park & Preserve

Soundscape Draft Report 2006

Healy Ridge

Foggy Pass

West Fork Yentna River

Muldrow Glacier

Toe of the Ruth Glacier

Caribou Creek

Denali National Park & Preserve
Soundscape Draft Report 2006

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BACKGROUND

The ever-increasing human-generated sounds at Denali National Park and Preserve (Denali) have become an important resource issue because of their detrimental impact on the natural soundscape and visitor experience. In the newly revised Denali Backcountry Management Plan (BCMP), soundscape measurements have been identified as an important indicator of the level of human impact on park resources. Soundscape measurements are objective with methods that are easily reviewed by the public, which will provide strong support for future management decisions. Park planners have increasingly expressed a desire for more soundscape data so that they can make informed decisions about the sound level standards that will be set in the BCMP. Without these data the park will have little information to make management guidelines or support management decisions that may affect the quality of the Park's soundscape.

The initial push for Denali to begin soundscape inventories began with Director's Order 47 (DO-47). Robert Stanton issued the order in 2000 directing park managers to identify baseline soundscapes and related measures. DO-47 states that "natural sounds are intrinsic elements of the environment that are often associated with parks and park purposes…They are inherent components of 'the scenery and the natural and historic objects and the wild life' protected by the NPS Organic Act." DO-47 directed park managers to "(1) measure baseline acoustic conditions, (2) determine which existing or proposed human-made sounds are consistent with park purposes, (3) set acoustic management goals and objectives based on those purposes, and (4) determine which noise sources are impacting the park and need to be addressed by management." Furthermore, it requires park managers to "(1) evaluate and address self-generated noise, and (2) constructively engage with those responsible for other noise sources that impact parks to explore what can be done to better protect parks."

The primary purpose behind the Denali soundscape study has been to measure the level of influence overflight traffic and snowmachine traffic has on the Park's soundscape. Understanding the natural soundscape is important to evaluate the levels of impacts human-generated sounds may have on this important resource. Different habitats have specific soundscape characteristics that are an important attribute of the natural system, with distinct impacts on the human perception of the environment. The natural soundscape is generally comprised of two main sound categories, physical and biological. Physical sounds are created by physical forces (wind, rock fall, rivers, etc.), whereas biological sounds are created by organisms (birds, frogs, plants, etc.). The presence and abundance of sounds from these two categories is used to characterize different habitats. Impacts on the natural soundscape and on visitor experiences come from human-generated sounds.

Equipment used

Denali has been working closely with the National Park Service Soundscape Program Center developing soundscape monitoring techniques and applications. Automated acoustic data loggers, designed by Skip Ambrose at the NPS Natural Soundscape Program Center, collect one-second decibel data as well as digital recordings

using a systematic sampling scheme (5 seconds every 5 minutes), and 10 second recordings of sound events exceeding a user-defined threshold (usually 55dBA) and duration (usually 5seconds). Calibrated Type 1 Larson-Davis Model 824 sound level meters, Type 1 Larson-Davis PRM902 microphone preamplifiers, and Type 1 G.R.A.S. 40AE microphones, with windscreens, are used to collect 33 one-third octave band frequency (12.4-20,000Hz) sound pressure levels each second of the sampling period. Sound Monitor™ (Far North Aquatics, Fairbanks, Alaska) software, running on a Windows™ - based Panasonic™ CF-45 laptop computer, control and store the acoustical data. Each system collects CD quality digital recordings (44.1KHz, 16-bit) using an external sound card. The acoustic data loggers, contained within weatherproof containers, are powered by 12 volt battery and photovoltaic charging systems. The system can operate continuously for long periods, provided there is enough sunshine.

Specific methodologies and protocols for equipment type, microphone type, microphone placement and height, and other factors are described in the guidelines in the Draft Programatic Soundscape Management Plan (NPS, 2005). These protocols were developed following guidance of Ambrose and Burson (2004) and were based on American National Standard Institute S12.9 (1992), Federal Aviation Administration's "Draft Guidelines for the Measurement and Assessment of Low-level Ambient Noise" (Fleming et al. 1998), and "Methodology for the Measurement and Analysis of Aircraft Sound Levels within National Parks" (Dunholter et al. 1989).

The equipment used for monitoring the soundscape is shown in Figures 1 and 2. Detailed equipment lists used at each location sampled can be found in Appendix C. The equipment is described below:

- **Data Logger (Laptop).**
  - *Panasonic Toughbook* running *Windows 2000* or greater and using *SoundMonitor™* software developed by *Far North Aquatics*, Fairbanks, AK.
- **Sound Level Meter (SLM) and Microphone**
  - *Larson-Davis 824* Type 1 Sound Level Meter (SLM). Type 1 microphone and preamp with both a *Larson-Davis* foam and *Rycote* (fuzzy) windscreen.
- **High Quality Digital Sound Card and Omnidirectional Microphone**
  - *M-Audio MobilePre* USB powered external sound card with 48V Phantom microphone power for a *Sennheiser ME 62* omnidirectional microphone or, *G.R.A.S. 40AE* Type 1 omnidirectional microphone with *G.R.A.S. 26CA* Pre-amp.
- **Power Supply**
  - At the high latitudes of Denali with the system currently used (1.0 Amp draw), a minimum of 160 Watts of solar panels are necessary for summertime applications. Wintertime applications require up to 2000Watts of solar panels.
  - 140 Amp hours worth of deep cycle batteries are generally sufficient for retaining enough power during summertime applications. The battery power must be ample enough to last between solar charges that may be insufficient for weeks at a time due to cloud cover.

The equipment is secured in a way that there is no self-induced noise (e.g., from loose wires). The equipment is protected from animal mischief through the use of conduit, strong containers for the digital equipment, and in some cases, using an electric fence. The Draft Programmatic Soundscape Management Plan (NPS, 2005) has extensive protocol instructions that were developed by the National Park Service Soundscapes Program Center for using the equipment and measuring sound in national parks.

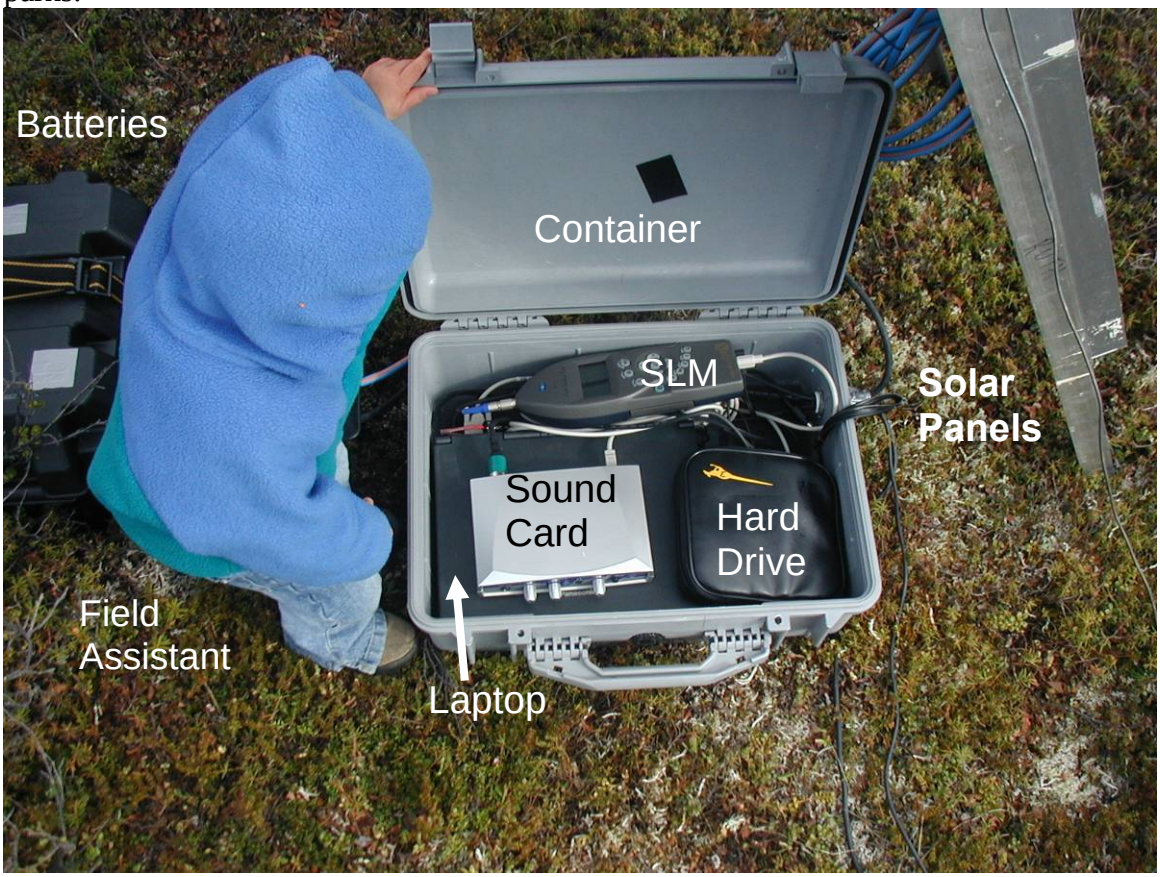

Figure 1. Photograph of the inner workings of a sound station. Sound stations run off solar panels and batteries. They contain a laptop, external sound card, external hard drive, and a sound level meter, which are all contained in a *Pelican* Case.

Figure 2. Photograph of the microphones used for audio recordings and measuring sound pressure levels.

Data collected

Two types of data are collected at a sound station: audio recordings and sound pressure levels. Two types of audio recordings are made; one type at user defined time intervals and the other triggered at user defined sound levels. Sound pressure levels are taken every second. The data collected are:

- **Events** - audio recordings that are triggered by loud sounds at user defined exceedance levels. The user defined exceedance levels traditionally used at Denali have been sounds greater than 55dBA for 5 or 10 seconds and 90dBA for one second. An audio recording of an event is made during the event for 5 seconds before and after the event.
- **Audibility Audio Recordings** - made at user-defined intervals. Traditionally, at Denali, audio clips recorded for 5 seconds every 5 minutes have been sufficient for identifying sound sources. This data is used to calculate the percent time and number of times sound sources are audible throughout the day.
- **Sound Levels** - taken every second. Recorded are the overall A-weighted Leq, and the Flat Weighted Leq of each third octave. Leq is the energy equivalent sound level, which is the level of a constant sound over a specific time period that has the same sound energy as the actual (unsteady) sound over the same period. The A-weighted sound pressure level (dBA) is weighted based on limits of human hearing.

SAMPLING PLAN

Understanding baseline soundscape conditions using statistically valid sample schemes and techniques are a necessity for properly characterizing the soundscape of Denali and for abiding by Alaska National Interest Lands Conservation Act (ANILCA) requirements (Gibert, 2004). We propose to complete a stratified random sampling plan, based on acoustical zones and management zones, randomly sampling grid points of the Long Term Ecological Monitoring (LTEM) park-wide systematic grid. Although Denali has been working on three smaller soundscape studies over the last three years, the primary purpose of these studies was to inventory targeted areas for impact levels of motorized vehicles. Sampling locations through 2005 were selected based strictly on specific project needs and cost of access. Although this data may be used as an initial measure of these targeted areas, by statistical design, the data cannot accurately be extrapolated over the entire area of Denali.

With the assistance of Trent McDonald, a statistician from Western EcoSystems Technology Inc., a sampling plan has been worked out through the 2005 season to get a leg up on the 2006 field season. The sampling plan went through many stages of complexity of stratification but came back around to a very simple plan.

The first step in designing a sampling plan is to identify the driving factors. The primary driving factor behind the sampling plan design is to quantify the motorized sounds and compare these motorized sounds to the natural soundscape. A second driving factor considered was the benefit that the audio recordings taken at each location could be analyzed for identification of birdcalls (Daw and Ambrose, 2003). With this in mind, the soundscape sampling design could include co-locating sound stations where traditional bird counts are made. Since the bird crew and vegetation crews are utilizing the LTEM grid, to standardize long-term monitoring projects in the park, it was decided that the soundscape sampling plan would also utilize the LTEM grid as the basis of the sampling plan. The third driving factor behind the sampling plan design is the total number of stations that a single soundscape program manager can maintain during a summer field season. After considering the last five years of experience, the maximum estimated number of stations one person can maintain is five stations (one more than the current number of four stations). The fourth driving factor behind the sampling plan design is the return cycle for a long-term monitoring plan. The vegetation and bird sampling plans are both on a ten-year cycle, which seems applicable for a soundscape sampling plan.

After identifying the driving factors behind the sampling plan design a level of practicality and efficiency had to be devised. Through discussions with the CAKN managers during the soundscape scoping meeting held on November, 29 2004, the consensus was that the sampling plan would be most efficient and best extractable if it was stratified. The first drafts of the sampling plan stratified the LTEM grid points into four strata:

1. Acoustical zone
    a. Boreal Forest
    b. Alpine Tundra/Scrub
    c. Non-Vegetated/Alpine
    d. Riparian
2. BCMP Zones
    a. High
    b. Medium
    c. Low
3. Within / Outside the footprint of common flight-seeing routes (see Fig. 6) and the SW Military Operation Area.
4. Hikable / Non-hikable

After developing a complex stratified sampling plan Trent McDonald suggested it was not necessary. What we noticed when we simply looked at the spatial extent of each of the strata was that their components were nearly equal in area. For example, there are 121 LTEM grid points that fall within the footprint of common flight-seeing routes and the SW Military Operation Area, whereas114 LTEM grid points fall outside the footprint. Since the LTEM grid points are divided nearly 50/50 it makes no sense to stratify the points by the flight footprint. The same pattern exists when the acoustical zone stratification is made and when the BCMP zones are applied. In the end, a coarse grid was agreed upon that would provide the most statistically robust and spatially diverse sampling plan.

The final sampling plan is designed using a coarse grid made up of the LTEM grid. The number of points in the coarse grid is driven by the number of stations available per year (5) and the length of time each station should be established at each location. To properly characterize the natural soundscape, stations should be established throughout the entire field/tourist season from July to the end of August (one station may be established during the winter months during some years and the shoulder seasons will be attempted at limited locations). To maximize the spatial coverage with only five stations we decided it was best to sample four locations through the entire field season and rotate the fifth station through three locations, one month each. Two of the month-long stations would be established for the coarse sampling grid with one month free to allow management to choose a desired/imperative location. In the end, during each year there will be six locations sampled of a coarse sampling grid. For a ten year return cycle that means there are sixty locations to be sampled. A coarse grid of 60 points was made up of the LTEM grid (Figure 6).

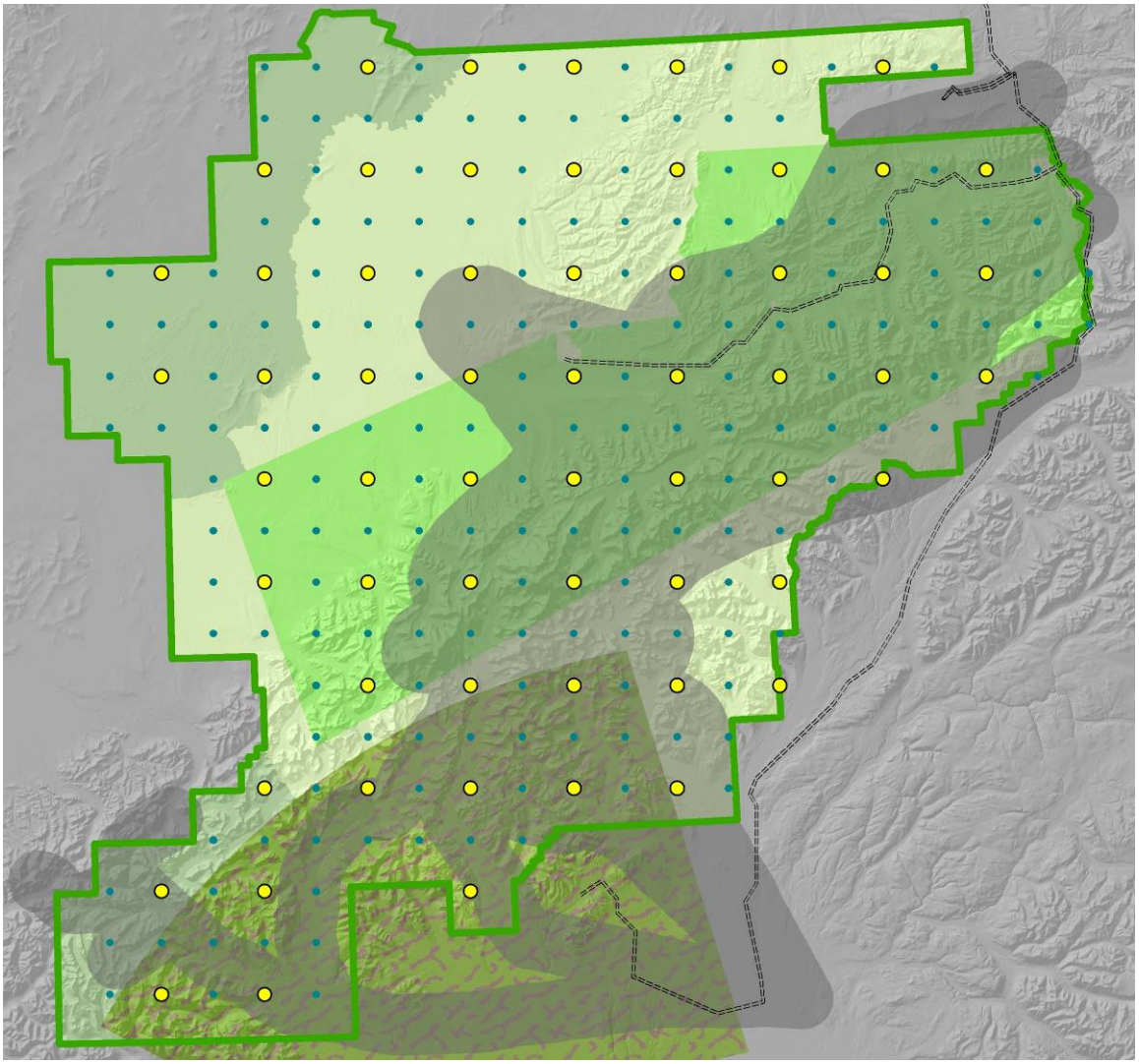

Figure 6. Map showing the coarse grid of sixty points to be sampled. The coarse grid was made up from the finer LTEM grid. Also shown in the map is the footprint of the common flight-seeing paths (grey) and the SW military operation area (camouflage).

The final step was to select which six sites would be sampled each year. To keep each year spatially spread out a systematic selection was chosen over a pure random selection (which results in clustering during some years). The technique used is similar to choosing players for ten hokey teams from a group of children. Having the children count off from one to ten starting from one corner. A similar technique was done by labeling the coarse grid from one to ten starting at the SE corner in order of the numbering system of the LTEM grid points. The first round resulted in diagonal lines of nearby points selected for each year, which is a poor spatial arrangement. The count off was done again from the new list of points. All the points were sorted by year then re-numbered one to ten. The result was a satisfactory spatial arrangement for each year. Figure seven shows the coarse grid of sixty points labeled by year to be sampled starting in 2006. Note that for each year the points are spread out spatially. One other important note is that nearly every year has a location that is hikable, which originally was the most

limiting stratifying category. With this systematic sample design the soundscape of the park can be adequately represented with a statistically sound sampling plan.

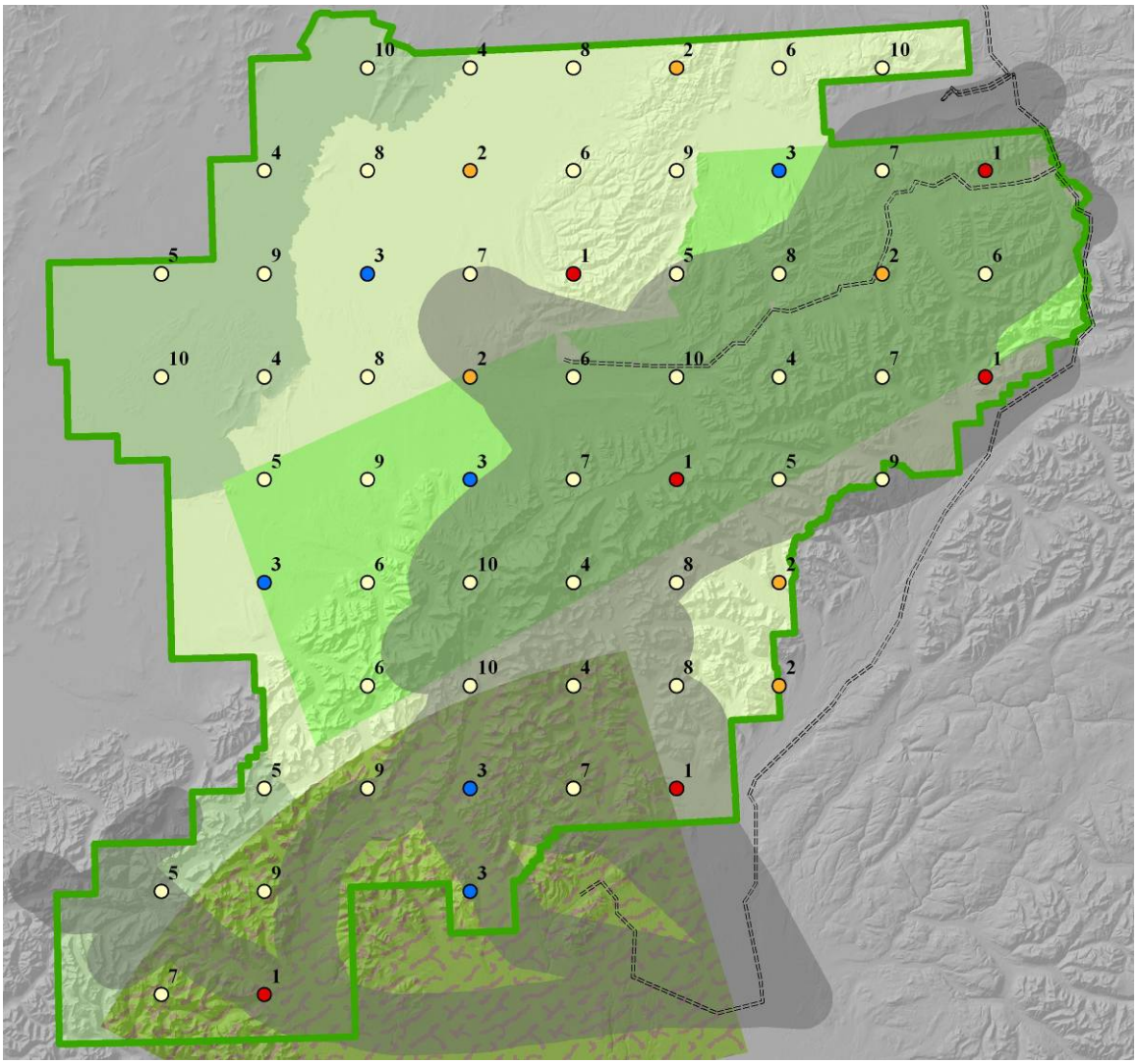

Figure 7. Map showing the coarse grid of sixty points to be sampled labeled by the year to be sampled (starting year 1 in 2006). Also shown in the map is the footprint of the common flight-seeing paths (grey) and the SW military operation area (camouflage).

2006 SUMMARY

The primary focus for 2006 was to complete the first year of data collection and analysis as outlined in the above park wide sampling plan. The station locations up to 2005 were selected primarily for support of specific projects with specific focus areas.

2006 Sound Station locations

The time period sound stations were in place during 2006 and the amount of usable data collected are shown in Figure 4. There were six stations placed during the 2006 field season:

FOGG - located in Foggy Pass;
HEAL - located on the South side of Healy Ridge, North of Savage campground;
WFYR - located on the South bench of the West Fork of the Yentna River;
MULD - located on the Muldrow Glacier, ~2 miles up from the bend;
RUGL - located on the West bench, at the toe of the Ruth Glacier;
CARB – located on Caribou Creek, 1 mile for the end of skyline drive.

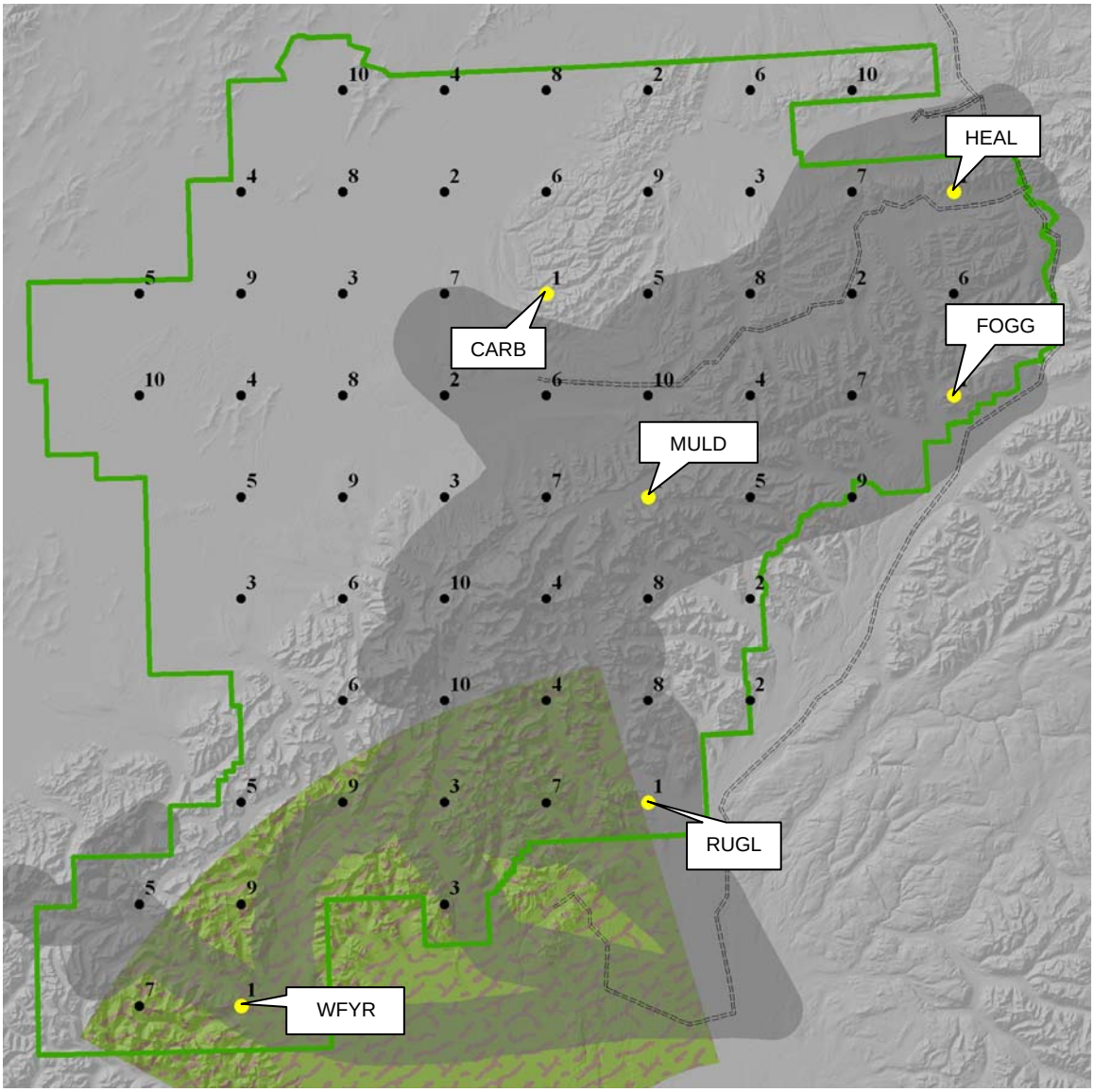

Figure 3. Map showing the sound station locations placed for 2006, indicated by the white callouts. Common flight-seeing paths footprints are shaded in dark grey. The Military Operating Area is shown in Camouflage.

2006 Soundscape Sound Station Occupation Times (-), Data Collected (●), Usable Data (○), Analyzed Data (●).

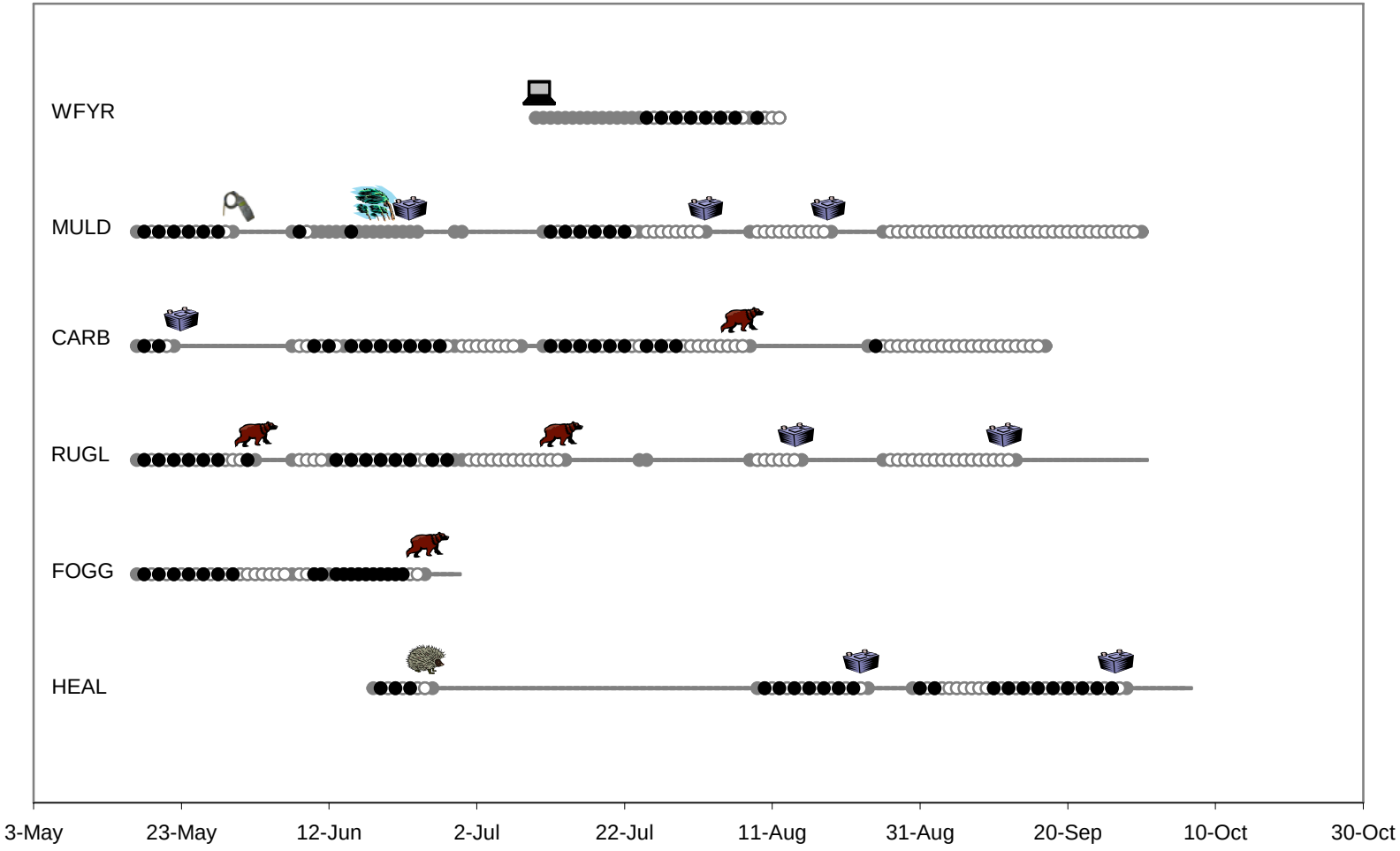

Figure 4. Chart showing the 2006 sound station occupation times, data collected, and usable data analyzed (for station locations refer to map in Figure 3). Small characters indicate reasons for loss of data. Characters are: bear attack; small animal attack; computer malfunction; with battery overcast weather; sound level meter malfunction; sun with battery overloaded solar controllers; human error.

2006 Data Collection and Analysis

This is a summary of preliminary findings based on the analysis of approximately 60% of the data recorded during the 2006 field season. As such, this report is a draft, and is intended for distribution to park managers and planners with the aim of refining the packaging and presentation of the data so that it is most useful. If you would like to see the data represented differently so that better address a specific need, please contact the author.

For the 2006 field season the proportion of usable data (327days) to the number of days each station was located and available to collect data (588days) was 55.6%. This is an improvement over the 2005 proportion of 51.5%, and the 2004 proportion which was 30%. The strongest influence driving down the success rate was the HEAL location (Fig. 3) where an animal chewed through the SLM microphone cable on two occasions. The second most influential cause of disruption was multiple incidences of bears disabling the RUGL and CARB stations. A portable electric fence manufactured by UDAP™ was installed around these stations, but it is believed that the batteries that power the fence electrifier were not able to last the full two weeks between site visits. Solar-tended fence electrifiers have been purchased to address this problem. Details of the successes, failures, and brief summaries of the data collected for each station follow.

Healy Ridge

The purpose of the HEAL location (Fig. 3) was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #213 was stratified as a hikable, Old Park (designated Wilderness) location and randomly selected from all hikable locations.

The only problem incurred at the HEAL location was an animal of some kind chewing through the SLM microphone cable on two occasions (Fig. 4). The problem was remedied by sheathing the external cables in a think plastic spiral conduit, chosen over metal for its light weight (as this was a hikable station). All hikable stations in the future will employ this technique as a precautionary measure.

Water and wind, in descending order, dominated the soundscape at the HEAL location. An average of 6.5 motorized sounds were heard per day, with a fairly constant distribution thought the season (see Appendix E). All the motorized sounds were from aircraft over-flights. Sounds from the park road, approximately 2.5 linear miles away, were never audible. If present, they were likely masked by constant sound from the fast moving creek at the bottom of the drainage.

Foggy Pass

The purpose of the FOGG location (Fig. 3) was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #134 was stratified as an Old Park (designated Wilderness) location and randomly selected from all locations requiring aircraft access.

This was the first stop of the roving station and was intended to be occupied for only 1 month. Data collection went very smoothly, with the only problem incurred being a bear attack just a few days before the station was slated to be moved (Fig. 4). This caused a delay in deployment to the WFYR site due to having to order a replacement microphone, but had little impact on the data collection at FOGG.

Birds and wind, in descending order, dominated the soundscape at the FOGG location. An average of 19 motorized sounds were heard per day, with increasing frequency in mid to late June (see Appendix E). All the motorized sounds were from aircraft over-flights. A near constant, variable background noise was audible at this location. It was too faint to be identifiable, but could have been water in a distant stream, or the distant sound of traffic on the Parks Highway, approximately 5 miles away.

West Fork Yentna River

The purpose of the WFYR location (Fig. 3) was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #6 was stratified as a New Park Preserve and Military Operations location and randomly selected from all locations requiring aircraft access.

This was the second stop of the roving station as was intended to be occupied for only 1 month. Due to the delay in deployment caused by the bear damage at the HEAL location and also by a computer malfunction which caused the first two weeks of data to be unusable, the third planned location for this station, Eldridge Glacier, was abandoned. This action was necessary in order to allow enough data to be collected to make a reasonably robust acoustical profile of this site. Aside from the computer malfunction, data collection went smoothly, and it was good to be able to get data in this area, as it is one of the most difficult locations in the park to access in terms of distance.

Sounds of water from the West Fork Yentna River dominated the soundscape at the WFYR location. An average of 10 motorized sounds were heard per day, with a fairly constant distribution thought the sampling period (see Appendix E). All the motorized sounds were from aircraft over-flights. What sounded like a military flight exercise was captured on the afternoon of August 2nd, with jet noise averaging 60 dBA over some samples and peaking to 81 dBA on one occasion.

Muldrow Glacier

The purpose of the MULD location (Fig. 3) was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #105 was stratified as an Old Park (designated Wilderness) location and randomly selected from all locations requiring aircraft access.

Problems incurred at the MULD location were mostly power related. A battery wiring problem had caused half of the battery bank to be disconnected and the batteries to go dead on multiple occasions. Early on it was thought that the mountains to the south were preventing adequate sun from reaching the solar panels. When more panels were to be added, the wiring problem was discovered and addressed. The only other glitch came

when high winds broke one of the tie-downs, causing the system case to fall over and the SLM inside to lose power.

Wind and rock avalanches, in descending order, dominated the soundscape at the MULD location. Rock avalanches were heard in quantity on most days, and seemed to be most prevalent from 6 AM to 4 PM. An average of 15.7 motorized sounds were heard per day, with considerably more occurrences in July than May (see Appendix E). All the motorized sounds were from aircraft over-flights.

Toe of the Ruth Glacier

The purpose of the RUGL location (Fig. 3) was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #34 was stratified as a New Park location and randomly selected from all locations requiring aircraft access.

Problems incurred at the RUGL location were mostly due to bear tampering. A long period of cloudy weather also caused the batteries to become depleted. The battery operated electric fence used at this site did not appear to be effective, and was often torn down even if the sound equipment was not harmed. These fences have been shown to be effective against bears, so it is a possibility that batteries were dying before the fence was disturbed. The battery powered fence electrifiers are to be replaced with solar-tended electrifiers next season to address the battery life issue.

Bird calls dominated the soundscape at the RUGL location, with wind, rain, and insects also being prevalent. The Ruth Glacier is a very popular corridor for flight-seeing tours based out of Talkeetna, and as such, propeller plane sounds were abundant. An average of 40.9 motorized sounds were heard per day, with occurrences increasing from mid May through June (see Appendix E).

Caribou Creek

The purpose of the CARB location (Fig. 3) was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #183 was stratified as a New Park location and randomly selected from all locations requiring aircraft access. This site was located a short distance from the end of Skyline Drive, which enabled it to be accessed by ATV when creeks were not flowing high.

Data collection at CARB went fairly smoothly, with the exception of one power failure and one incident of damage by bear. The battery operated electric fence used at this site also had problems with battery life, but was rarely disturbed. The battery powered fence electrifiers are to be replaced with solar-tended electrifiers next season to address the battery life issue.

The sound water from Caribou Creek, wind, and birds, in descending order, dominated the soundscape at the CARB location, with bird sound declining significantly after mid-July. This site is generally outside of most flight-seeing corridors, but is

located close to the Kantishna airstrip. As such, over flight frequency was varied, with some days having several, and some very few. An average of 3.5 motorized sounds were heard per day; a light relatively level of impact compared to some of the other sites sampled (see Appendix E).

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APPENDIX A: Funding and Personnel

The soundscape program was funded for 2006 from the Franchise Fee Demo program and a Regional Resources Block Grant. These funds will be used to continue inventorying the soundscape in Denali by implementing a random sampling plan. The following figure are approximate; please contact the author for comprehensive budget details.

Personnel

- $32,959 Soundscape Program Manager: Chad Hults GS-9 Term with 3Mo Furlough
- $10,957 Soundscape Program Technician: Jared Withers GS-5 Seasonal
- $1977.60 Larissa Yocum – additional data analysis.

Aviation

- $23,324 Helicopter and Fixed-wing

Supplies

- $21445

APPENDIX B: Publications, Presentations, and Trainings

Permits

- DENA-2001-SCI-0026 "Soundscape Study of Denali National Park and Preserve." Valid April 16, 2001 to December, 31, 2008.

Education/Presentations/Public Outreach (by Jared Withers)

- 07/27/2006 Introduced soundscapes to kids of the Denali-Susitna Exploration Camp.
- 09/02/2006 – 09/03/2006 Presented Denali's Soundscape Monitoring Program at the Denali Burough School District Teachers Workshop.
- 09/12/2006 Presented "Denali Soundscape Study" at the Alaska Science Symposium.

Reports

- 2006 Annual Report

Training (Jared Withers)

- B3 Helicopter Passenger
- Helicopter Manager
- UAF "Meaningful Interpretation" class

APPENDIX C: Equipment Lists

Station Location	**Equipment List (see below)**
<u>2005</u>	
FOGG	Gs
HEAL	Ps
WFYR	Gs
MULD	Gs
RUGL	Gs
CARB	Ps

Equipment List K (Audio through a *Sennheiser* mic and *MoblilePre* soundcard)

G = Gray 4 ft^3 plastic box **s = Sennheiser mic, g = G.R.A.S Mic**

#/Station Item

- 2-5 *Kyocera* 85W Solar Panels
- 0-2 *Kyocera* 35W Solar Panels
- 1-4 Angle Aluminum Solar Panel Frames
- 3-5 Batteries 100Ah Gel Cell
- 1 30A *Trace Engineering* Solar Controller
- 1 Laptop (*Panasonic Toughbook CF-45*) with 40Gb HD and Win XP, 192Mb RAM.
- 2 *Bogen* Tripods (Microphone Stands)
- 6 Microphone Stand Anchor Screws
- 1 Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Rycote Windjammer* "Fuzzy" Windscreen
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard

  Setup g
  - 1 G.*R.A.S. 26CA* Pre-amp
  - 1 *G.R.A.S. 40AE* Microphone
  - 1 BNC Cable *Belden* (25')
  - 1 BNC Female-XLR female connector

  Setup s:

- 1 *Sennheiser K6P* Power Module
- 1 *Sennheiser ME62* Microphone Capsule
- 1 XLR Cable (25')

- 1 Home Rigged Environmental Kit (PVC mic tube, cloths hanger bird spike, duct seal)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* "Fuzzy" Windscreen

Equipment List P (Audio through a *Sennheiser* mic and *MoblilePre* soundcard)

P = Pelican Case 1520 **s = Sennheiser mic, g = G.R.A.S Mic**

#/Station Item

- Solar Panel setups
  - McBAR, BLDR – 8 *Solarex MSX Lite* 20W
    - 4 - 6'x1 ½"x1/8" aluminum angles, 4 – 6'x1"x1/8" aluminum angles, 2-4'x1"x1/8" aluminum angles
  - UEFK – 6 *Solarex MSX Lite* 20W, 1 Kyocera 35W
    - 16 Tent Stakes for Solar Panels
    - 16 Aluminum Rods to raise top edge of Solar Panels (1/4" x 18")
  - TOKO – 2 Solarex 50W, 2 Solarex MSX Lite 20W
    Changed To, 3 Kyocera 35W, 2 Solarex MSX Lite 20W
    - 4- 6'x1 ½"x1/8" aluminum angles, 2 - 34"x1"x1/8" angle aluminum angles
- 4 Batteries 35Ah (TOKO – 2 100Ah)
- 1 10A *Sun Saver* 10 Solar Controller
- 1 Laptop (*Panasonic Toughbook CF-45*) with 40Gb HD and Win XP, 192Mb RAM.
- 1 Duct Seal for microphone cables
- UEFK
  - 2 - *Bogen 3372* Light Stands (Microphone Stands)
  - 6 - Microphone Stand Mesh bags for Weight
- McBAR, BLDR, LEFK, TOKO
  - 2 - *Bogen* Tripods (Microphone Stands)
  - 6 - Microphone Stand Anchor Screws
- 1 *Pelican Case* 1520
- 1 Lock (P-1 from B&U)

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike, duct seal, straw)
- 1 *Rycote Windjammer* "Fuzzy" Windscreen

- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard
- 1 Home Rigged Environmental Kit (PVC mic tube, cloths hanger bird spike, duct seal)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* "Fuzzy" Windscreen

  Setup g
  - 1 G.*R.A.S. 26CA* Pre-amp
  - 1 *G.R.A.S. 40AE* Microphone
  - 1 BNC Cable *Belden* (25')
  - 1 BNC Female-XLR female connector

  Setup s:
  - 1 *Sennheiser K6P* Power Module
  - 1 *Sennheiser ME62* Microphone Capsule
  - 1 XLR Cable (25')

APPENDIX D: Percent Exceedence (L_x)

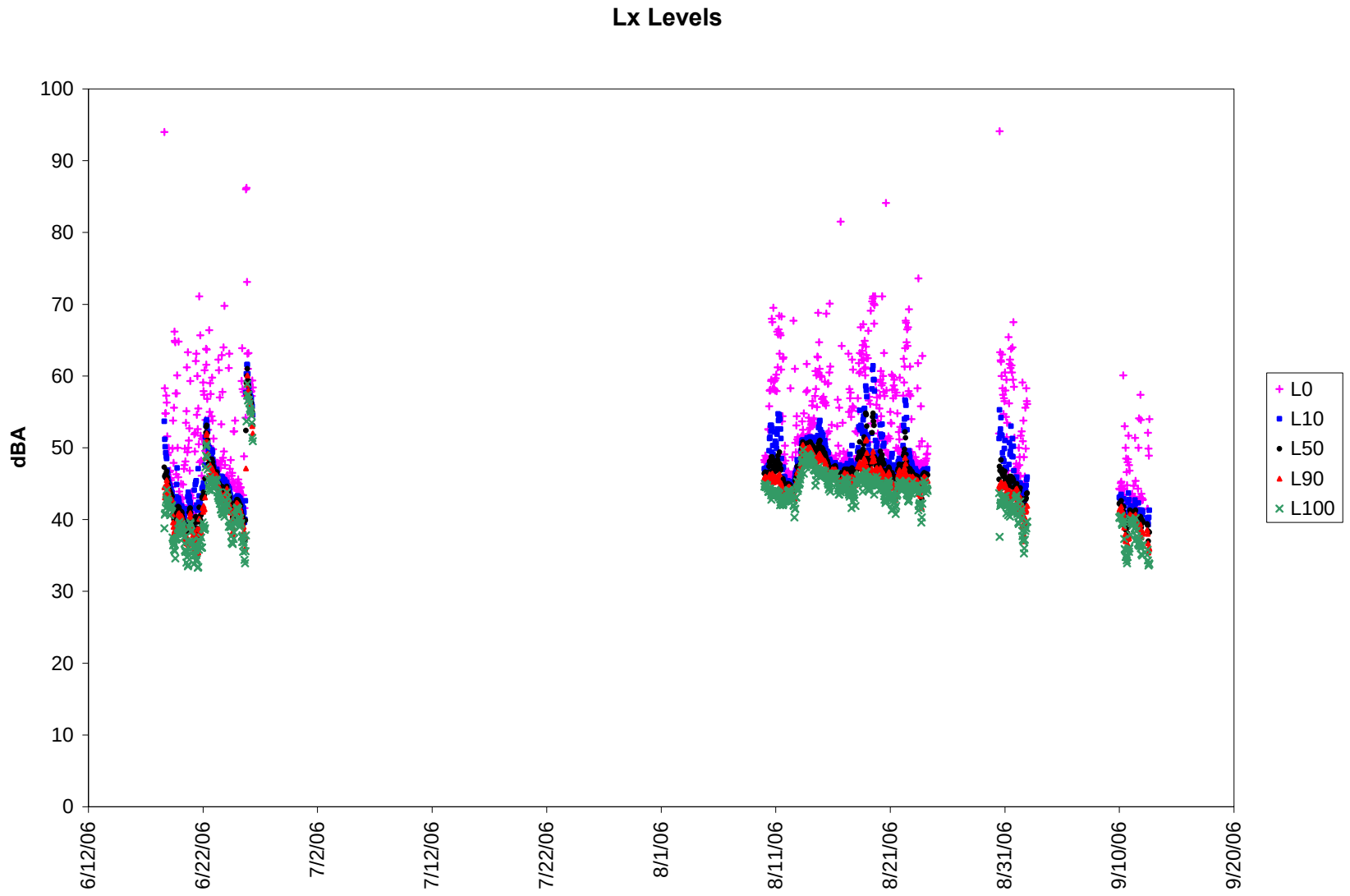
The charts on the following pages represent the Percent Exceedence levels (Lx, see definition below) for all locations sampled during the 2006 season. Percent exceedence levels are calculated for each hour. Each point on the charts is a percent exceedence level calculated for one hour. The first chart for each location shows percent exceedence levels of L_{100}, L_{90}, L_{50}, L_{10}, and L_0. L_{100} is the minimum sound level measured during the hour and the L_0 is the maximum sound level measured during the hour. The second – fourth charts show the L_{10}, L_{50}, and L_{90} values respectively.

Percent Exceedence (L_X)

These metrics are the sound levels (L), in decibels, exceeded x percent of the time. The L50 value represents the sound level exceed 50 percent of the measurement period. L50 is the same as the median. The L90 value represents the sound level exceeded 90 percent of the time during the measurement period. For natural ambient environments, these levels generally differ by less than 3 to 5 dB because natural levels usually do not vary much over short periods of time (e.g., during an hour or two, unless there are highly variable conditions). L50 and L90 are useful measures of the natural sounds because in wildland situations, away from developed areas, they are less likely to be affected by non-natural sounds. Put another way, non-natural sounds in many wildland areas are likely to affect the measured sound levels for less than 50% of the time, and almost certainly for less than 90% of the time. L50 is used when there is high certainty that no non-natural sounds affect the measurements. L90 is used when non-natural occur during measurements.

Adapted from: Ambrose, S., Donaldson, M. (In Press). Sound Levels In and Near the YUKON Military Operations Areas, Alaska, 1999-2003 (Draft). NPS Internal Report, 78pp.

The data for the charts below were compiled using a new macro developed in December 2005 by Chad Hults. The macro was created using Visual Basic for Applications in Excel. The macro grabs the L_X values L_{100}, L_{90}, L_{50}, L_{10}, L_0 from the SPL*.xls files created by the ConvertSPLtoXLS macro that was created in 2004, which is contained in the SPL Macr.xls file. There is a ReadMe file for all the macros created within the folder containing the macros.


Lx Levels
dBA
100
90
80
70
60
50
40
30
20
10
0
6/12/06
6/22/06
7/2/06
7/12/06
7/22/06
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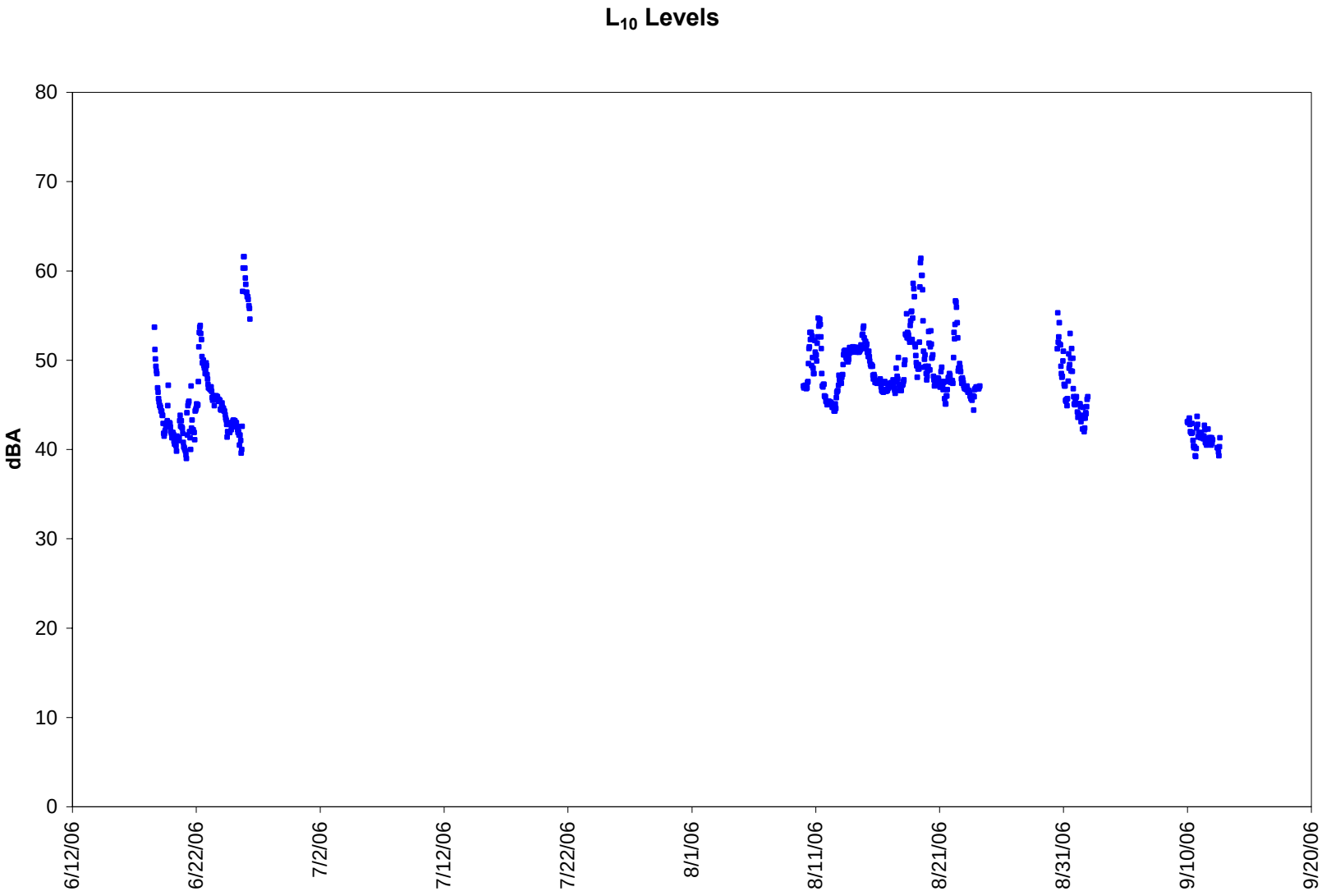
L0
L10
L50
L90
L100


L10 Levels
dBA
80
70
60
50
40
30
20
10
0
6/12/06
6/22/06
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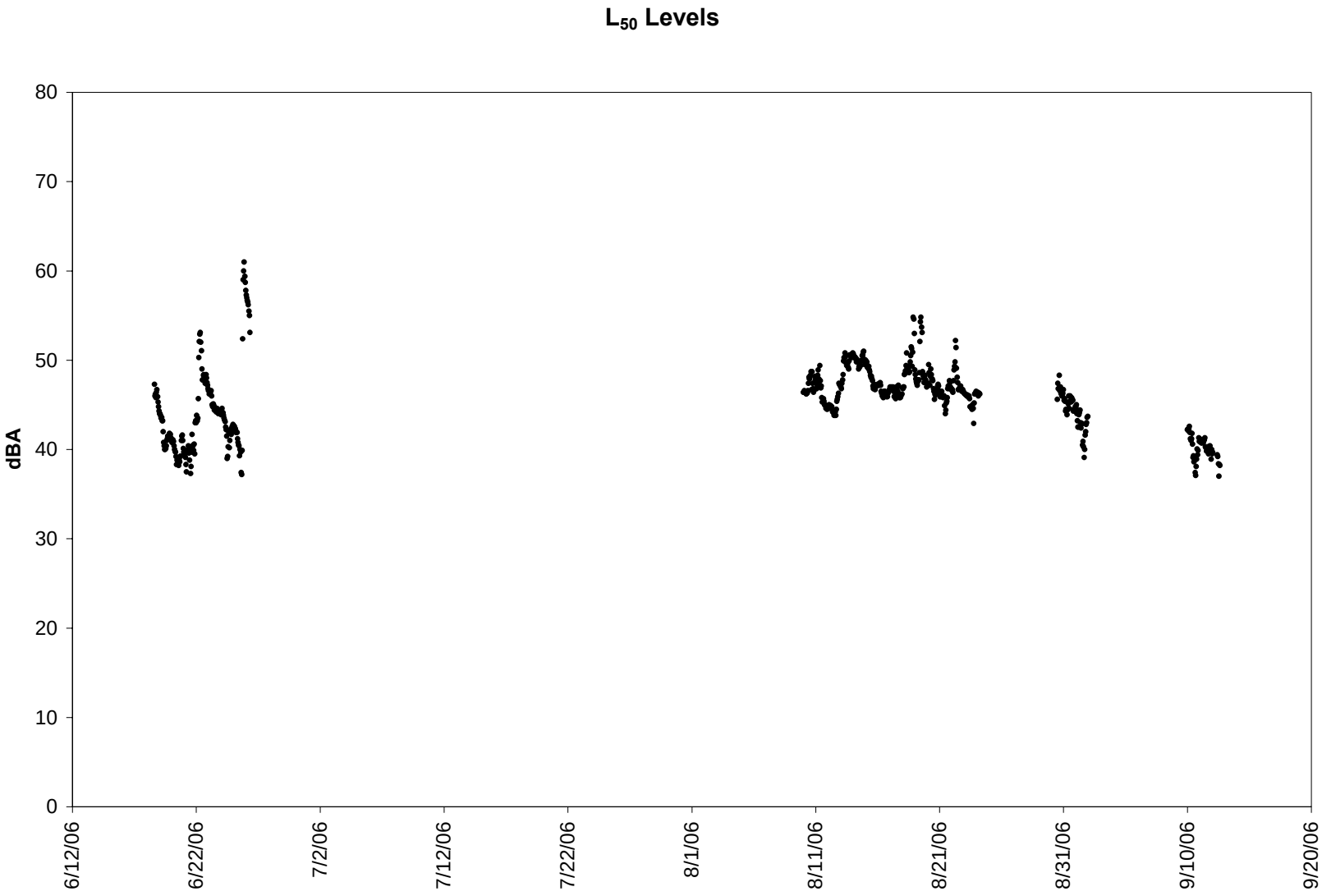
9/10/06
9/20/06


L50 Levels
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70
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50
40
30
20
10
0
6/12/06
6/22/06
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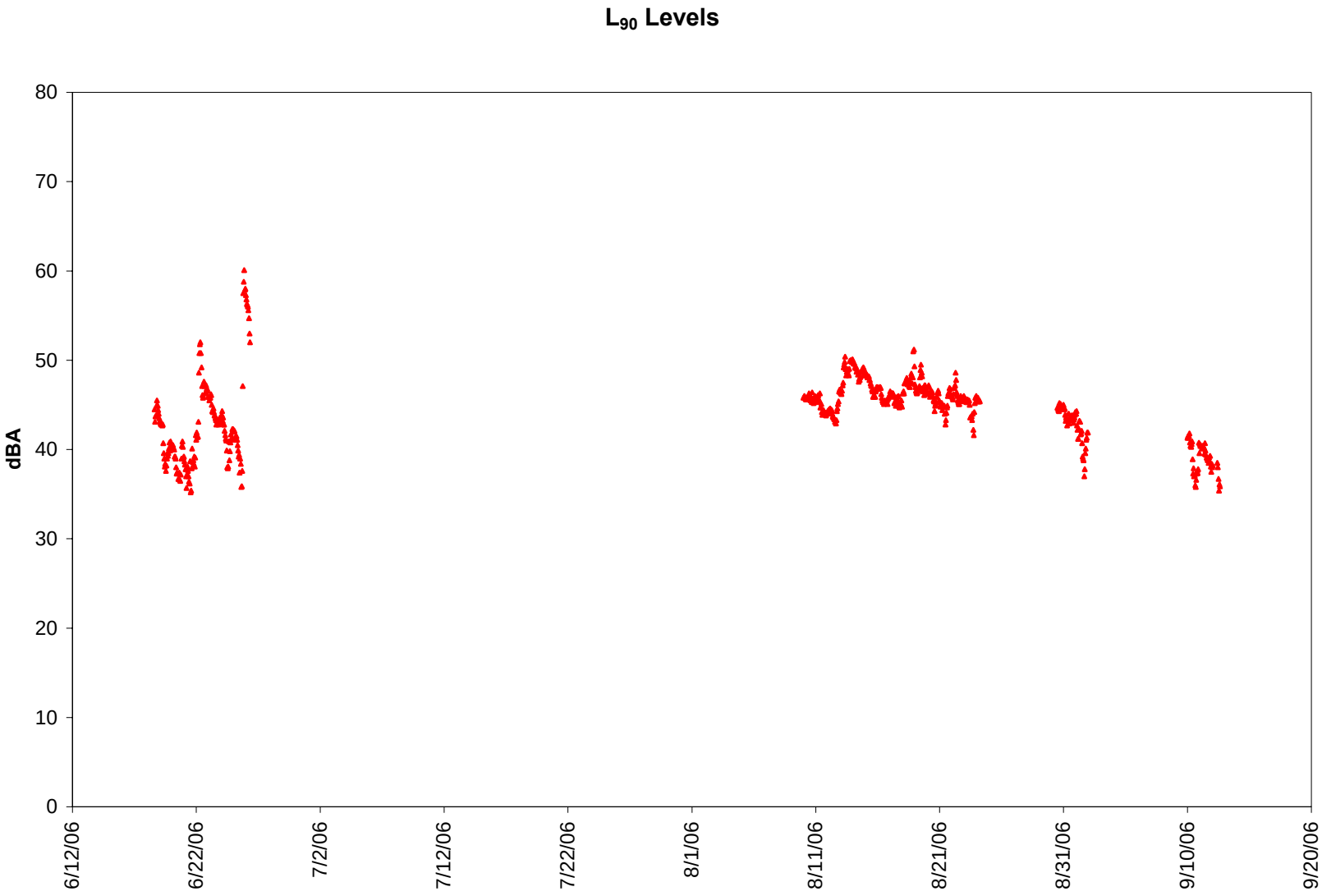
9/20/06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70
60
50
40
30
20
10
0
6/12/06
6/22/06
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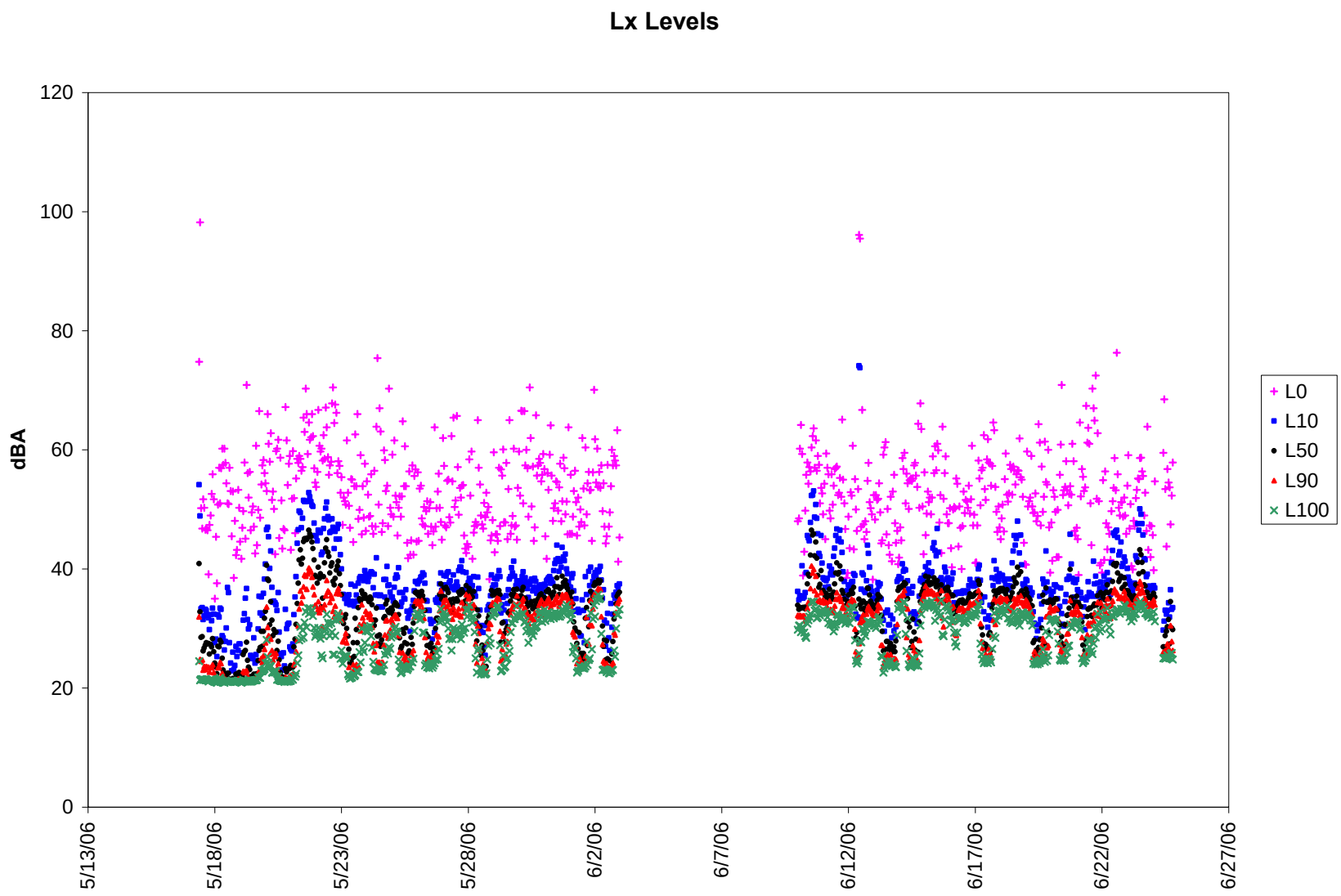
9/20/06


Lx Levels
dBA
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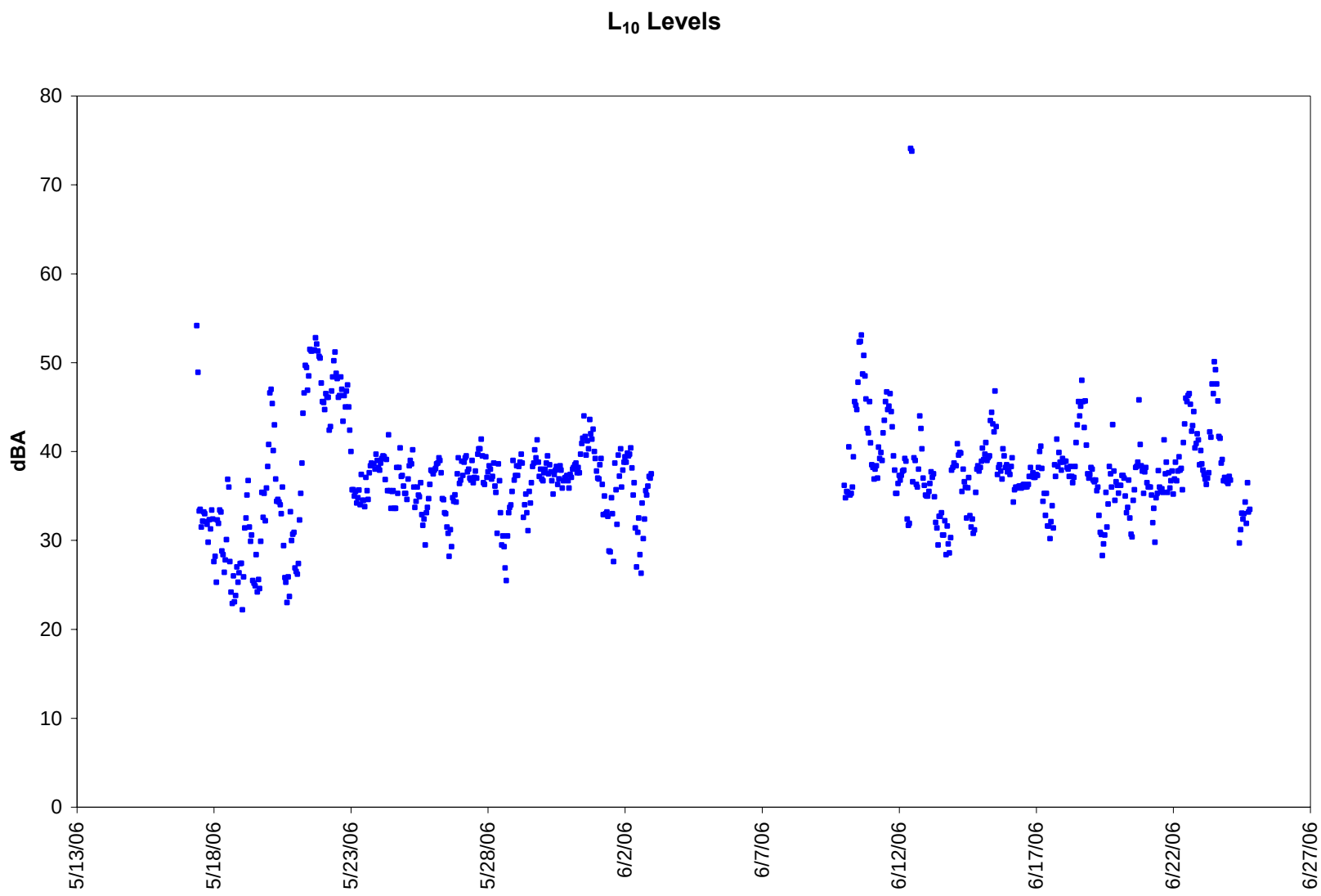
100
80
60
40
20
0
5/13/06
5/18/06
5/23/06
5/28/06
6/2/06
6/7/06
6/12/06
6/17/06
6/22/06
6/27/06
L0
L10
L50
L90
L100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dBA
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50
40
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20
10
0
5/13/06
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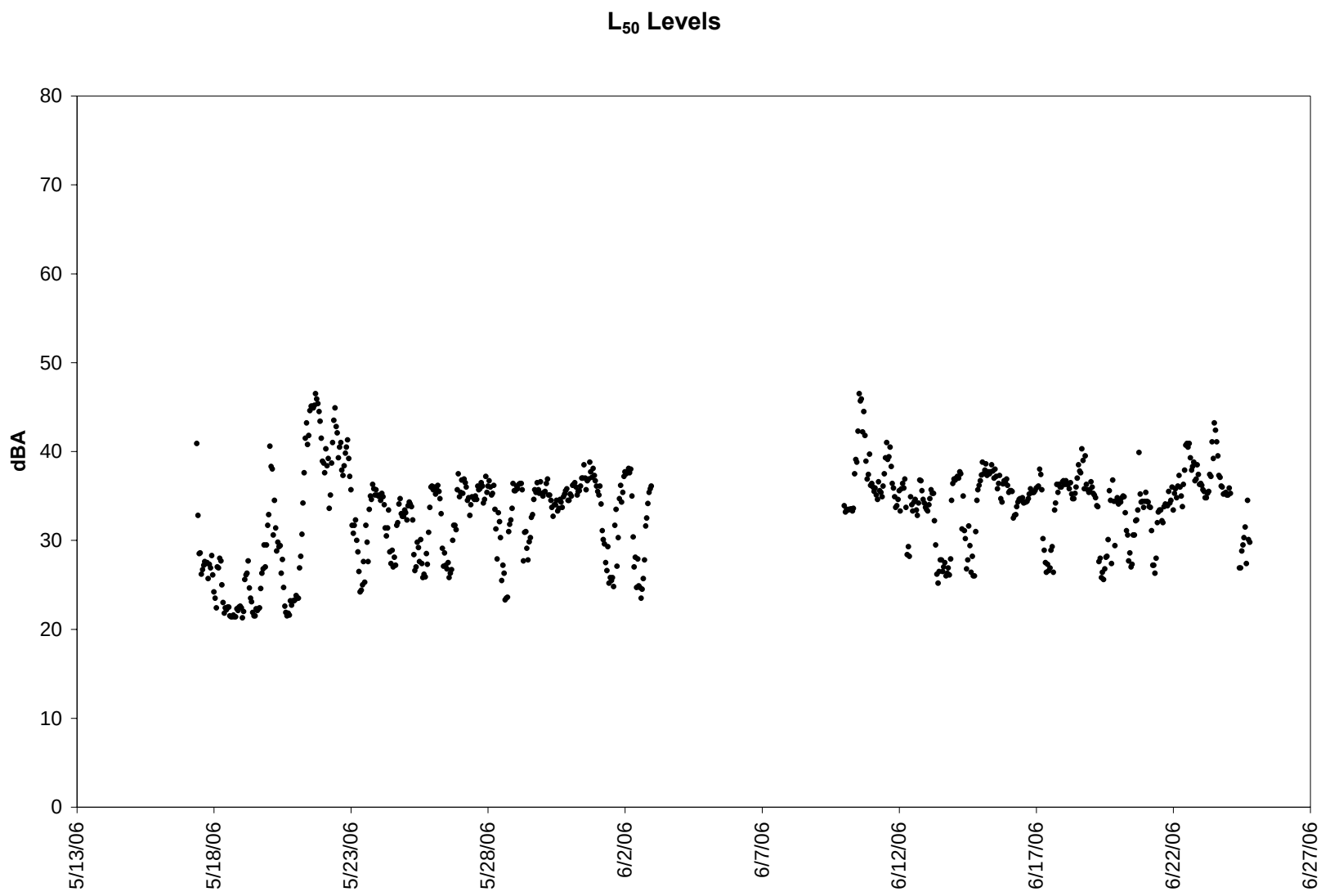
6/22/06
6/27/06


L50 Levels
dBA
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5/13/06
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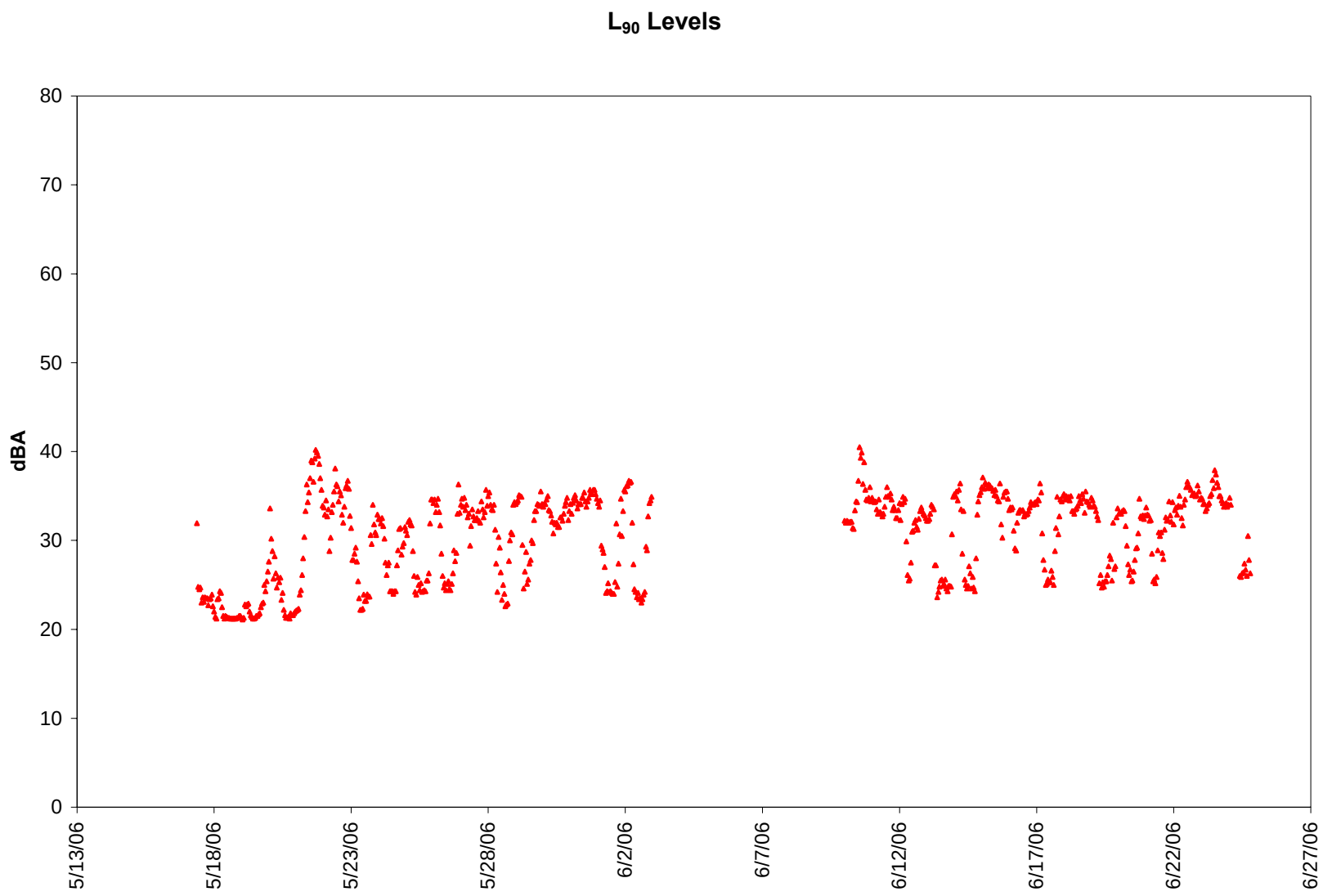
6/27/06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70
60
50
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20
10
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5/13/06
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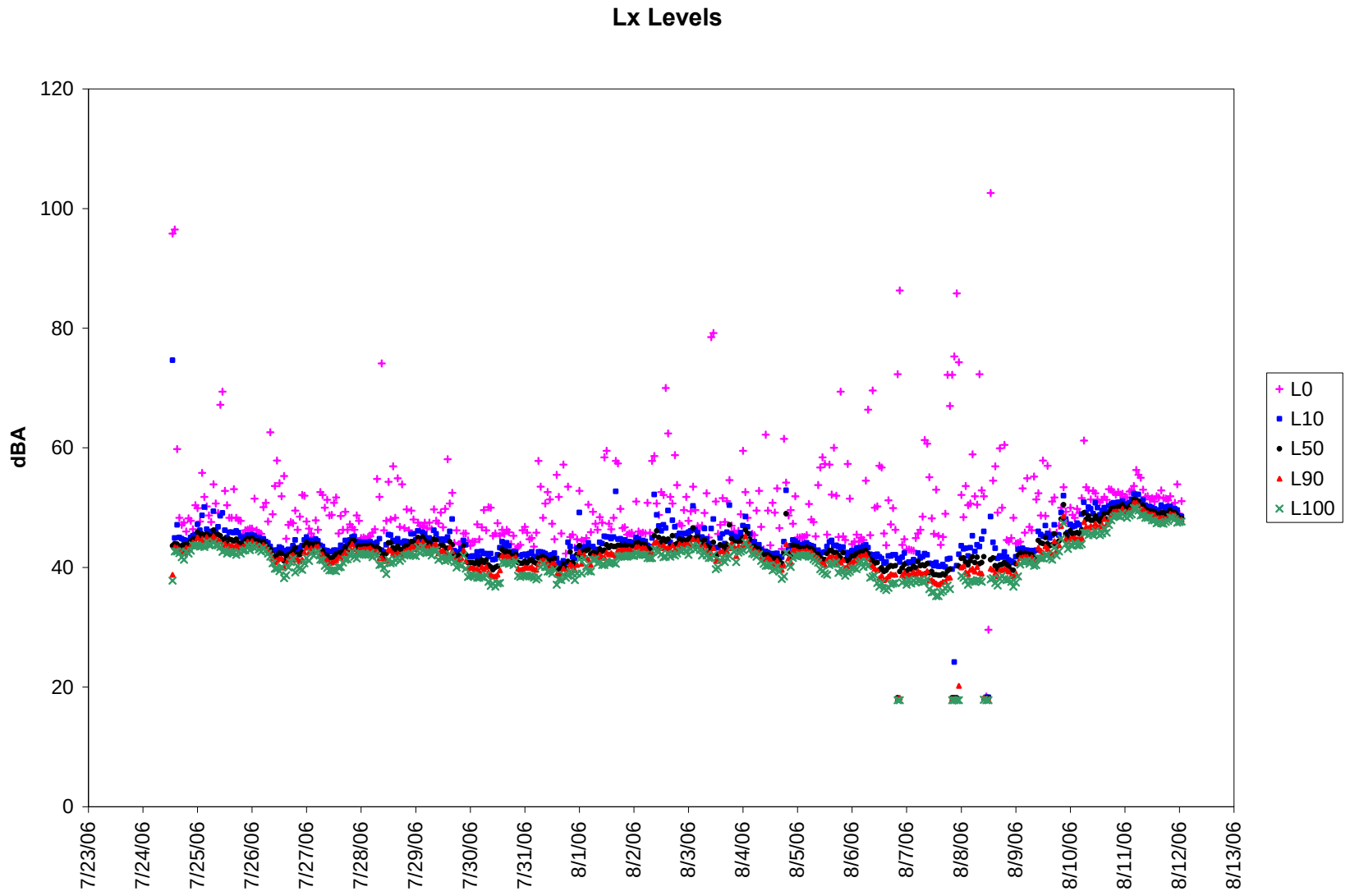
6/27/06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dBA
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7/23/06
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7/28/06
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L0
L10
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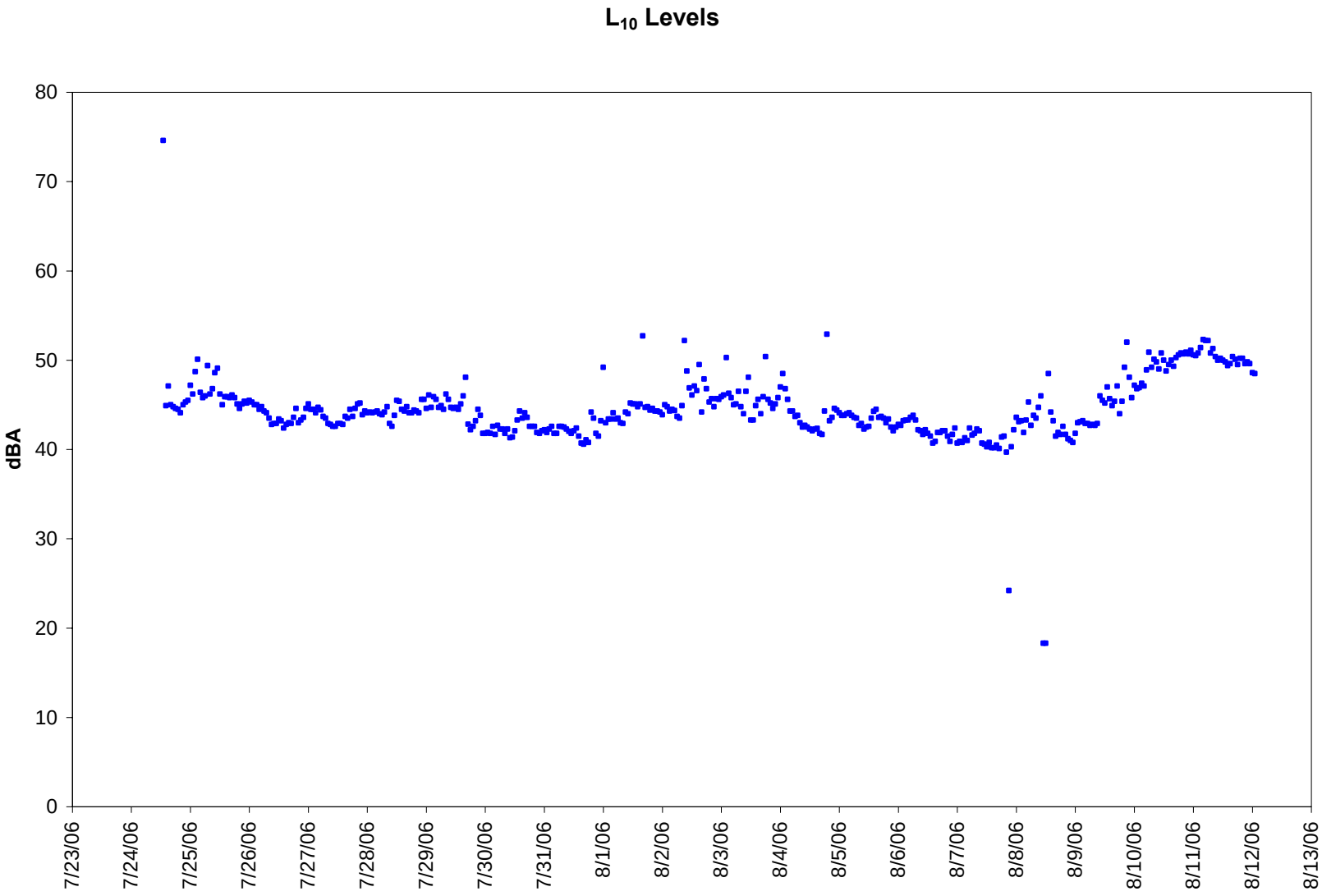
L90
L100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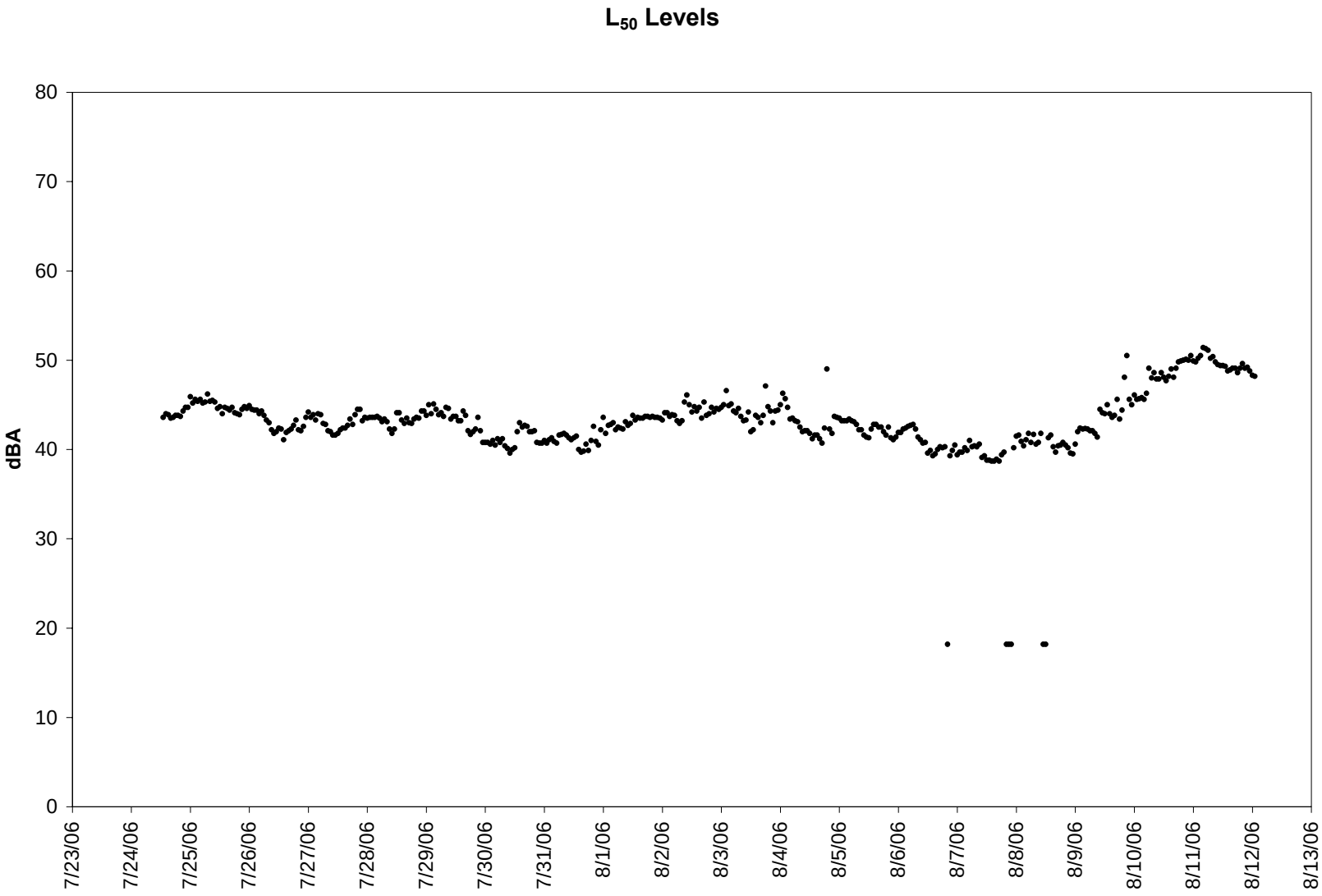
L50 Levels
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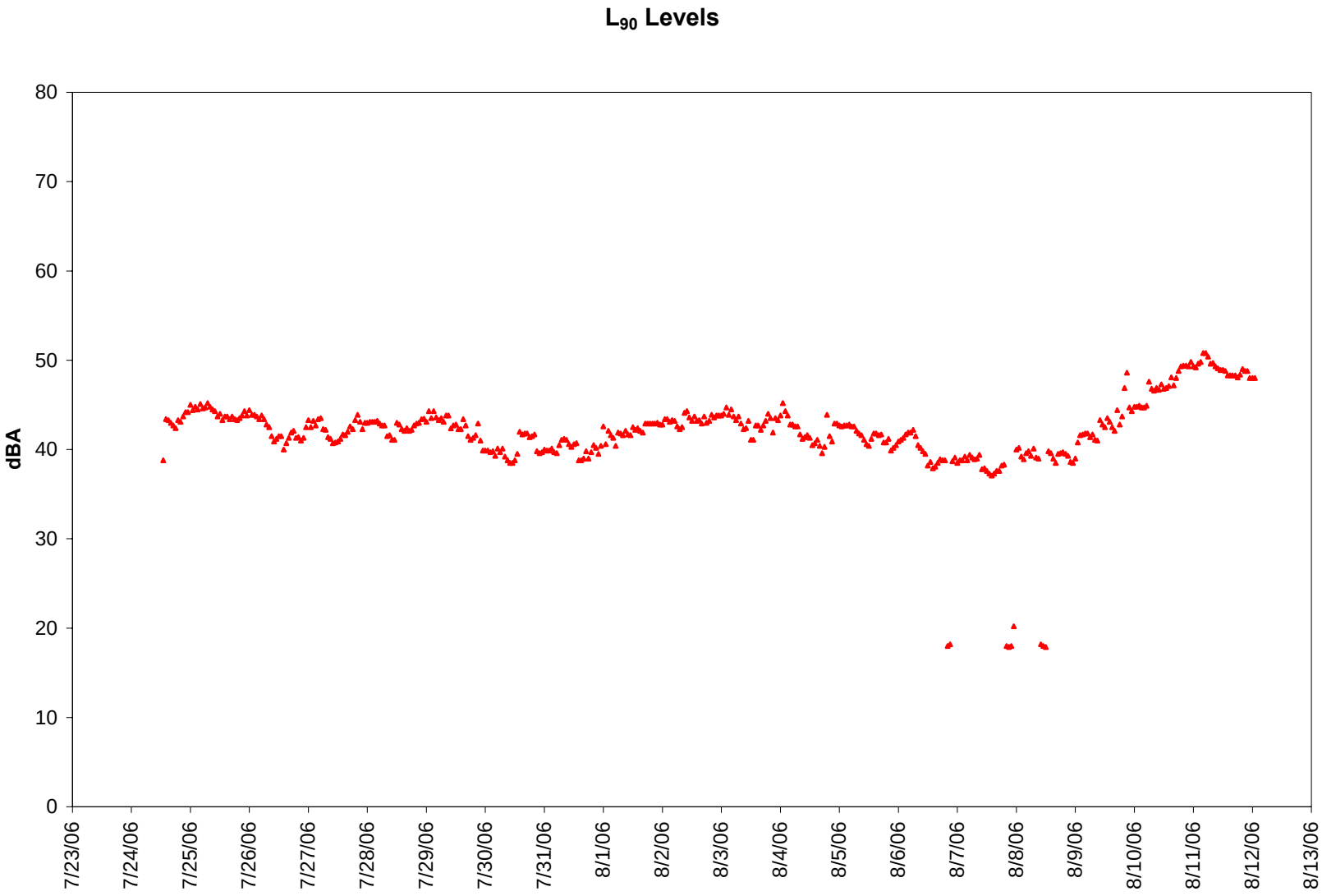
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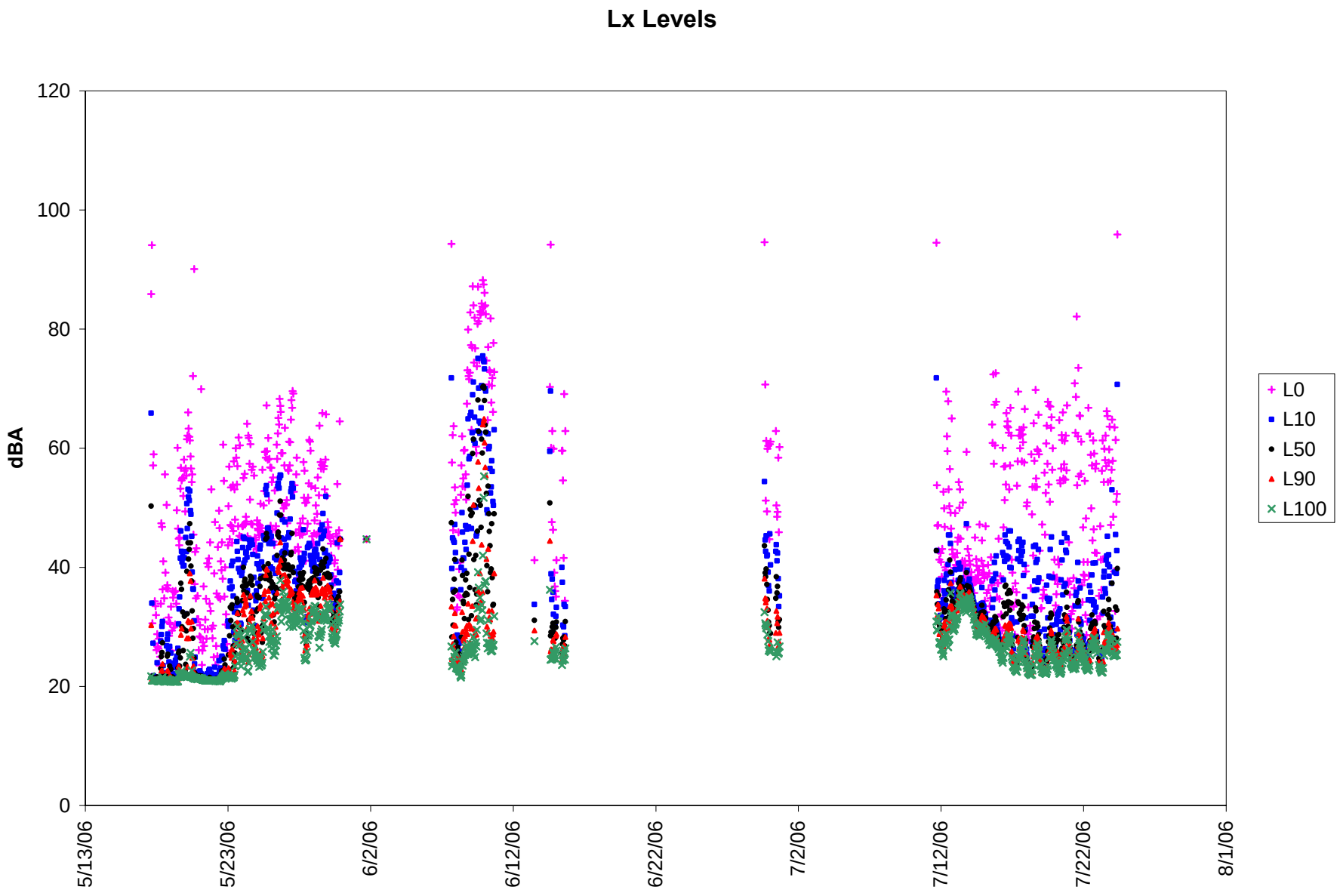
Lx Levels
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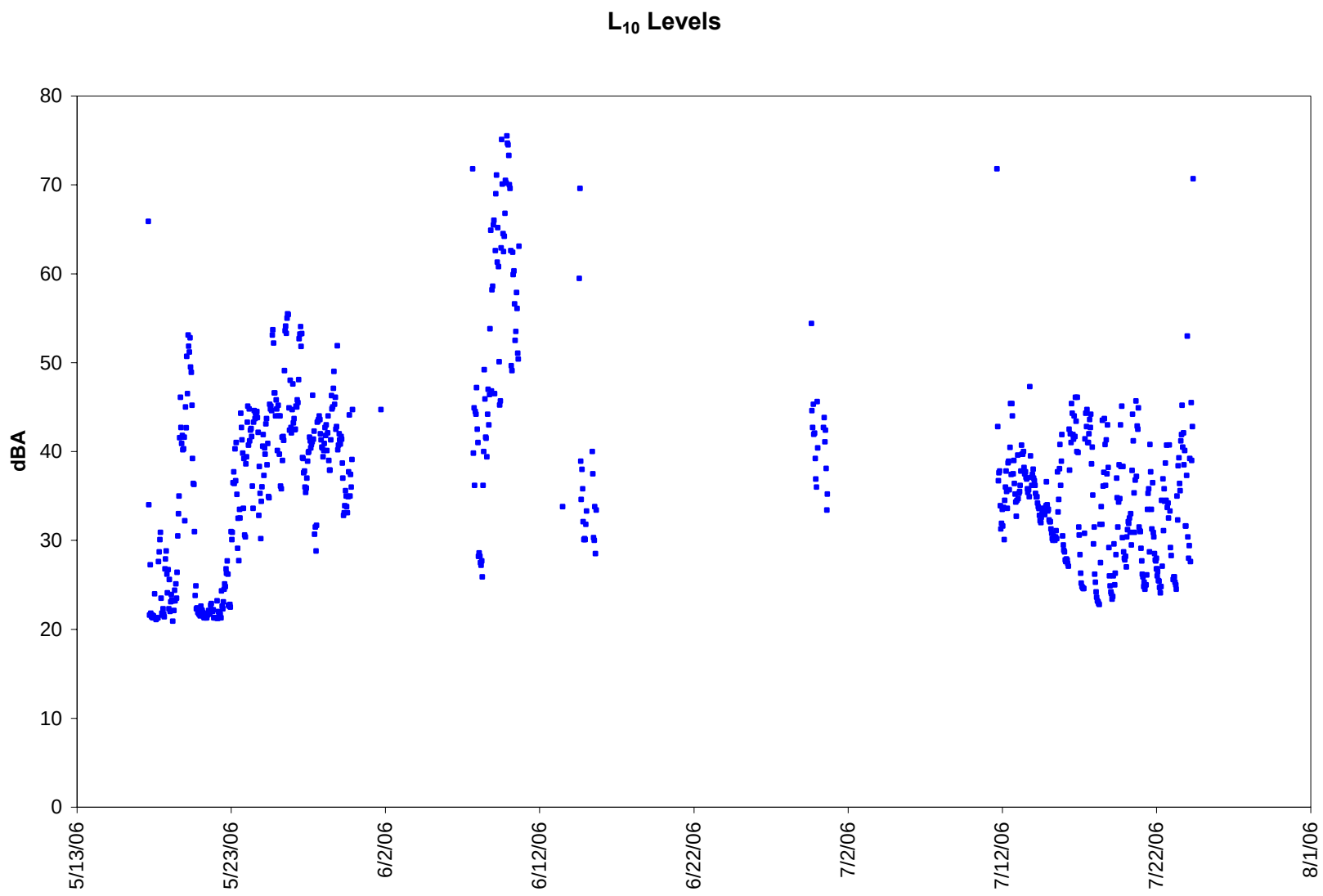
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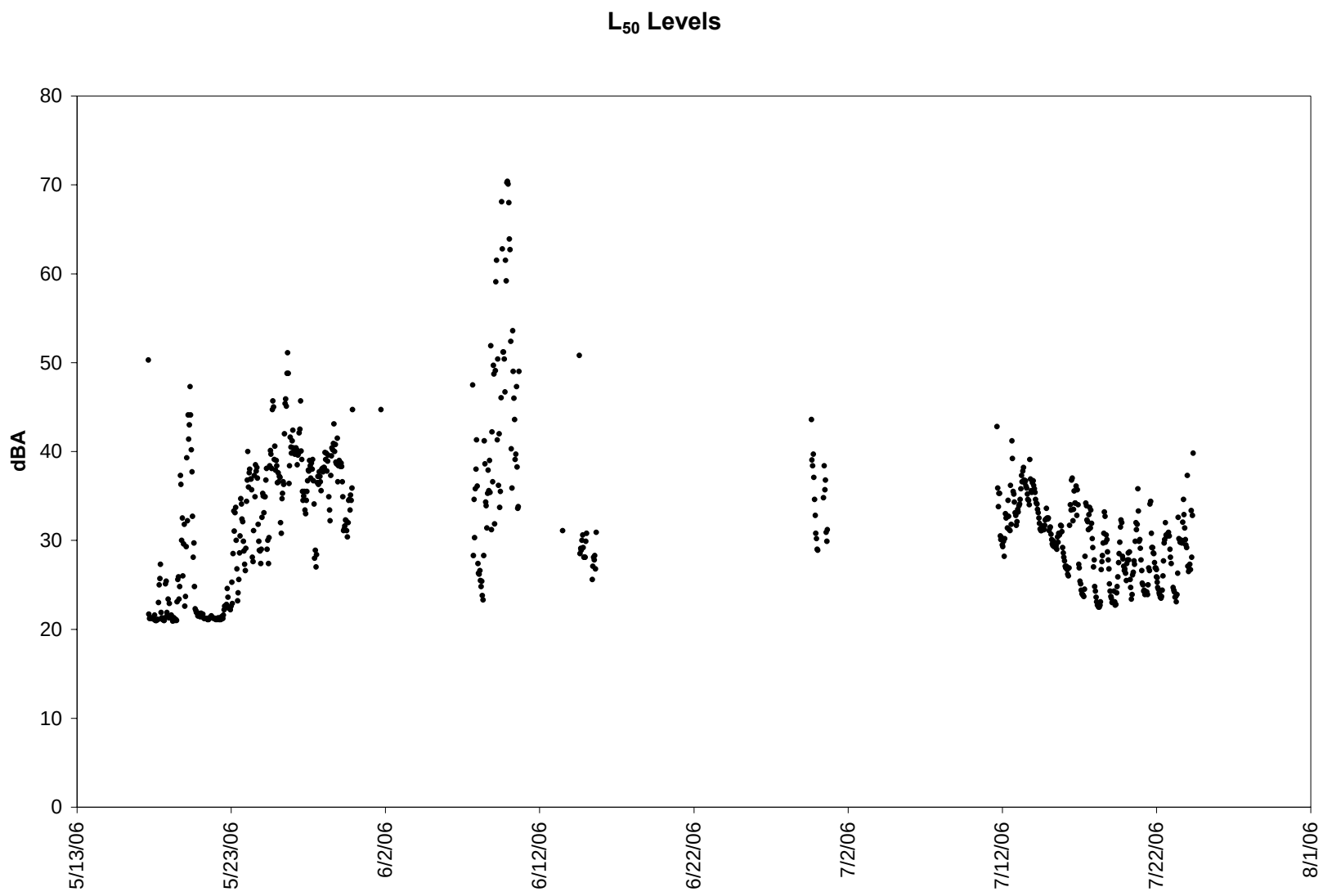
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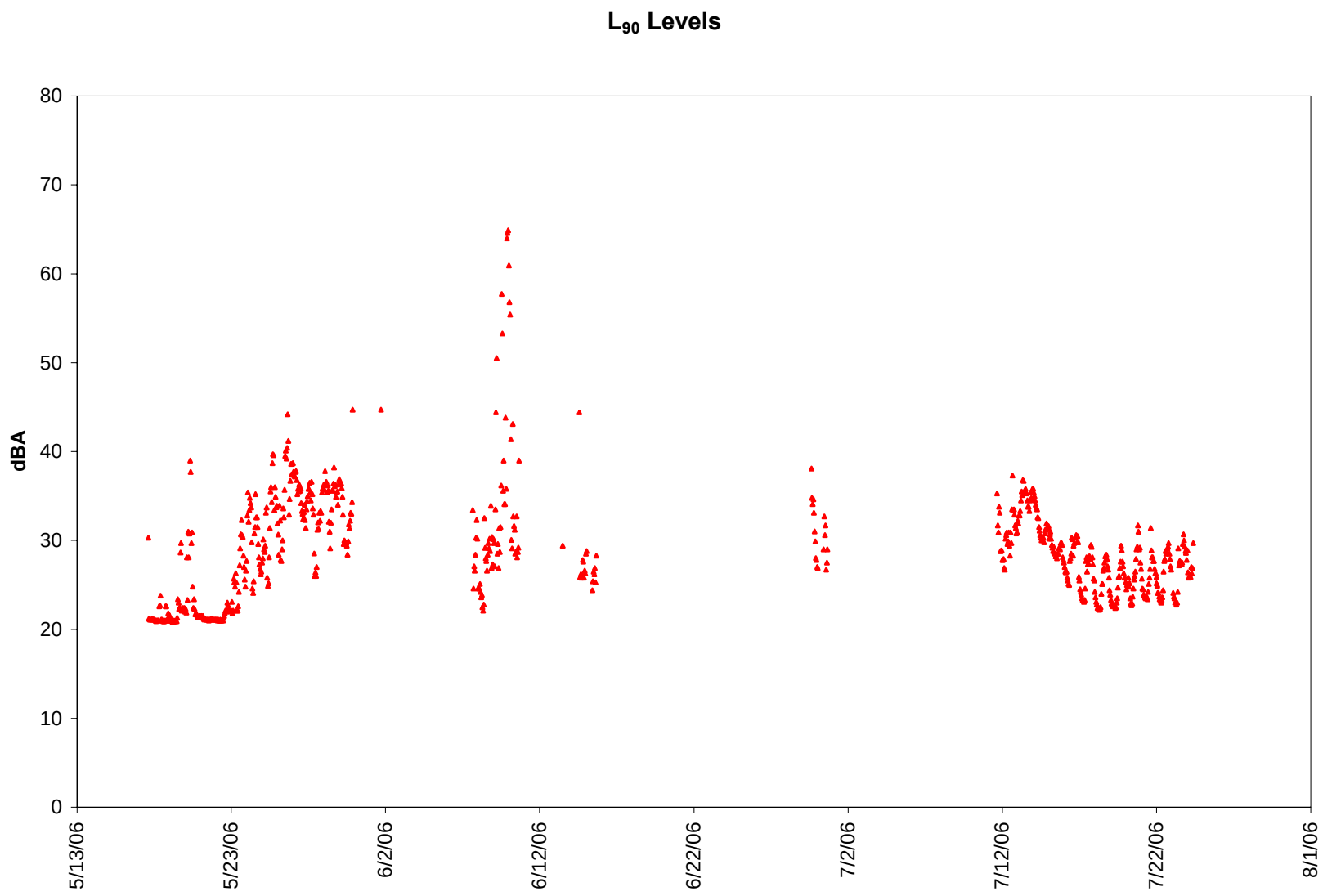
8/1/06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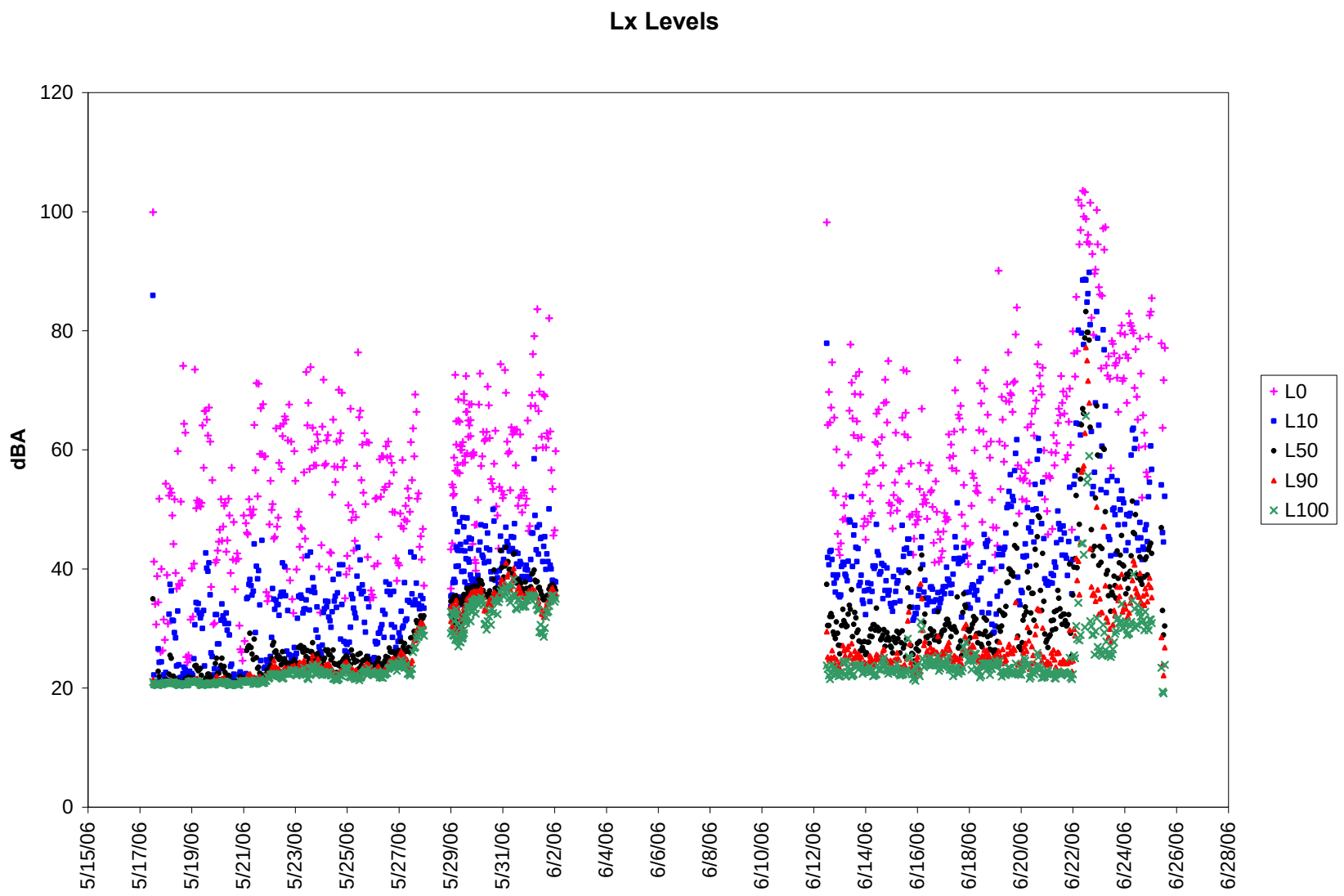
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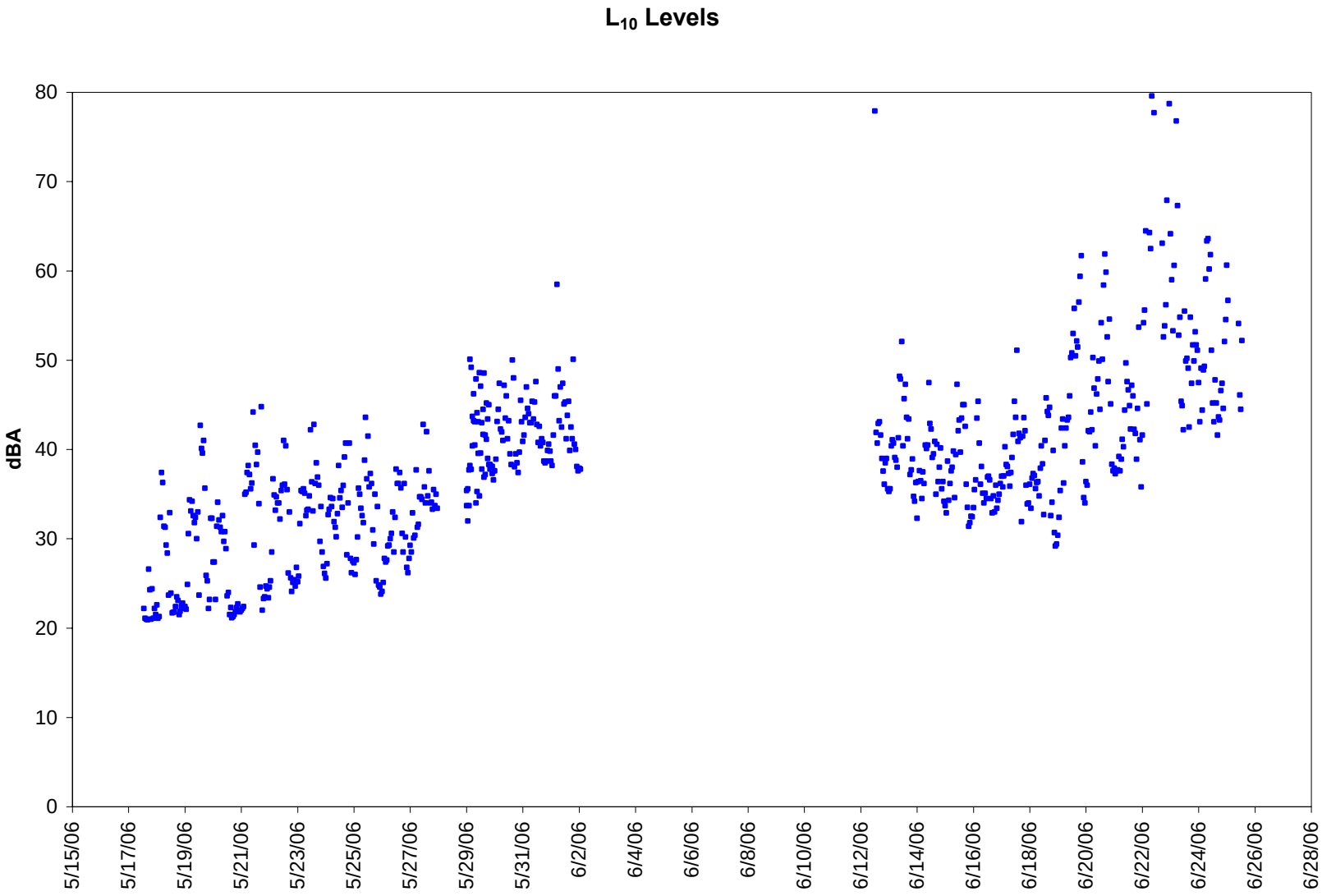
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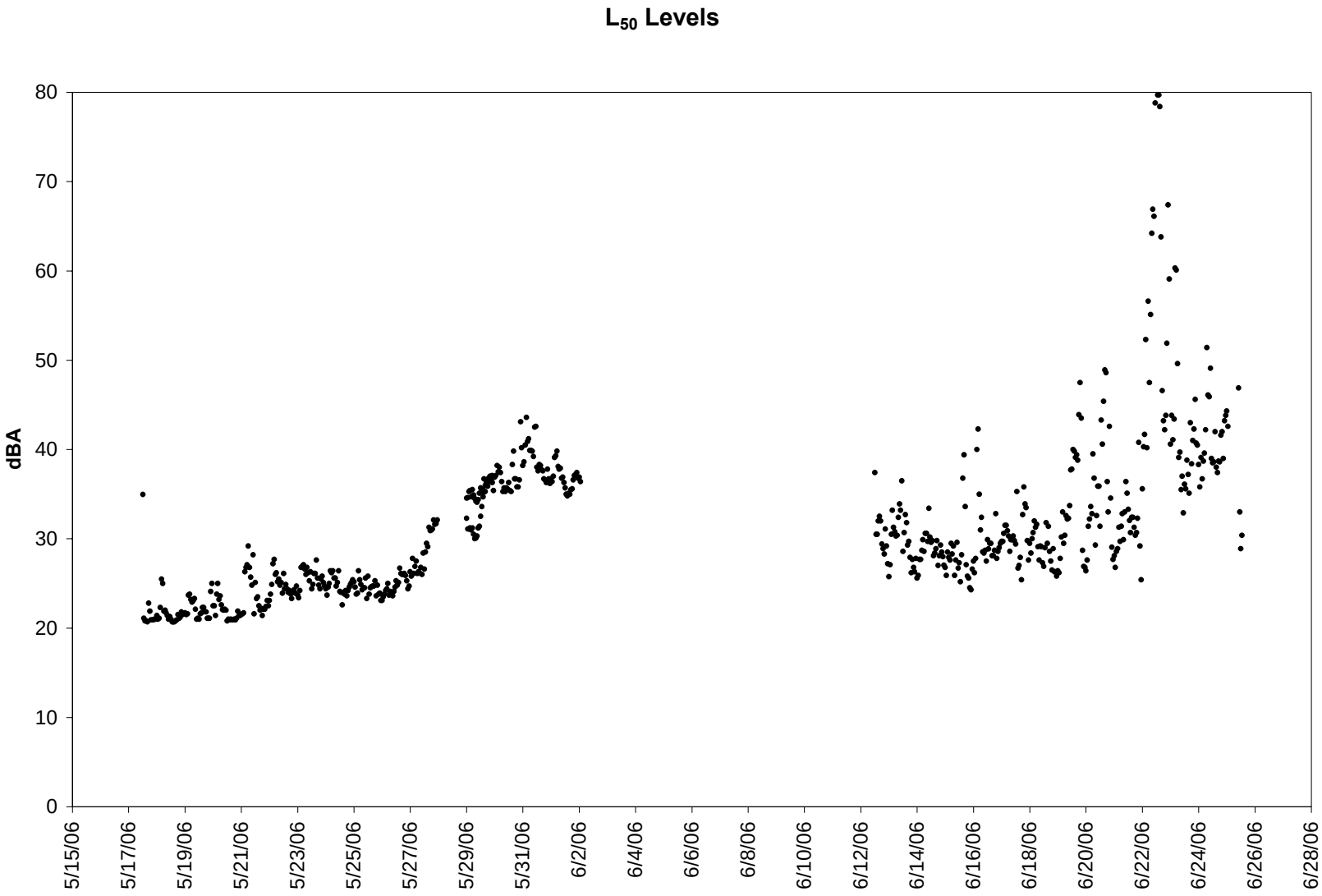
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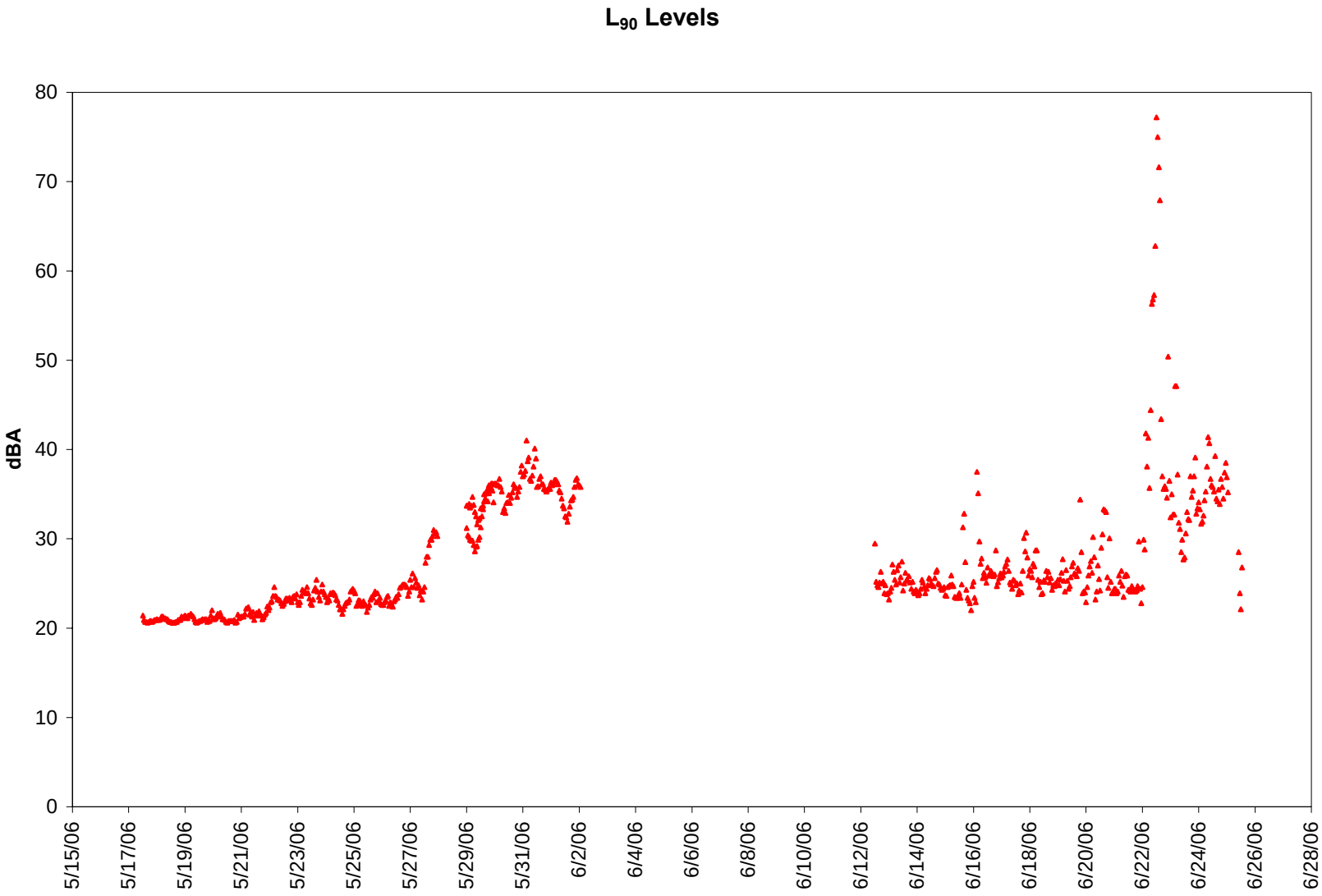
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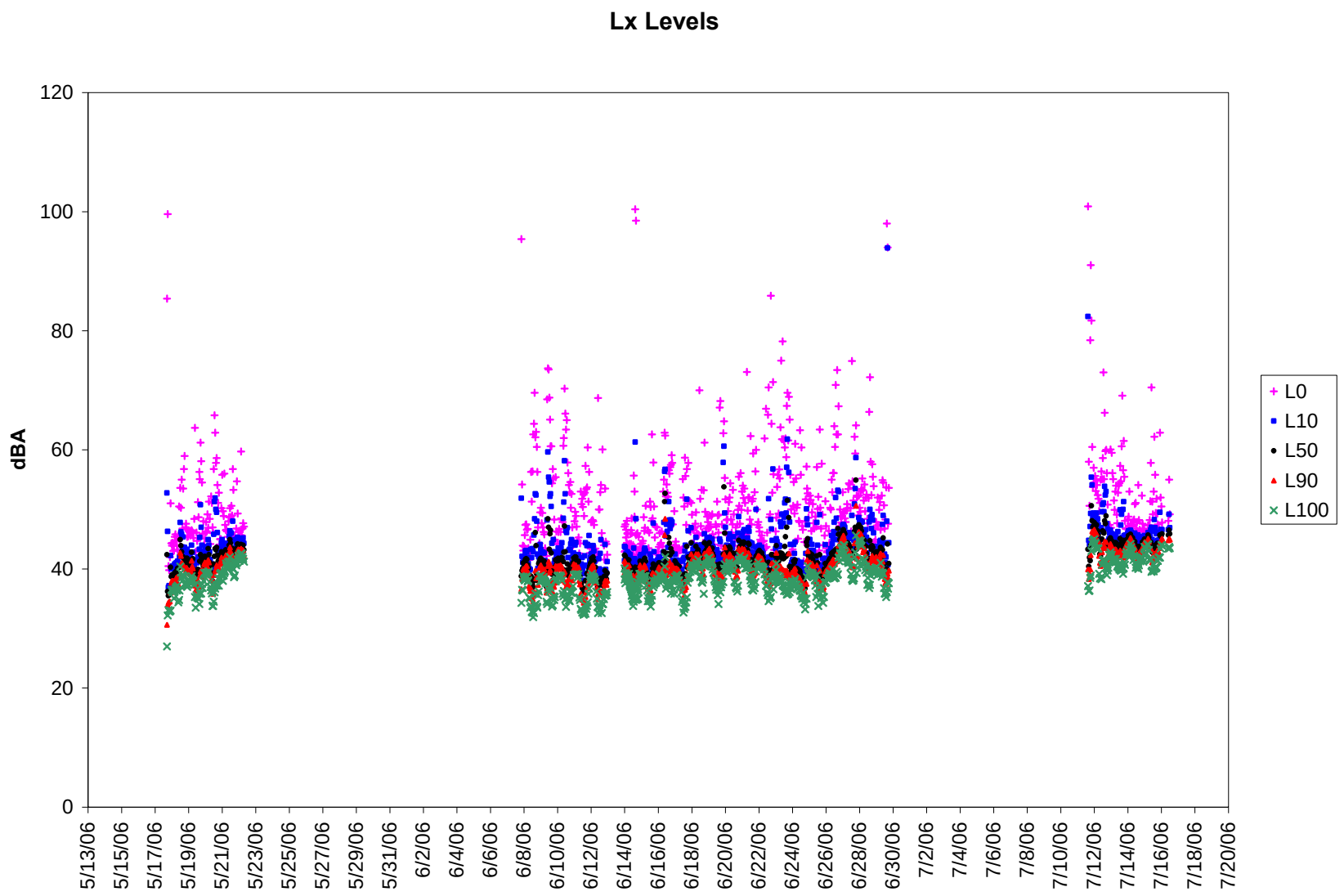
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dBA
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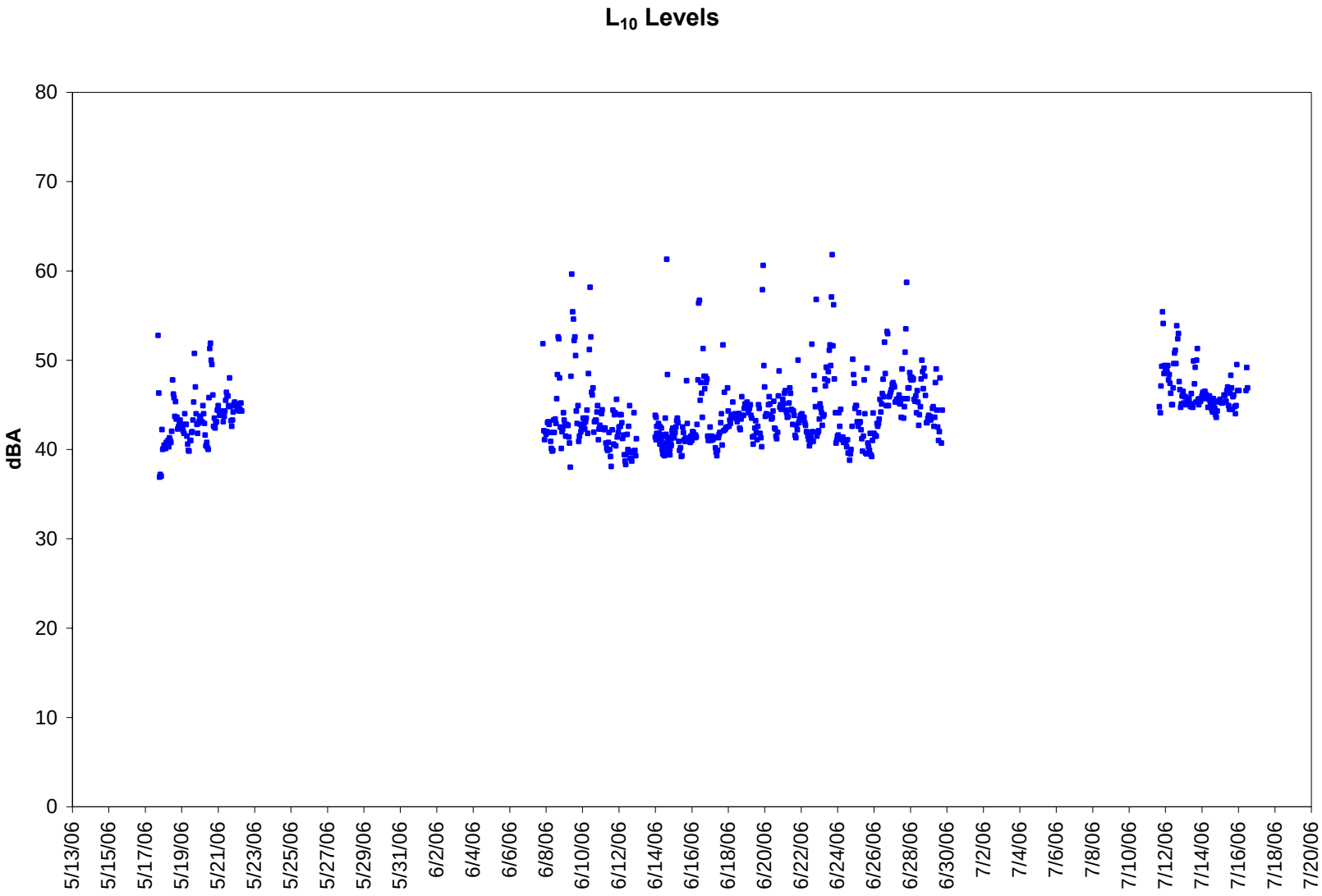
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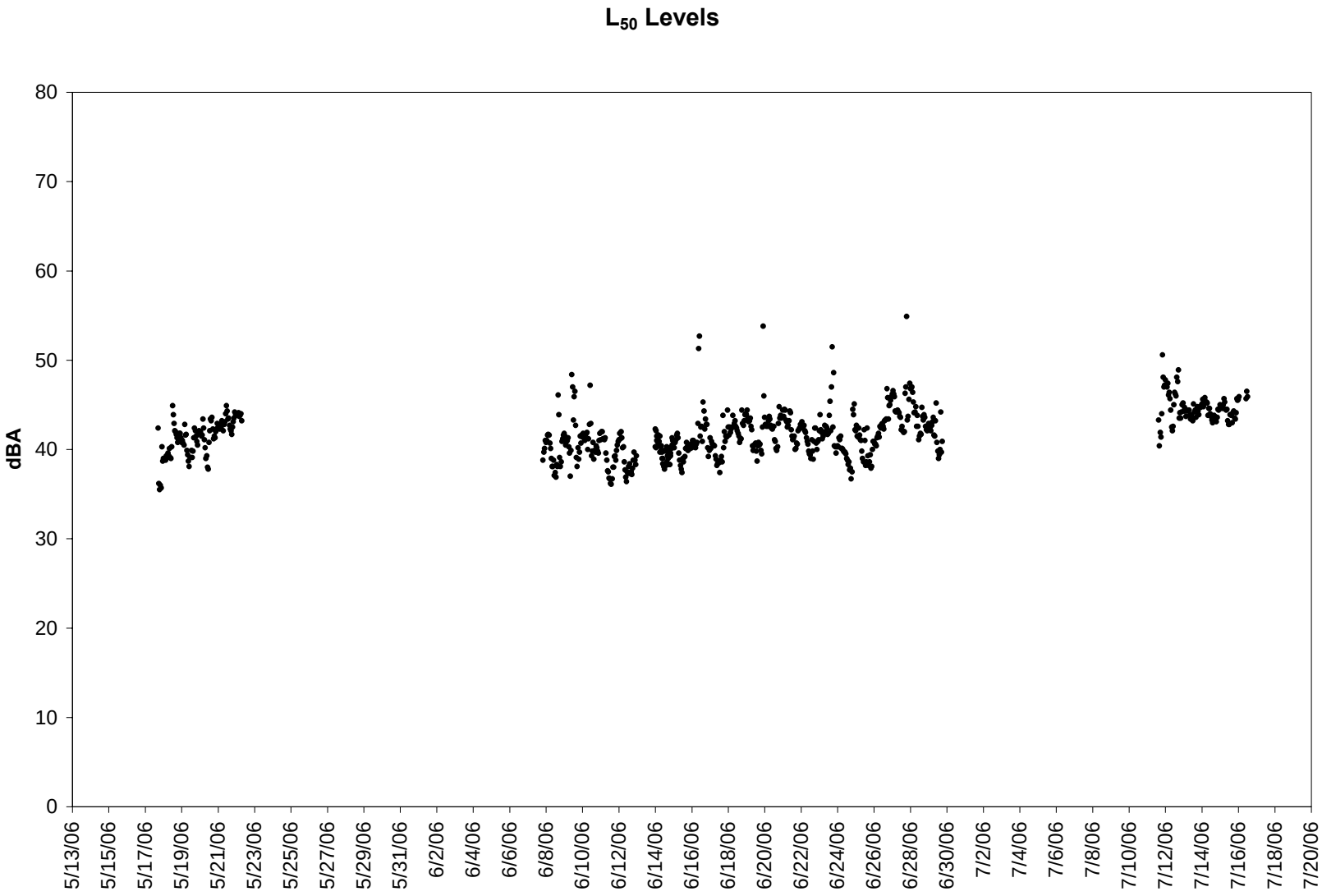
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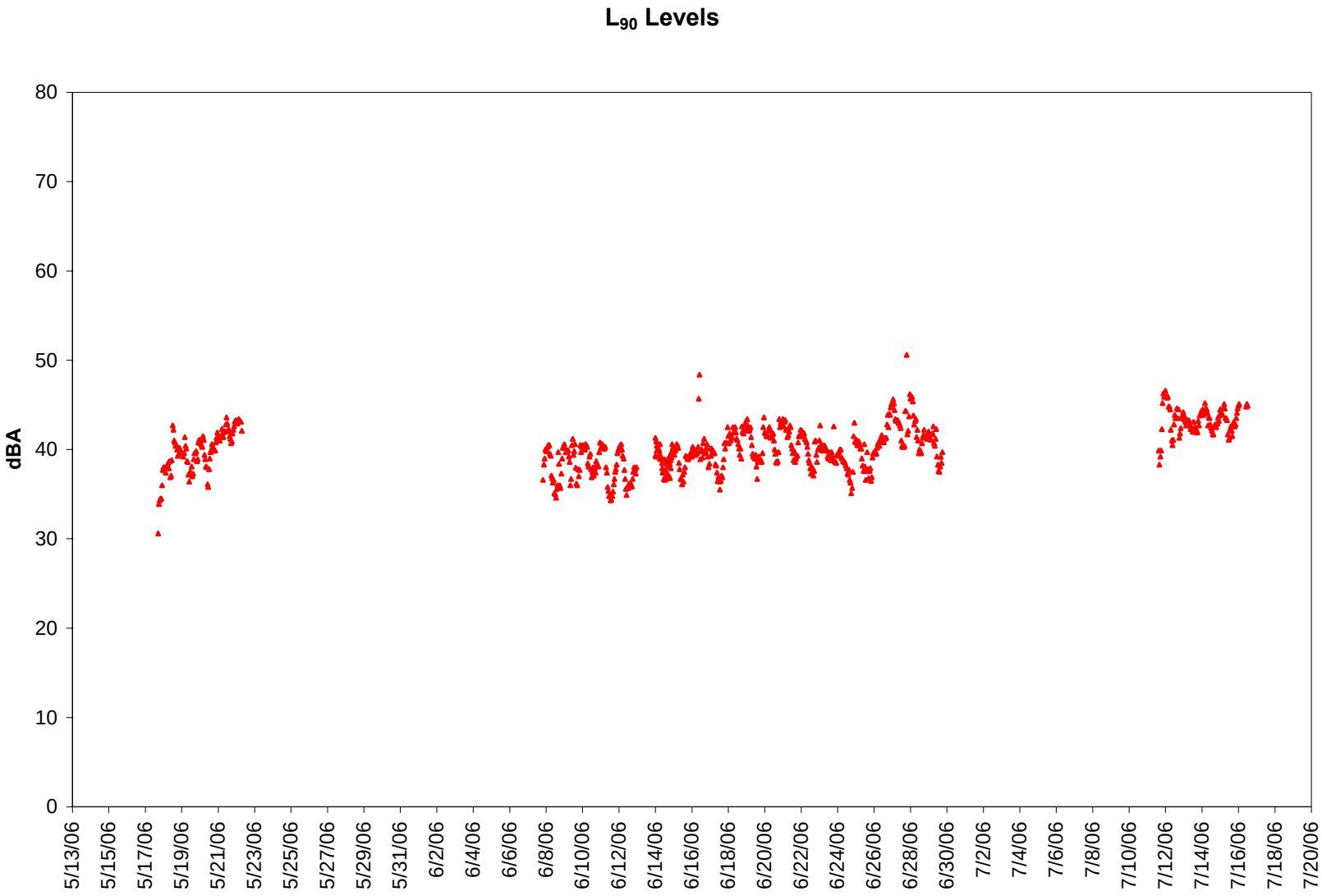
L90 Levels
dBA
80
70
60
50
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APPENDIX E: Location Descriptions and Data Analysis

A summary of the data analyzed for the stations established during the 2005 field season (Fig. 8) are presented on the following pages. Each section begins with a location description cover sheet. Following the description cover sheet are selected charts that summarize the data analyzed thus far from each location. Each data compilation summary completed for each location contain ten charts; one chart showing the sum of all sounds identified, four charts characterizing the natural soundscape, based exclusively on audibility, and five charts relating to backcountry management planning, which show the levels of motorized sounds. The charts for each compilation are as follows:

General Soundscape Characterization (Using Audibility Only)

1. All sounds identified per day within the 288 5sec audio clips recorded every 5 min.

Natural Soundscape Characterization (Using Audibility Only):

2. Physical sounds identified per day within the 288 5sec audio clips recorded every 5min.
3. Biological sounds identified per day within the 288 5sec audio clips recorded every 5min.
4. Bird sounds identified per day within the 288 5sec audio clips recorded every 5min.
5. Insect Sounds identified per day within the 288 5sec audio clips recorded every 5min..

Levels of Motorized Impacts (Using Sound Levels and Audibility):

6. Motorized Sounds identified per day within the 288 5sec audio clips recorded every 5min.
7. Sum of Motorized Sound Levels Per Hour.
8. Percent Motorized Sounds Audible Per Hour.
9. Number of Motorized Sounds Greater than Natural Ambient Levels.
10. Motorized Sound Levels.

Explanation of the Calculations for Charts 9 and 10:

9. The number of motorized sounds greater than natural ambient levels is found by calculating the difference between two values; natural ambient and sound level of each motorized sound identified.
    a. Natural ambient: The natural ambient level is calculated for each hour of each day by first calculating the % time motorized sounds are audible for each hour (% motor/hr). The natural ambient for each hour is calculated by removing the top motorized percentage (% motor/hour) from all of the sound levels for the hour. The median is

then taken (L50), which is an approximation of the natural ambient level. In this calculation there is the assumption that the majority of motorized sounds are greater than natural ambient. Preliminary tests done by Skip Ambrose from the National Park Service Soundscape Program Center (personal communication) have shown that this calculation is consistently within 1dB of the actual natural ambient level calculated by removing all motorized sound levels for an hour identified by a continuous recording for the hour. The motorized sound level is calculated as explained in #10 below. A motorized sound is considered greater than the natural ambient level if the overall sound level during the time a motorized sound is audible, as calculated in #10 below, is greater than 3dBA than the natural ambient level for that hour.

10. The motorized sound levels are calculated by first identifying which of the 288 five second audio segments, recorded throughout the day, contain motorized sounds. The time for each segment is then identified. Then the median of the ten seconds of sound levels nearest each audio clip is calculated. The median of these ten seconds is assumed to be representative of the motorized sound level plus the natural ambient level.

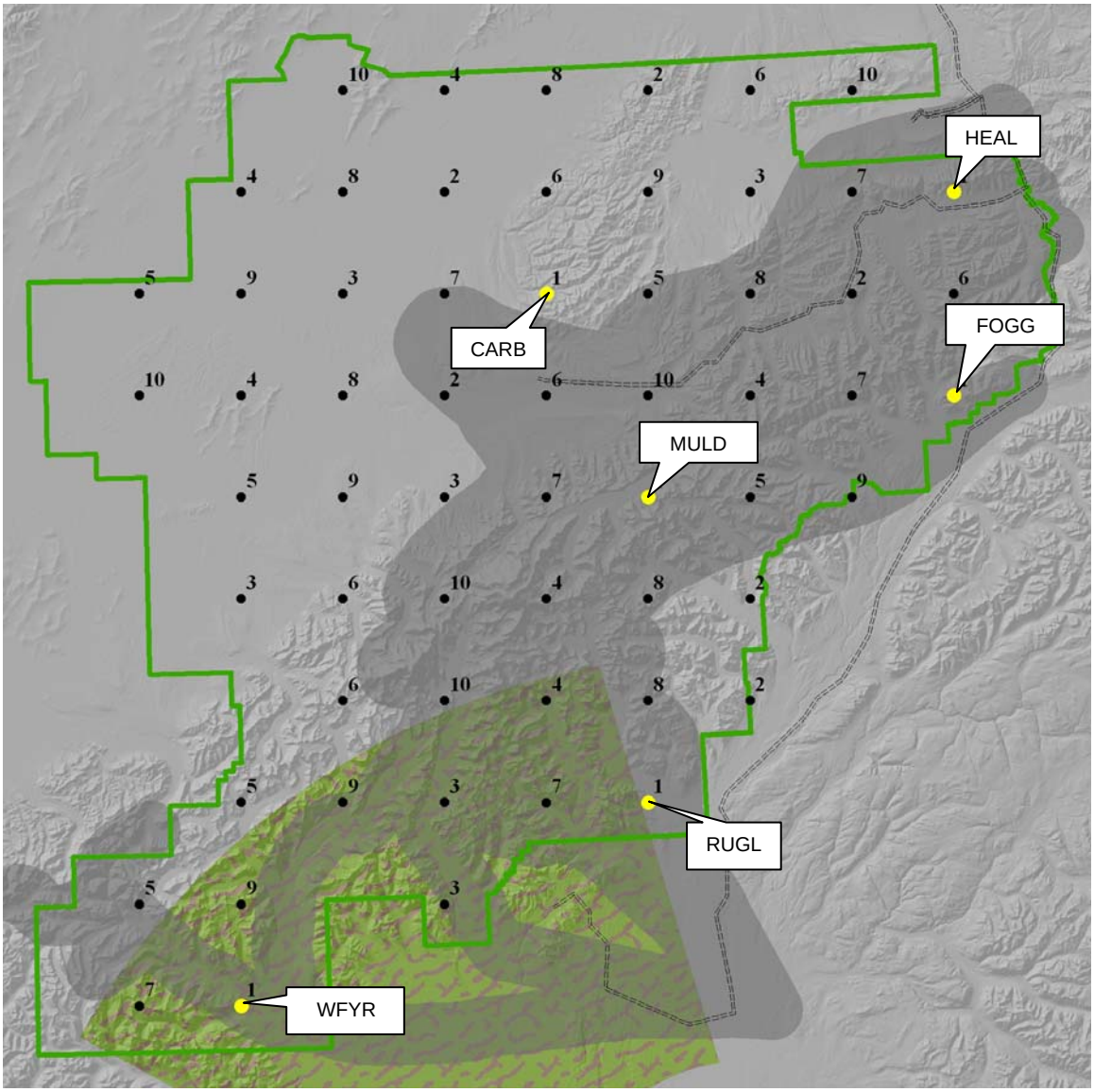

Figure 8. Map showing the sound station locations placed for 2006, indicated by the white callouts. Common flight-seeing paths footprints are shaded in dark grey. The Military Operating Area is shown in Camouflage. Data analysis charts for the 2005 charts are presented in this appendix.