

**ELIE, MANITOBA, CANADA, JUNE 22, 2007:
CANADA'S FIRST F5 TORNADO**

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1. INTRODUCTION

On June 22, 2007, an historic tornadic event occurred at the small town of Elie, Manitoba, Canada. A tornado tracked through the southwestern edge of the community, obliterating three homes and severely damaging a fourth. The preliminary damage assessment pointed to F4-F5 damage. Canada had never officially recorded a tornado of that magnitude so the tornado was conservatively given a preliminary rating of F4. The survey team wanted more time to assess the information.

At the Elie damage site, building construction and the exact track and evolution of the tornado were of primary concern. One important question was whether the ground speed of the tornado was unusually slow. Was the resulting damaged intensity due more to a relentless battering by a slow-moving weaker tornado than by simply one with much stronger wind speeds?

The paper will summarize the event and examine some of the critical evidence and techniques used to determine the final assessment.

**2. CANADIAN TORNADO CLIMATOLOGY
AND DAMAGE SURVEYS**

Tornadoes are common in Canada. Generally 50-80 tornadoes are reported to Environment Canada's Meteorological Service of Canada (MSC) each year. The Canadian prairie provinces have the majority

of these events. The locations of historical prairie tornadoes are usually near communities and highways, suggesting that more unreported tornadoes are likely occurring in the more sparsely-populated areas.

Canada continues to use the Fujita scale (Fujita, 1971) unlike the U.S. National Weather Service which has recently adopted the Enhanced Fujita Scale (Texas Tech University, 2004). The primary differences between the two scales are 1) the level of detail in damage indicators and 2) the strength of the wind speeds producing the damage. Otherwise, the rank of the tornado damage is equivalent. An F3 is equivalent to an EF3, though the official wind speeds are somewhat different.

The official MSC records show that there have been no documented F5 (EF5) tornadoes in Canada. Nine tornadoes have been officially recorded as F4 (EF4). Given that the majority of the tornadoes occur on the sparsely populated Prairies, it is not surprising that there have not been many recorded F4s. Indeed, the majority of F4s have been in the more densely populated Southern Ontario. Still, three of the top four killer tornadoes in Canada have occurred on the Prairies.

A study by Grazulis (2000) looking at just killer tornadoes suggested that at least 20 F4 tornadoes have occurred in Canada, and that two of those tornadoes may have reached F5 intensity on the Prairies. Another research project underway by a retired meteorologist on historic Prairie tornadoes points to a few additional F4s than is officially recorded, but that there is no clear evidence of any F5s. Still, another project researching Ontario tornadoes (see Sills et al, 2004) has not published a new F5.

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Most tornadoes today are not surveyed on-site in Canada due to limited resources. Areas with local MSC resources will often see damage surveys, especially for more notable events. In recent years, storm damage surveying has become more formalized. MSC staff are given training sessions and only trained surveyors can conduct the surveys. The surveyors of the Elie tornado were trained MSC staff.

3. PRELIMINARY DAMAGE SURVEY

The three-member damage survey team arrived in Elie at about 9:30 in the morning. Damage was mostly confined to a flour mill about 1 km west of the town and to a number of homes in the south-westernmost corner of Elie.

Four homes and a number of adjacent buildings were completely destroyed. Two nearby homes suffered modest damage. All home were modern, 1970's vintage, wood framed, and single story. Each had a poured concrete foundation and an attached garage. Three of the homes had basements.

The easternmost destroyed house (#1), was completely swept away, including the floor joists (figure 1). Other than a few small building fragments, there was no debris anywhere on the property. The home immediately to its east suffered damage consistent with F1 intensity, while the home immediately to the west (house #2) was completely destroyed. House #1 had no basement.



Figure 1. Foundation of House #1.

Some parts of the sill plate remained attached to the foundation (figures 1 and 2). The sill plate was bolted to the foundation

with slightly larger than standard J-bolt-type anchors. Large heavy washers were also used. The sill plates were 2x6 and markings on the top of these plates suggested the home was of 2x6 construction. This form of construction is typical in Manitoba, due to the need for extra insulation for the cold prairie winters. However, 2x6 construction was less common 30 years ago.



Figure 2. Sill plate with anchor bolt still attached to the foundation on House #1.

There was no evidence of any rotting of house #1's remaining sill plates. Some of the plates appeared to have shattered under great stress. Where sill plates were missing, a few bolts had been sheared off while others were bent towards the north or northwest. Some bolts remained vertical. Many of the washers on the remaining sill plates were freshly recessed, suggesting that the sill plate was being pulled upward. All of this evidence pointed to the walls of the home being well attached to the sill plate. Preliminary assessment was strong F4 damage, though there was some discussion of a possible F5 rating. Fortunately no one was in the home at the time of the tornado as the level of destruction appeared not to be survivable.

House #2 (figure 3), immediately to west of house #1, was almost completely obliterated. Only a small piece of an outside wall attached to a fireplace hearth remained standing. The main floor joists, which had been set in the foundation during construction, remained intact. Some debris remained nearby and on the main floor against the wall fragment. The home appeared to have 2x4 wall construction. Preliminary assessment of the home was

strong F3 to weak F4. No one was in the home at the time of the tornado.



Figure 3. Remnants of House #2.

The next home to the west (house #3) was completely gone with only the open basement remaining (figure 4). There were no notable pieces of the home on the property.

There were no sill plates remaining on the poured concrete foundation, nor was there evidence that anchor bolts were used. However, the main cross beam supporting the floor joists appeared to have been attached the basement walls.

The attached garage sill plates had been bolted to the garage concrete floor. Some of the pressure treated sill plates remained. These plates also showed evidence of the washers having become freshly recessed. Preliminary assessment of this home's damage was weak F4. People in this home at the time of the tornado took shelter in the basement and survived without serious injury.



Figure 4. Foundation of House #3.

House #4 (figure 5) just to the west of house #3, was the south-westernmost building in the town of Elie. At the time of the investigation, it was believed that this was the first of the four destroyed homes to be struck by the tornado.

This house still had some exterior walls and a portion of the roof intact. The floor joists had been set into the concrete foundation during construction. The joists were attached to the rim joints which were in turn bolted to the exterior of the foundation. The flooring and walls were attached to this structure. The exterior sheathing was plywood. This extremely well built home was given a preliminary damage rating of Strong F2 to possibly weak F3.



Figure 5. Remains of House #4.

Surrounding the area of these homes were scattered debris, pieces of furniture and appliances, overturned and crumpled vehicles, and trees that had been sheared off or denuded and the remains debarked.

About 150 metres south of the destroyed homes, a heavily damaged $\frac{3}{4}$ tonne van, still filled with building material, was found laying on its side in a field, along with various other random pieces of debris. There was no indication that it had been rolled there. The team erroneously concluded that either a) the van had been there before the tornado, or b) the ground was in such a state that it might not show the evidence of such a vehicle rolling.

After touring the area of most severe damage, the team attempted to determine the areal extent of the tornado's path. Damage was surveyed at the town's flour mill, which was much less severe, and at a farm about 4 km northwest of Elie.

Interviewing the residents of the area revealed that this farm was the likely area of the first touchdown of the tornado. Much of the tornado's track was through open fields.

Due to limited time and resources, no aerial survey was conducted. However, aerial video and photographs by the media and private pilots were later made available to the survey team.

3. SECOND DAMAGE SURVEY

A lot of information was collected on the one-day survey at Elie. While the preliminary assessment of F4 damage was proclaimed, F5 damage was also evident to the investigators. The investigators were keenly aware of the attention and scrutiny an announcement of an historic F5 tornado would draw, both from the media and from the meteorological community.

An extensive review of the evidence collected was made over the following weeks. This review pointed to one of the four homes a having strong evidence for F5 damage. However, the survey had also noted that the tornado had moved relatively slowly, apparently covering a direct distance of only 4 km. The survey team was suspicious that the destruction actually resulted from a weaker tornado that had simply remained over the home for an unusually long time.

As the tornado had impacted a community situated next to the Province's busiest highway, dozens of videos and photographs were collected, including from two MSC meteorologists who were separately chasing the storm. This information provided a more detailed picture of the tornado's track and evolution.

Two videos in particular provided two different views detailing the track and destruction. One was taken from a fixed location about one kilometer south of the town and captured the entire lifespan of the tornado. A second video captured most of the tornado's evolution from varying locations between one and two kilometers west of Elie. One vantage point captured the destruction of the four homes and flour mill from a fixed location about two km west-northwest of the town. It became clear to the survey team that an exact track and

timeline could potentially be established through the triangulation of these two videos and by supplementing this with other photographic, video and damage survey evidence.

A second survey was conducted about 5 weeks after the original using video captures and eyewitness photographs (including aerial photographs of the damage) in combination with the original damage survey data. The team determined photographer/videographer locations and took photographs to match what the eyewitnesses had taken. Where evidence remained on-site, additional photographs and measurements were made.

Later, the team re-examined the evidence and a much clearer tornado path and evolution emerged. Still, this reassessment pointed to some additional gaps in the data and a follow-up survey was conducted. This third survey collected GPS coordinates of critical landmarks within the video images, plus additional measurements of the precise damage track.

4. DISCUSSION

A number of factors limited some of the damage assessment. The survey team was initially limited by ongoing on-site safety issues. This kept the survey team at bay for part of the survey while keeping potential eyewitnesses away from the site. There were also multiple damage sites including a second F3 tornado about 15 km away. On the day of the survey, another outbreak of significant tornadoes occurred over the southwestern part of the province. This required the survey team to spend the second survey day surveying three new long-track tornadoes. This prevented some additional work at the Elie site. Still, a lot of information was initially collected and the flood of eyewitness accounts, photographs and video after the event allowed investigators to fill in most of the remaining details.

The collected information painted a much clearer picture of the tornado's path (figure 5). Rather than traveling about four kilometers, the tornado had meandered for about 6 km; twice performing a full loop. One of the videos revealed that the tornado has struck the flour mill twice! The tornado

struck the mill from the north than looped east then back north through an adjacent field. The tornado strengthened and turned back south over the mill. A large grain truck parked at the mill had tumbled through the nearby field with the tornado.

The survey team turned its attention to the destroyed homes. An attempt was made to synchronize the two critical videos for the time the four homes were destroyed.

Using the GPS landmarks, sight-lines were projected from the videographers' positions (figure 6) through the tornado's near-surface mid-point on a detailed digital map of the area. Once common positions were determined, the two videos were synchronized to the time. Since one of the two videos was not continuous, the videos had to be resynchronized when necessary. To confirm the synchronization was accurate, notable flying debris or specific events were tracked.

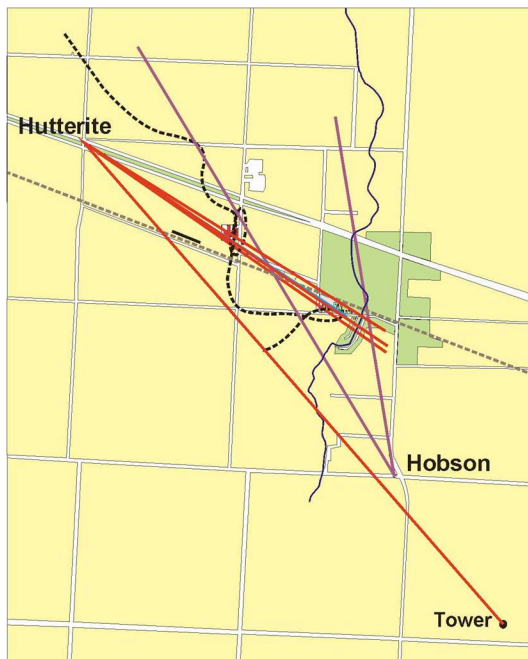


Figure 6. Example of video triangulation work. "Hutterite" and "Hobson" refer to videographer locations. The town of Elie is the green shaded area. "Tower" refers to a transmission tower landmark. The curving black dashed line represents the entire tornado track. The lines represent the some of the sight-lines used for the triangulation.

This approach revealed a much clearer picture of the evolution of the tornado and the path it had taken. For example, one video may show that the tornado was

stationary while the other video was showing the tornado moving to the left. That meant that the tornado was actually moving directly away from the first videographer.

From this video evidence, it was revealed that the tornado had not tracked through the homes from west to east. The tornado had actually tracked through the field south of the homes, then turned north into House #1 then curved back to the west through the remaining three homes. A re-assessment of original eyewitness accounts and through follow-up interviews, confirmed this evolution.

What also emerged was that the tornado remained over each home no more than 30 seconds and that the failure to the structures occurred quickly. This ruled out the slow-moving tornado theory.

The mystery of the cargo van in the field was also revealed. One of the videos clearly showed the van being hurled high into the air. The third survey found the impact site where the van had landed face first, the grille and headlights still embedded in the resulting deep depression in the field. The van bounced once and landed in its final resting place about 15 metres away.

The video also pointed to a possible reason the tornado became so destructive. The tornado was at its largest shortly before striking the homes. The tornado appeared to enter its "roping out" phase and began to quickly narrow. The video shows what appears to be a rapid increase in the tornado's rotation. It appears that at the transition to the roping out phase, the conservation of angular momentum spun up the circulation rapidly. Eventually the "roping out" tornado appeared to gradually weaken. It is possible that tornadoes could be at their most intense as they make this transition when the mature circulation does not have time decrease proportionally to the shrinking funnel. This aspect may be worthy of further research.

5. SUMMARY

On June 22, 2007, the small community of Elie, Manitoba, Canada was grazed by a very intense tornado. Of the four homes severely damaged, three had been obliterated. Some of the evidence pointed

to an F5 tornado. Still, the investigators conservatively gave a preliminary damage estimate of F4 then devoted more time to confirm their suspicions. One of their concerns was whether the tornado was weaker but was moving so slow-moving that it had relentlessly pounded the houses into a higher level of destruction.

The tornado event was captured by many photographs and videos. This provided a unique opportunity to test the investigators' theory. In the weeks following the event, additional on-site work was done to correlate photos and videos to the damage surveyed. This led to additional insights into the event. Finally, using the locations of some videographers, their video, and landmarks in the area, the when and how the homes were destroyed were established. The results demonstrated that the structural failures were quick. The structural assessments indicated that the homes were well-built and generally well-secured. In particular, one of the destroyed homes met all of the requirements for the highest damage rating. Together, the evidence confirmed the initial suspicions of the storm damage survey team and the tornado was officially upgraded to Canada's first F5.

5. REFERENCES

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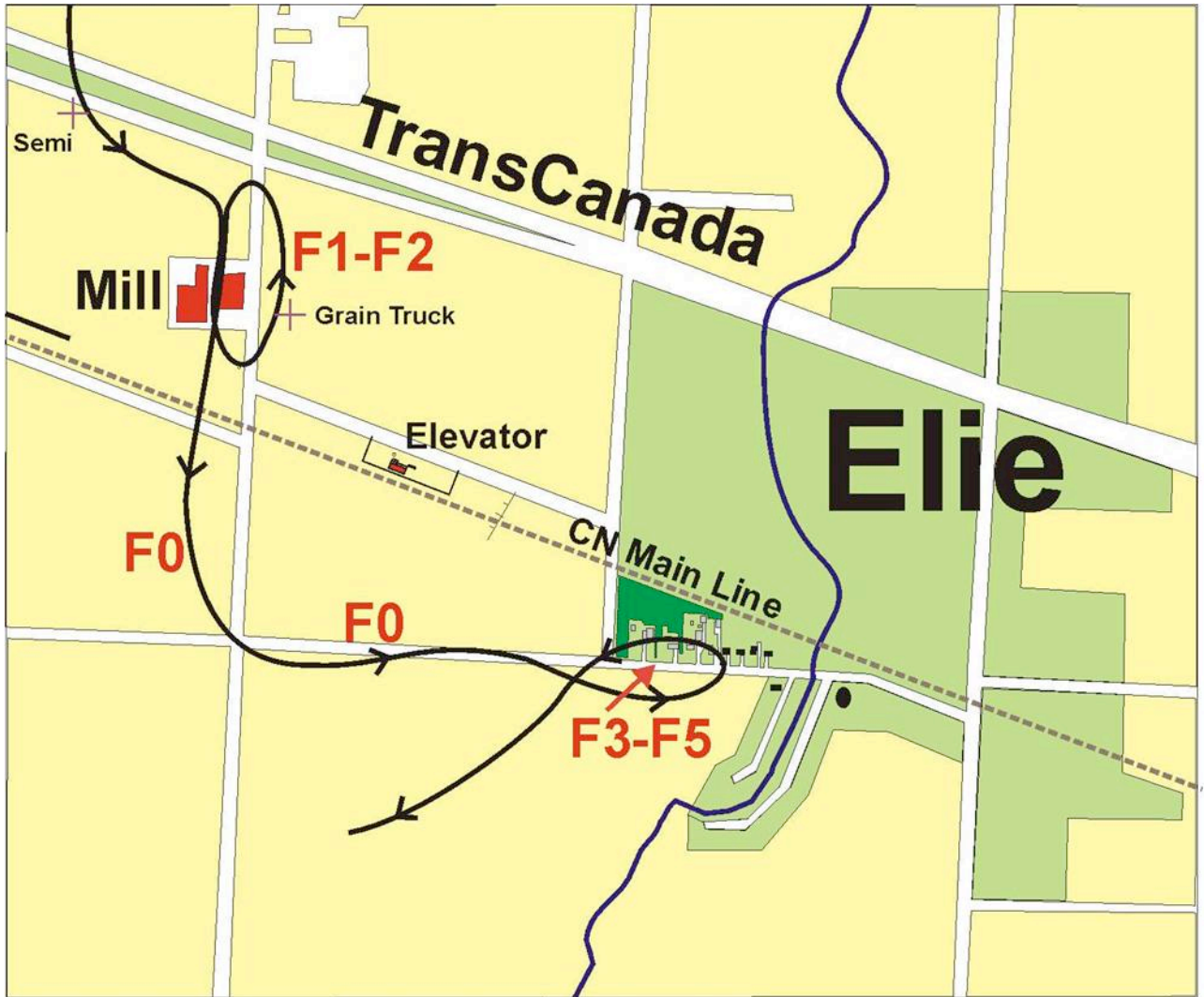


Figure 5. Detailed map of tornado track.