This DVD contains files transferred from a 1/2" IRIG 7-track instrumentation tape.

The files (spread across all the DVDs) are:

Flathead_Lake_IRIG_Direct_File_1_of_2_Track_02.wav
Flathead_Lake_IRIG_Direct_File_2_of_2_Track_02.wav
Flathead_Lake_IRIG_Direct_File_1_of_2_Track_04.wav
Flathead_Lake_IRIG_Direct_File_2_of_2_Track_04.wav
Flathead_Lake_IRIG_Direct_File_1_of_2_Track_06.wav
Flathead_Lake_IRIG_Direct_File_2_of_2_Track_06.wav

These files are essentially what was transferred from the tape and
are at 48,000 samples per second (48 ks/s) and are 16 bits in depth,
linear PCM coding. The split between the two files occurs at 3h41m47s
and at a semi-convenient break point. The two files of each group
butt together, there is no overlap.

I say "essentially" because the original transfers were at a lower
level, but 24 bits. These files have been "normalized" so that the
highest peak is at full scale and then bit reduced to 16 bits.
The signals were dynamic range limited in the analog domain, not
the digital domain.

Track 02 contains seismic samples that are delayed, on average,
about 670 Âµs from those on Track 04. The Track 02 samples
and the Track 04 samples at times show remarkably different waveforms,
but the alignment between "shots" on the two tracks suggest that they
are two views of the same shot rather than two separate shot series
as we doubt the alignment between two runs over this period of time
would be this consistent.

Track 06 contains unmodulated carrier which can, in some instances,
be used to null out some flutter effects in an FM instrumentation system.
This was not done for the FM demodulated files that we made.

The following two files:
Track2 Demodulated Downsampled 1000__01.wav
Track4 Demodulated Downsampled 1000__01.wav

represent our FM demodulation of tracks 02 and 04 and then downsampled
to 1ks/s. These contain the entire active six hours of signal
(see below for a more detailed log) in a more compact form for low-frequency
seismic analysis. Please note that due to limitations of the audio software
utilized in creating these files, they are tagged as 8ks/s files, but
if reproduced at that speed will reproduce at eight times real time.
Please ignore the sample rate of these files when analyzing them.
They are indeed 1ks/s.

Additional files are:
Voice_Log_at_717_seconds.wav
Voice_Log_at_22100_seconds.wav

These are announcements on the voice channel, announcing breaks in the tape.

The first one is approximately at the end of what I'd like to call the test
section (see below). The second is some time after the modulation stops.
The raw transfers continue to the end of FM carrier which is past the end

of modulation of the carrier (more below).

Track 07 (recorded on a different head) had test tones recorded near the end. We have extracted those test tones into file

Track_07_Direct_Tones_starting_at_22408_seconds.wav

This runs for 25m42s.

These are included as the only other recording found on the tape.

The low frequency perturbations on the direct signals appear to be from a tape that was improperly bulk erased. While it might have been added after recording, we suspect that it was added prior to the recording as there appeared to be little or no damage to the actual recording other than the very low frequency found on the tape.

Let's address the low-frequency background noise--the whumps--on the odd tracks, but also visible somewhat on the even tracks, especially the voice track.

If we look at the waveform near the start and near the end of the tape, we find:

	Start	End	Ratio
Frequency of tone:	5.6 Hz	3.8 Hz	1.5
Repetition time:	15.6 s	8s	2
Implied Pack Diameter:	9.3"	4.8"	2
Approx meas. diameter	9"	4.5"	

I am totally convinced that this < 10 Hz component is definitely related to a demagnetization or degaussing effort on the tape pack as it was wound on the reel and has absolutely nothing to do with any recording that was made. This is just noise induced most likely from poor bulk tape erasing which is, unfortunately common in the audio world and manifests itself by a whump-whump-whump during fast wind.

The amplitude increases nearer the hub, especially on tracks 1 and 8, but is noticeable on all tracks.

When feeding the FM demodulators, we included DC removal and high-pass filtering at 30 dB / octave starting at 100 Hz. The files on the DVDs are not filtered. The filtering was provided by Algorithmix Sound Laundry, run as DirectX plugins in Samplitude.

Tape Log, tracks 2 and 4 (all times in seconds from start of file)

00000 Start of file
00037 Start of tape
00190 Break
00581.5 Start of test tones, track 04 only
00782.5 Start of seismic run
01383.5 Start of motor? on track 02 - background noise increases
02094 Background noise decreases
03298 Looks like original tape was stopped then started
03455 Seismic shots resume
03860 Minor break, 3 shots missed
03901-03933 Electrical noise in recording
04010 Missed shot

04175-04188 2-3 missed shots
04586 Two missed shots, background noise dropped for 6 seconds
04654 Missed shot
05772 Missed shot
07702-07828 MAJOR BREAK
09416.5 Missed shot
13296-13321 BREAK
13524.5 and 13628.5 shot interval changes with two shots close together
15007.5-15089 Electrical signal troubles with audio cables, hum
16652 Track 04 signal fades out slightly and back over ~ 10s.
17591-17621 BREAK
17621-17689 Track 04 signal low
21538 END OF DATA
22758 END OF FM CARRIER (note this argues that the Direct-to-FM
       conversion occurred at the copying of the original tape
       and the original was Direct or Audio tape.
23313 END OF TAPE (bulk erasure signature continues to this point)
23329 END OF FILE

Equipment used.

The tape was played on the only Sony APR-16 convertible 1/2-inch and 1-inch 16-channel audio tape recorder ever made. It was a prototype based on the APR-24 2-inch 24-track recorder that saw substantial production.

We have a custom-made IRIG 7-track plus cue head assembly made for this machine using the Applied Magnetics heads from a Racal Store 7 DS. The odd/even delay is non-standard, but that was not a factor in this project.

The tape was reproduced at 3.75 in/s and the expected frequency response of that was 20-20,000 Hz, providing an effective response of 10-10,000 Hz at 1.88 in/s, the actual recorded frequency. The machine did align to the "direct" constant-flux curve within approximately 2 dB. Absolute level was not calibrated.

All channels should be the same polarity, but it is uncalibrated as per the IRIG spec.

The signals were digitized by an RME Multiface, 8-channel 96 ks/s 24-bit converter with a low frequency response down 3 dB at 2.9 Hz.

The digitization was at 96 ks/s 24 bit and then those files were played out through the RME Multiface to a Racal Store 4 DS instrumentation recorder configured so that it would take the direct input and then demodulate it through its Wideband 1 IRIG FM demodulators. The demodulated FM output was recorded back through the RME multiface. This was done in real time, taking about 6.5 hours to complete.

The demodulated data was run through two passes of decimation from 48 ks/s to 1 ks/s. The first pass was 48 to 8 ks/s, the second was done by boosting the speed of the 8ks/s file to 64ks/s and then downsampling again to 8 ks/s, the lowest limit of Samplitude 8.3, our audio editing package.

Tape Condition:

The original tape and reel were in excellent condition. The tape is "heads out" i.e., the start of the program is at the outside of

the reel. We carefully wound the tape back onto the supplied reel at 30 in/s play speed in order to provide a smooth tape pack. The worst issue was the poor bulk erasing of the tape prior to the recording, and there may have been some dropouts that a sophisticated cleaning machine might have reduced. We were pleased, however, with the overall performance of the tape as judged against audio tapes we are used to processing.

Work performed by Richard L. Hess, 2006 July.

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