

B.3 PREVIOUSLY IDENTIFIED SEISMIC EVENTS AT WTC

In September 2001, researchers at LDEO analyzed seismic records from the WTC disaster and reported their findings for five major events at the WTC site (Kim et al., 2001); the event time, equivalent magnitude on the Richter scale, the dominant period of ground vibration, and the duration of the signal are shown in Table B-2 for the major events. The origin times listed in column 3 of Table B-2 are taken from Kim, et al. (2001), and were also used in the FEMA report (McAllister 2002). These times were estimated from PAL records assuming that large amplitude arrivals corresponded to signals that had traveled with a speed of 2 km/s. Hence, $34 \text{ km} / 2 \text{ km/s} = 17 \text{ s}$ and the origin time was estimated as 17 s earlier than the signal arrival time. In the fall of 2003, origin times of the first four events were slightly revised based upon re-examination of the seismic data. There was a seismic arrival about 4 s prior to the surface wave arrival on three-component records from the collapse of WTC 2. The seismic arrival was found on the north-south component record, which is the radial component and is roughly aligned with the longitudinal direction of wave propagation. This seismic arrival was identified as an S wave with a speed of about 3.4 km/s propagating through competent bedrock (the Manhattan schist of the Paleozoic age). The travel time of the S wave was 10 s ($34 \text{ km} / 3.4 \text{ km/s}$), which moved the origin time to 3 s later than the initial determination using 2 km/s Rayleigh waves. The revised estimates for the events associated with WTC 1 and WTC 2 are listed in column 4 of Table B-2.

The origin time for the collapse of WTC 7 (event 5) was also re-examined. In addition to the more accurate wave speed that led to a 3 s adjustment for the events in the towers that also applied to the timing of events originating from WTC 7, a misidentified phase in the earlier paper (Kim et al., 2001) led to the need for an additional 6 s correction to the event time; hence, 9 s was added to the earlier estimate, producing the current value of 17:20:42 EDT for the collapse of WTC 7.

When the current estimates for the time of impact of WTC 1 and WTC 2 by the first and second aircraft, respectively, are compared to the videographic evidence presented in NCSTAR 1-5A and Table 5-3 of Chapter 5 of this report, the agreement is within 2 s, as can be seen by comparing the first two entries of column 4 to the first two entries of column 5 in Table B-2. The times attributed to the collapses of WTC 1 and WTC 2, however, differ between the seismic study and NCSTAR 1-5A by about 10 s (compare entries 3 and 4 of column 4 to entries 3 and 4 of column 5 in Table B-2). The reason for the discrepancy is that NCSTAR 1-5A used the sudden tilting of the upper portion of the towers to signal collapse initiation; a seismic signal, though, is not generated until a substantial portion of the building debris hits the ground. If this time interval is accounted for, the NCSTAR 1-5A times compare well with the seismic origin times.

The current estimate for the collapse of WTC 7 based upon the seismic data is 10 s earlier than the time reported in Table 5-1 (Chapter 5), that is based upon the video record. (Compare the bottom entries of columns 4 and 5 in Table B-2). Table 5-1 used the global collapse of the building as the marker for the event (i.e., the downward movement of the north face), not the first evidence of downward motion of the east penthouse, which occurred about 7 s earlier (see Table 5-3). The implication of the relative timing of the seismic signal and the visual observation is discussed later in this Appendix after the details of the seismic signature have been presented.