Mitigating Residential Properties Damage and Fire Losses Caused By Lightning Strikes in Washington Township/City of Dublin, Ohio

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CERTIFICATION STATEMENT

I hereby certify that the following statements are true:

1. This paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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ABSTRACT

The problem investigated was lightning causing damage and fires to residential properties in Washington Township/Dublin, Ohio averaged 30% of annual fire losses from 1994 to 2003. This historical research project was to provide decision makers with justification for adopting codes/standards in protection of residential properties by answering the following questions: Are residential properties vulnerable to lightning?; Is there a pattern to lightning strikes in WT?; and What is a good method of mitigating lightning strikes to residential properties?

Research consisted of gathering lighting information/data, GIS mapping, literature review, and interviews. The research supports the supposition that residential properties are vulnerable, with no predictable pattern to lightning strikes, and suggests methods of protecting properties. The findings support justification and identify recommendations for adopting a pragmatic lightning protection standard.

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INTRODUCTION

Statement of the Problem

Historically, lightning causing damage and setting fire to structures has been occurring for more than two centuries. Fire departments have been generally responding and mitigated to the best of their abilities and equipment these events as a matter of routine as they were "an act of God" so to say and unpreventable.

In the summer of 2003, The WTFD experienced six lightning events causing damage and fires to residential properties from May to August. This number of events in this time period seemed excessive and the department was at a loss in what if anything can be done to mitigate these types of losses. This series of events brought to light the purpose of this research project.

Beginning in 1994, the Washington Township Fire Prevention Bureau (WTFPB) in its Annual Fire Investigation Reports began recording all investigated damage and fire loss amounts which included specifically losses due to lightning strikes to residential properties for WTFPB Annual Reporting system.

In the researching of these reports, it was found that lightning-caused damage and fire losses to residential properties over the past ten years (1994-2003) had averaged around 30%. Note: during this time period nearly a third of annual residential property damage and fire losses are attributed to lightning strikes. The WTFPB recorded estimated damage and fire losses to the affected residential properties during the period above have amounted to $ 1,119,086.00.

Therefore the problem this study will investigate is that lightning-caused residential properties damage and fire losses in Washington Township/City of Dublin, Ohio (hereafter known as WT) have averaged 30 % however efforts in mitigating these losses has been minimal.

The Washington Township Fire Department (WTFD), which provides fire protection for, realizes this reoccurring problem of its residential property being damaged and fires caused by lightning strikes. This research project will address what can be done to mitigating residential property damage and fire losses caused by lightning strikes in WT.

Historically as today, the reporting of lightning strikes specifically to residential property is just investigated and duly recorded with little attention or understanding of why and where it occurs.

The WTFD as the community's fire service, recognize and respond accordingly to on-going situations that threaten the lives of the public and property. Prior to this research project, lightning-caused damage and fires to residential properties had not been addressed.

Purpose of the Study

The purpose of this study was to identify critical information and to provide decision maker's at WT with justification to develop and implement new policies and procedures in the protection of residential properties from lightning caused damage and fires. In recognizing and responding to the results of this research project in WT, the decision makers might create methods to mitigate property damage.

Research Questions

The following questions will be answered by this historical research:

1. Are residential properties vulnerable to lightning?
2. Is there a pattern to lightning strikes on residential properties in WT?
3. What is a good method of mitigating lightning strikes to residential properties?

BACKGROUND AND SIGNIFICANCE

The WTFD provides fire protection services to WT residents and the City of Dublin, Ohio. The department's coverage area encompasses Franklin, Union, and Delaware Counties, which border and lie in the northwest corner of Franklin County in Central Ohio.

In the summer of 2003, The WTFD experienced six lightning events causing damage and fires to residential properties from May to August. This number of events in this time period seemed excessive and the department was at a loss in what if anything can be done to mitigate these types of losses. This series of events brought to light the purpose of this research project.

Beginning in 1994, the Washington Township Fire Prevention Bureau (WTFPB) in its Annual Fire Investigation Reports began recording all investigated damage and fire loss amounts which included specifically losses due to lightning strikes to residential properties for WTFPB Annual Reporting system.

From 1994 to 2003, the WTFD has responded to a reported 23 damage and fires in residential structures attributed to lightning. As a Fire Prevention officer for the WTFD, the author of this study began noting if a possible pattern in the relative proximate locations of these lightning-caused incidents. Curiosity about this continual pattern led to this research study.

The WTFPB has been keepings statistics on all reported and investigated fires, including damage and fires to residential properties caused by lightning. Since 1994, the WTFPB has noted, investigated, and tallied a total of twenty-three (23) lightning strikes to residential properties (Appendix A). These lightning locations were tabled for imputing into a Geographical Information System (GIS) map (Appendix B) for locations and possible patterns. GIS mapping technology was just recently made available to the WTFD in cooperation with the City of Dublin

GIS Department. The use of GIS mapping provides a better view of the overall picture of lightning event locations. Researching into mapping out lightning strike locations for researching into mitigating these damage and fire losses to residential properties has not been realized or attempted until GIS technology became available. Hence no research has been done on mitigating lightning-caused damage and fire losses to residential properties.

As noted in Appendix C, residential property damage and fires ranged from as high as 80% in 1998 to 0% in 1997. On the average, lightning-caused damage and fire losses to residential properties over the past ten years (1994-2003) averaged 30% of WT's total reported annual residential property fire losses. Estimated total damages to those twenty-three structures affected was $ 1,119,086.00.

WTFD's coverage area is composed primarily of upscale residences, many valued at prices ranging from $500,000.00 to several million. If 30% of the residential losses in the coverage areas are caused by lightning strikes, the mitigation of these events deserves to come to the foreground for study.

This research project is justified in general terms, in that any fire loss that's preventable should be a concern as to the overall mission of the WTFD. It is also justified because this single facet accounts for such a large segment of recorded damage. If research findings of this report are significant they could lead to reducing property damage and losses in the future.

LITERATURE REVIEW

Are residential properties vulnerable to lightning?

Linn (1993) an extension farm safety specialist authored an article on protecting farms from lightning damage and fire. The article considers "farms" to include farm houses as well as silos, barns and other buildings of a working farm. It was included in this study because it is one of the few studies available that examines structures and lightning strikes, rather than focusing on the phenomenon of lightning itself. The article claims that there are four ways lightning can enter any building: (1) by direct strike, (2) by striking an object extending from the building, (3) by striking a nearby object such as a tree and jumping to the building, and (4) by striking a power line or fence attached to the building. Since all four of these potential routes exist with residential properties as well as other structures on a farm, it is reasonable to infer that all residential properties are vulnerable to lightning in much the same manner as farm structures. The author also points out that lightning strikes buildings because they are better electrical conductors than the air and provide an easier path to ground. When lightning strikes, temperatures of around 50,000-degrees Fahrenheit heat are generated thus residential properties can be damaged or ignited.

The National Fire Protection Association [NFPA] is one of the world's largest ANSI certified, consensus standard-setting organizations. NFPA (1999) describes common building materials as including wood, brick, stone, and concrete building materials that are also used in residential properties. NFPA (1997) states that heat and mechanical damage may be caused by the passage of lightning through these common construction materials, which it characterizes as, "…higher impedance paths…" (p. 780-40). Thus, the NFPA appears to support the notion that

the materials from which residential properties are constructed are vulnerable to damage if struck by lightning.

Viemeister (1972) although a dated resource; is a text still referenced in current articles and journals read during this research project. The author is very detailed in the description of the science and weather and the science of lightning and in protecting property from lightning strikes. The author notes that high terrain or areas higher than surrounding or elevated areas brings the Earths potential closer to the thunderclouds (p.141). Therefore the author offers evidence that simply the height or elevation of structures can bring closer to the potential for a lightning strike. Also noted in the text is that, air moving across the lay of the land that is turned upwards by structures, trees, and topography forcing hot air upwards and contributing to movement of the positive and negative charges floating along the earth (p.77). This offers the probability that as wind or storms approach the potential for lightning to strike is increased due to the increase of upward moving positive and negative charges of with lightning may seek for grounding. Residential structures notably are surrounded by other structures, trees, and their vulnerability can be affected by the lay of the land. The author describes in the text that lightning (electrons) when produced is simply looking for a path to ground (positive) in that taller objects are even more positively charged than the ground upon which they stand (p.112). Thus, the author implies that certain structures are especially vulnerable to lightning strikes including those on higher elevations and those surrounded by potential pathways for lightning such as tall trees, The WTFD coverage area includes some high ground and many areas with tall individual trees and small forests close by residences

Is there any pattern to lightning strikes on residential properties in WT?

Cao, Xiang, & Wilson (2004) studied lightning strikes in Mecklenburg County, North Carolina; from 1993 to 1995 using a relatively new technology (at the time) called Geographical Information Systems (GIS). The authors measured monetary loss from fire department records to sort severity of damage to individual properties into five categories ranging from slight to severe. They found that the majority of lightning damage occurred in the south planning district, which historically absorbed much of the suburban growth and contained mostly single-family residences. This study also appears to support the notion that lightning strikes to residential properties are common; however, these authors did not report how often or how many lightning strikes occurred. They reported only the level of damage done to specific areas. Further, they did not mention lightning damage in existing communities or other developed areas, but they did encourage further study.

Powell (2001) interviewed Dr. Raymond Hayes of American Electric Power (AEP) Dolan Laboratory located in Groveport, Ohio. Dr. Hayes stated in the article "that if you suspect a lightning strike in your area, historical data is available to confirm lightning activity in a particular area." Dr. Hayes needed date, time and an exact address, or longitude and latitude to confirm lightning activity within a range of 500 meters. Dr. Hayes provided information on lightning activity for locations/areas. This article provided Dr. Hayes as a resource and information needed for obtaining lightning strike information.

Svitil (2003) stated in her article that science confirms that urban areas experience more lightning activity than those living away from more populated areas. The author noted that an atmospheric scientist with Brazil's National Institute for Space Research in Sao Jose'dos Campos, used Brazil's extensive lightning-detection network to measure summer flashes over

three metropolitan areas. The scientists stated that "heat emitted by buildings, cars, and pavement creates heat islands where temperatures are higher, clouds are deeper, and lightning is more likely" (p. 14). The scientist's findings support that a pattern may exists in areas more vulnerable to lightning than others. The author's interview of the researcher indicated that metropolitan areas have increase exposure to lightning activity. This study was helpful to my research in that WT is a small metropolitan area and lies on the western edge of a large metropolitan area Columbus, Ohio. Conversely, the article did not identify the sizes and locations of the three metropolitan areas mentioned and infrastructure.

Vaisala (2003) as a company develops, manufactures, and markets products for measurement in environmental protection, cost savings, and improve safety including lightning detection. This resource provides a software program called STRIKEnet$_{sm.}$ This program is referred to on the web site as an "online lightning verification report," as it objectively and accurately can report individual lightning strikes at specific locations. This company charges a fee for providing information for the end-user in determining if lightning activity was present for specific location or area. This resource is a scientific-based GIS tracking system for mapping lightning information in determining locations and possible patterns of lightning from both a strike and activity standpoint. This resource is useful for tracking localized long-term lightning activity and locations up to or within 5 miles from the address or latitude/longitude co-ordinance. As noted, the service is fee based and requires minimal costs and equipment to start and maintain. Membership is required for any requests.

What is a good method of mitigating lightning strikes to residential property?

Kithil (2004) is president and CEO of the National Lightning Safety Institute (NLSI). The NLSI provides expert training and consulting for lightning problems. This author noted in this

resource that “Benjamin Franklin perceived that lightning striking an elevated grounded rod would follow a ‘path of least resistance’ to earth, and his invention advanced fire safety…and still holds true today” (p. 1). The author’s opinion supports the use of and installation of the Franklin Rod system for protecting structures. Thus, the Franklin Rod system can act as the basis of comparison for methods of mitigating lightning strikes.

Lightning Eliminators Company, Inc. (2003) is a firm that engineers and manufacturers global lightning protection equipment and offers information on their web site to help clients better understand the threat of lightning. Their web page describes two types of lightning protection systems most prevalent. They are Lightning Rods (LR) or Air Terminal (AT) systems which offer a path to ground and the Charge Transfer System (CTS) which prevent lightning strikes by discharging the site being protected. This resource provided information on these two referenced types of lightning protection equipment available on world markets and offers further basis for their comparison.

Uman & Rakov (2002) wrote in their summary that conventional lightning protection systems for ground-based structures are composed of AT, down conductors, and grounding electrodes for passing the lightning current to the earth and must be electrically well connected. This efficiency of this system of the conventional approach has been well demonstrated in practice (p.1809). This system has proven its effectiveness and lightning elimination systems in prevent the initiation of lightning in the thundercloud and are unlikely to be able to avert an imminent lightning strike (p.1809). Their article is referring to the claim that non-conventional systems as either Lightning Elimination or otherwise known as CTS or Early Streamer Emission (ESE) as two alternative systems commercially available under a variety of trade names that claim to be superior to the conventional lightning protection (LR/AT). The authors spoke on the

two alternative system mentioned above and that they termed unreliable. This resource provided additional significant information on the effectiveness of conventional lightning protection system.

Zipse (1999) wrote in his excerpt that "The CTS of preventing lightning strikes to protected areas is a valid concept and will replace the Franklin Rod method in many applications" (p. 2). The author is an electrical engineer and noted authority on lightning protection. The excerpt is referring to changes in the lightning protection/electrical engineering community. In noting, that the CTS of lightning protection equipment is valid and reliable this author has supplied information that validates this system as a second effective mitigation resource.

Based on the findings and observations noted above in the literature review, research indicates that it's reasonable to assume that residential properties are vulnerable to lightning strikes in many ways. As noted, physical and environmental conditions and construction aspects can contribute to the likelihood of lightning strikes, and to the likelihood of these strikes causing damage and fires. The potential value lies in combining historical information and data along with GIS Technology for identifying and documenting lightning activity or patterns for a historical look at lightning frequencies and locations. Finally, these sources indicate that a lightning protection system (mitigation) are beneficial for protecting residential property.

PROCEDURES

Research began with all lightning-related information, damage and fire loss locations, and their estimated damages amounts from the past ten years (1994-2003) from the WTFPB Fire Investigation Annual Reports. Fortunately, this information was easily obtainable as it had been previously documented and then re-compiled for this research project.

This information was provided to Mr. Brian White of the City of Dublin Division of Information Technology Geographic Information System (DITGIS) department to create a GIS map for displaying the information noted above.

A questionnaire requesting lightning information and documentation was faxed to five neighboring fire department that align north and south along the western edge of Franklin County in Central Ohio along with the WTFD (Appendix H). These five fire departments cover increasingly populated areas of residential and commercial growth.

The questions as asked, focused on statistical information from the departments in question. The intent of these questions was to determine to what extent these departments are documenting their residential property damage and fire losses due to lightning strikes, and to provide data for the questions contained in this research project. The questionnaire was sent to Fire Prevention Bureau personnel seeking both information and statistical data. Receiving this information would enable the author to review additional data, to see is a pattern of lightning strikes was suggested in the broader area including WTFD.

An abundance of information was researched from organizations such as the National Lightning Safety Institute (NLSI), National Fire Protection Association (NFPA), the National Lightning Detection Network (NLDN), Insurance Information Institute (III), Institute of

Electrical Engineers (IEEE), and others on topics of structure vulnerability, tracking or patterns, and methods of mitigating lightning strikes.

AEP in the Central Ohio responded to a request and provided lightning strike information data from local experts in this field. Mr. Raymond Hayes and Mr. Paul Toomey e-mailed lightning tracking data. In an interview, Dr. John Schneider of AEP spoke about technical information and the accuracy of lightning information in regard to the science and weather of lightning activity.

Definitions of Terms

Charge Transfer System. "Systems produce conditions under which lightning either does not occur or cannot strike the protected structure" (Uman & Rakov, 2002).

Mitigation. "Mitigation includes any activities that prevent an emergency, reduce the chance of an emergency or lessen the damaging effects of unavoidable emergencies" (FEMA, 2004 p. 3).

Residential Property. Refers to single family (R1), multi-family structures (R2 & R3) (IBC, 2002).

Stroke/km2/time. "Flash density/ per square kilometer/ per year" (Vaisala, 2003)

Limitations of the Study

When performing searches on the three research questions, a substantial amount of the information found was on the science and weather of lightning, which was of little use to the

research questions. Some of the data/information from the NLDN is obtainable by fee or membership.

A drafted questionnaire that was intended to compare WT lightning strike damage and fires to neighboring communities did not produce the anticipated results. Four of the five fire departments surveyed returned their questionnaires with little, if any, information useful to this research project. One department failed to return any information at all. The failure of this questionnaire did not allow direct comparison of lightning damage and fires in residential properties of the surrounding agencies as was originally intended. From the limited data provided by the four responding departments, it is clear that either they have not been tracking lightning strikes as a significant cause of residential damage or they were unwilling to review their records to provide the information requested.

The hoped-for data might have proved or disproved any possible pattern of lightning strikes for a relatively specific location, on the northwest side of the city of Columbus, Ohio. Its absence diminishes from this study.

Finally, several of the companies found on the Internet that provide lightning protection systems listed information that was primarily sales-oriented and therefore quite self-serving.

RESULTS

1. Are residential properties vulnerable to lightning?

Linn (1993), it is evident from this research that lightning can strike or enter buildings by one of four ways (1) by a direct strike, or (2) through objects outside and connected to the structure, (3) glancing from a nearby tree, or (4) through a power line or ungrounded wire fence attached to the building. Also, NFPA (1999) the construction materials commonly used in residential property (wood, brick, tile and such) do not offer protection in "grounding" or resisting the effects of lightning and associated heat and damaging effects. Also, Viemeister (1972) stated in his text that "air moving across the lay of the land is turned upwards by structures, trees, and topography forcing hot air upwards and contributing to movement of the positive and negative charges floating along the earth."

2. Is there any pattern to lightning strikes to residential properties in WT?

The research to date has indicated that no predictable pattern exists. However historical data and information indicates areas of higher probability of lightning activity.

Research into any pattern of lightning strikes to residential property began by listing numerically dates of lightning strikes and their address locations in Appendix A, taken from WTFPB Annual Fire Investigation Reports, utilizing GIS technology available from the City of Dublin, Ohio. The information contained in Appendix A was provided by Mr. Brian White of City of Dublin DITGIS department and was inputted into a GIS map in Appendix B. The information displayed in the form of lightning strikes on the contained GIS map indicated a close-knit group of lightning damage and fires in the center and scattered locations elsewhere.

In Appendix C, annual lightning damage and fires were tallied with their estimated losses as a percent of the estimated total residential fire losses for the year. This appendix produced the information that 30% of the average annual fire losses in the WTFD coverage area are due to lightning damage and fires.

A questionnaire requesting lightning information and documentation was faxed to five neighboring fire department that align north and south along the western edge of Franklin County in Central Ohio along with the WTFD. These five fire departments cover increasingly populated areas of similar residential and commercial growth. The intent of these questions was to determine to what extent these departments are documenting their residential property damage and fire losses due to lightning strikes, and to provide data for the research questions contained in this project. The questionnaire was sent to the Fire Prevention Bureau personnel for requesting information and statistical data. Four of the five departments questioned responded returned their questionnaires with little that was useful to this research. Thus the data collected for this study was only from the WTFD coverage area. Adequate data from other departments may have provided more insight into whether or not a pattern of lightning strikes exists. This lack of data could originate from a number of sources. One is failure to keep adequate records. Another is a lack of interest in finding out the information perhaps believing it is not available.

Responding to an article indicating technology was available to determine if lightning struck a location or area, Dr. Raymond Hayes (R. Hayes, personal communications, July 11, 2003) was contacted by e-mail. Dr. Hayes responded by e-mail with written information (Appendix D) and a reference to a sample screen capture from Real–Time Lightning Tracking (LTrax). Dr... Hayes of AEP is the lead developer and supporter of LTraX. He explained LTraX as an archive and display system that saves NLDN data to a database, and to display lightning

activity in real time or from the archive. A sample of an LTraX information display (Appendix E) shows lightning flashes across the United States for one hour and is normally animated to sweep through as much as 24 hours before recycling.

A sample of Fault Analysis Lightning Location System (FALLS) Regional Lightning Stroke Density map which measures the amount of lightning activity for an area is defined by shading in Stroke/km2/time is shown in Appendix D. This is a sample of FALLS/Regional Lightning Stroke Density data for 1/1/2003 to 12/31/2003 and was provided by Mr. Paul Toomey of AEP (P. Toomey, personal communications, July 20, 2003). The grey areas indicate greater than 16 strokes (of lightning) per kilometer squared and the darker boxes indicate greater than 8 strokes per kilometer squared. Viewed in color, this display better demonstrates the information displayed. In the example, the least areas of lightning activity are scattered and smaller in comparison to the magenta (darker) area.

Appendix E is a copy of the FALLS/Lightning Time Trend for 1/1/2003 to 11/20/2003 for Dublin, Ohio as provided by Mr. Paul Toomey of AEP. This appendix displays lightning activity for the same time period as the Appendix D. Appendix E, displays lightning counts (activity) lightning activity for each month of the time period. As evident, most of the lightning activity is in the summer months of June, July, and August.

3. What is a good method of mitigating lightning strikes to residential properties?

The research indicates that the only way to protect residential properties is with a lightning protection system. According to Lightning Eliminators Company, Inc., (2003) there are the two types of lightning protection systems available currently. They are LR/AT and CTS. According to Kithil, (2004) “Benjamin Franklin perceived that lightning striking an elevated

grounded rod would follow a ‘path of least resistance’ to earth, and his invention advanced fire safety…holds true today” (p. 1). “Since lightning safety is a very site-specific subject, only you can make the best decision to reduce the risk to acceptable levels” (p. 2).

DISCUSSION

The results of this research concur with the finding of others in that residential properties are vulnerable to lightning. Linn (1993) a Farm Safety specialists authored an article on protecting farms from lightning damage and fire. The article claims that there are only four ways lightning can enter a building: (1) by direct strike, (2) by striking an object extending from the building, (3) by striking a nearby object such as a tree and jumping to the building, and (4) by striking a power line or fence attached to the building. Since at least one of the four of these potential routes exist with virtually all residential properties, it is reasonable to assume that residential properties are vulnerable to lightning. The conclusion of only four paths by which lightning can travel is limiting and somewhat dated in that changes in construction and materials may limit some entries and offer opportunities for other methods or means of entry. Additionally NFPA (1999) states that materials used in residential construction consist of "wood, brick, stone, and concrete" and NFPA (1997) states that heat and mechanical damage may be caused by the passage of lightning through these common construction materials, which it characterizes as, "…higher impedance paths…" (p. 780-40). Of these, only wood has the potential to catch fire.

Viemeister (1972) although dated, is very accurate and current in his text on the description of the science and weather of lightning and its effect on protecting property from lightning strikes. The author stated that "high terrain brings the Earths potential closer to the thunderclouds" (p.141). The author also offers evidence that elevation brings structures closer to the potential for a lightning strike and that "air moving across the lay of the land is turned upwards by structures, trees, and topography forcing hot air upwards and contributing to movement of the positive and negative charges floating along the earth" (p.77). Residential

structures are notably surrounded by other structures, trees, and can be affected by the lay of the land. This author clearly implies that structures are vulnerable to lightning strikes. The research in asking if residential properties are vulnerable to lightning is clear and indisputable.

Is there any pattern to lightning strikes to residential properties in WT? The authors Cao, Xiang, & Wilson (2004) in their study of lightning strikes in Mecklenburg County, North Carolina from 1993 to 1995, utilized the then-relatively new technology (at the time) called Geographical Information Systems (GIS). GIS systems have advanced considerably since their study. The researchers found that the majority of lightning damage occurred in the south planning district, which historically absorbed much of the suburban growth and contained mostly single-family residences. This study also appears to support the notion that lightning strikes to residential properties are common; however, these authors did not report how often or how many lightning strikes occurred. They reported only the level of damage done to specific areas. Further, they did not mention lightning damage in existing communities or other developed areas, but did encourage further study. No follow-up research was found referencing this study or any similar studies noted. This study was influential in this research project as it referred to GIS technology (even though it was new at the time) and the researchers had the same intent of utilizing their study to influence planners and residents.

Powell (2001) interviewed Dr. Raymond Hayes of AEP Dolan Laboratory in Groveport, Ohio. Dr. Hayes stated in the article "that if you suspect a lightning strike in your area, historical data is available to confirm lightning activity in a particular area." Dr. Hayes needs date, time and an exact address, or longitude and latitude to confirm lightning activity within a range of 500 meters. The article recommended Dr. Raymond Hayes as a resource and information needed for

obtaining lightning strike information. He is a good source and is commonly called on by insurance companies to assist in determining if lightning was a cause of damage or fire.

Svitil (2003) in her article states that science confirms that urban areas experience more lightning activity than those living away from more populated areas. The author noted in her article that an atmospheric scientist with Brazil's National Institute for Space Research in Sao Jose'dos Campos, used Brazil's extensive lightning-detection network to measure summer flashes over three metropolitan areas. The scientists stated that "heat emitted by buildings, cars, and pavement creates heat islands where temperatures are higher, clouds are deeper, and lightning is more likely" (p. 14). The findings support that a pattern may exist in areas more vulnerable to lightning than others, by virtue of structural and infrastructure. The author's interview of the researcher indicated that metropolitan areas have increase exposure to lightning activity. This study is actually of little use for statistical reference or confirmation that large populated areas are more at risk for lightning activity. The study was helpful to my research for information only. Conversely, the article did not identify the sizes and locations of the three metropolitan areas mentioned and their infrastructure.

Vaisala (2003) as a company develops, manufactures, and markets products for measurement in environmental protection, cost savings, and improve safety including lightning detection. This resource provides a software program called STRIKEnet$_{sm.}$ This program is referred to on the web site as an "online lightning verification report," as it objectively and accurately can report individual lightning strikes at specific locations. This company provides information (fee based) for determining if lightning activity was present for specific locations or areas. This resource is a scientific based GIS tracking system for mapping lightning information

useful in determining locations and possible patterns of lightning from both a strike and activity standpoint.

What is a good method of mitigating lightning strikes to residential property? The National Lightning Safety Institute (NLSI) provides expert training and consulting for lightning problems. According to Kithil (2004), who is president and CEO of the NLSI, "Benjamin Franklin perceived that lightning striking an elevated grounded rod would follow a 'path of least resistance' to earth, and his invention advanced fire safety…and still holds true today" (p. 1). The author's opinion supports the use of and installation of the Franklin Rod system for protecting structures and all lightning protection should be consistent with recommendations in the NFPA-780.

Lightning Eliminators Company, Inc. (2003) is a firm that engineers and manufactures global lightning protection equipment and sponsors a web site that intends to help clients better understand the threat of lightning. They refer on their web page to the two types of lightning protection systems most prevalent LR/ATS which offer a path to ground and the CTS/ALS Dissipation Systems which prevent lightning strikes by discharging the site being protected. This resource provides information on the two types of lightning protection equipment available on world markets.

Uman & Rakov (2002) refer in their article on non conventional lightning schemes fall into one of two classes known as either Lightning Elimination (LE) also known as CTS or Early Streamer Emission (ESE) as two techniques commercially available under a variety of trade names. These systems are claimed to be superior to the conventional lightning protection. Note: the authors describe these alternative systems as being unreliable. Research indicates no difference in capabilities of either lightning protection systems.

Zipse (1999) wrote in his excerpt that "The CTS of preventing lightning strikes to protected areas is a valid concept and will replace the Franklin Rod method in many applications" (p. 2). The author is an electrical engineer and noted authority on lightning protection. The excerpt is referring to a question in the lightning protection/electrical engineering community about whether the CTS is valid and reliable.

Based on the findings and observations noted above the literature review research indicates that residential properties are vulnerable to lightning strikes in many ways. It is evident that physical, environmental, and construction aspects are available and are the usual victims to lightning strike causing damage and/or fires. Also, there is value in utilizing available information with GIS Technology for identifying and documenting lightning activity or patterns for a historical look at frequency and locations. Growth and development of communities offers opportunities for increased lightning frequency. Finally, sources agree that mitigating lightning activity to residential properties is beneficial by recommending two types of lightning protection equipment along with environmental and physical recommendations for protecting residential property. Additionally, the Independent Protection Company, Inc. (2004) noted in their web-article that:

"with proper maintenance and periodic inspection, the system should last as long as you own your property. Many lightning protection systems have lasted 50 years with proper maintenance. Installing a LPS system for a residence, installed according to code and quality materials. Over the lifetime of your system, the costs are just pennies per thunderstorm."

Dr. John Schneider, Eng. of AEP in Columbus, Ohio (J. Schneider, personal communications, May 3, 2004). Was contacted and reviewed the findings in this research project

Dr. Schneider offered opinions on validity of the findings contained in the research. He offered two explanations in regards to Appendix D & E in that:

"To help the reader in understanding the information presented in the FALLS® map, a stroke is a 'finger' of lightning not visible to the naked eye coming off of the flash of lightning. Each flash averages 2-3 strokes but can have as many as up to 20."

In summary, the findings of others as listed and referenced in the literature review answered each research question. This area of this research was new, informative, and endless. Some of the information was accurate and some not so accurate requiring further research and consultation with Dr. John Schneider as noted above. This research project will assist in providing information, justification, and direction in adopting lightning protection guidelines for WT.

Kithil (2004) offers help in the way of codes and standards by suggesting that:

> "utilizing "items from Motorola R56, IEEE 1100, borrowing from FAA-STD-019d, copying some language from NASA-KSC-E0012E, and mixing some NEC 250 information would result is a very good document to satisfy the needs of the dispatch community for a pragmatic lightning protection standard. Some leadership is needed here. Please step forward." (p. 2).

RECOMMENDATIONS

Using the information uncovered in the course of this research project, the author recommends the following steps for WTFD:

1. Continue with and strive to improve upon the accuracy and documentation of lightning strikes, locations, dates, and damage amounts, placing this information onto a GIS map for on-going historical documentation.
2. Maintain a supportive/working relationship with American Electric Power contacts for LTraX® and FALLS®, information and any future scientific information on this subject.
3. Maintain information for development of a presentation on WT residential development and the need to consider installing Lightning Protection Systems based on this research and continuing information.
4. Consider developing a formal lighting protection ordinance for new construction in high-risk areas. This recommendation is in response to information provided by Kithil (2004) on codes and standards for the:

   > "dispatch community by utilizing items from Motorola R56, IEEE 1100, borrowing from FAA-STD-019d, copying some language from NASA-KSC-E0012E, and mixing some NEC 250 information would result is a very good document to satisfy the needs for a pragmatic lightning protection standard" (p. 2).

5. Further develop information available from FALLS to make a cumulative map of five and ten year patterns.

6. Continue working with WT building/zoning departments to enlightening them to the hazards and varying number of incidents of lightning strikes to residential property.

Recommendations for the third research question simply address considering lightning protection for both existing and new residential property. Future considerations may consist of recommend requiring lightning protection on commercially built residential housing.

In general, recommendations for readers who may wish to replicate some or all of this study within their own organization should include documentation and presentation of lightning strike information for easy of reference, as well as background information from research journals and library resources, Researchers should seek experts in the field and be discerning in the information obtained. Understand that this subject area is referenced more from the science/weather of lightning and personal safety than property protection.

Future readers might wish to pursue the question of why residential structures are struck or damaged. Future readers can become catalysts for new considerations and procedures to protect the property and lives of our citizens and fire safety forces.

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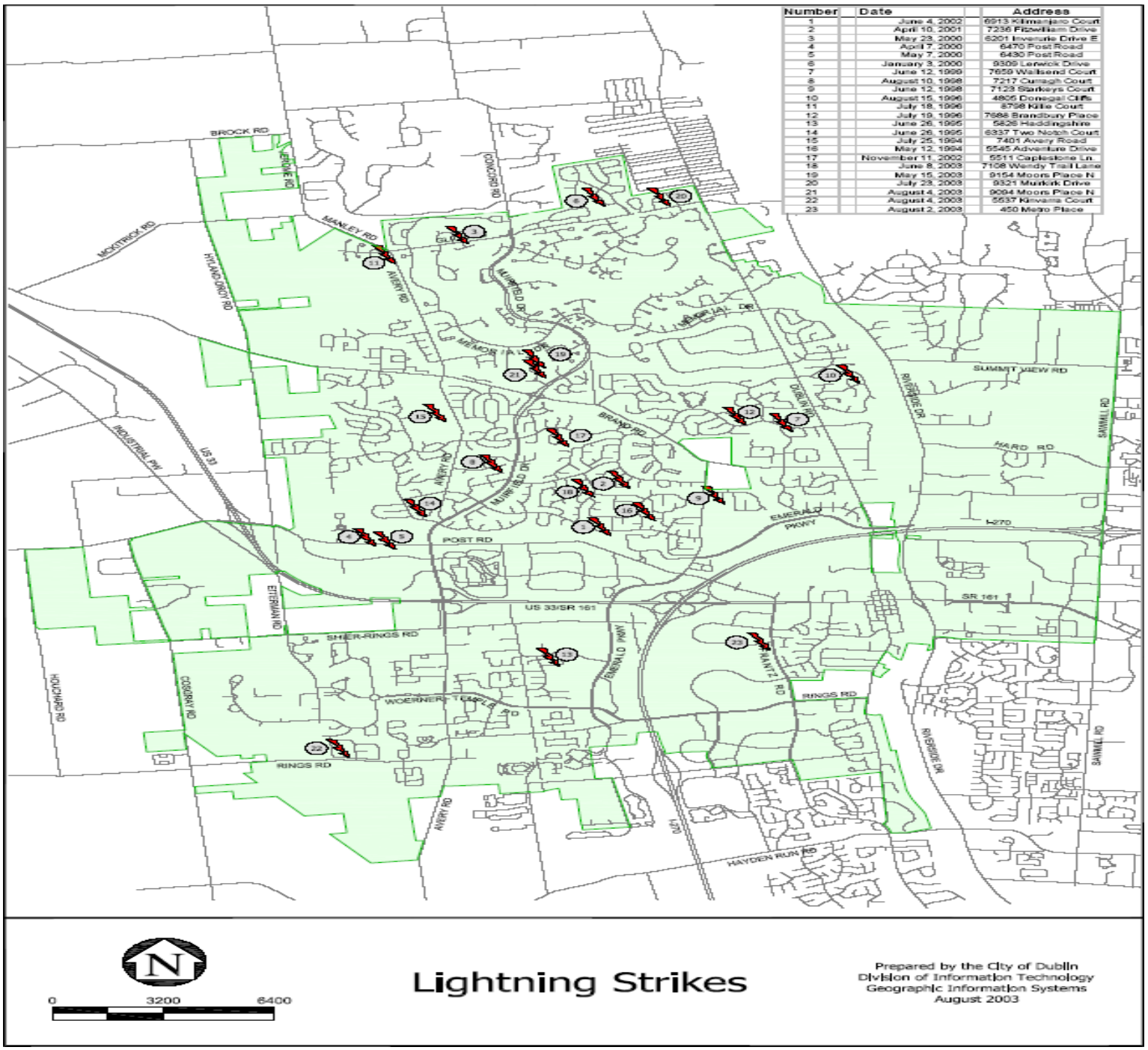
APPENDIX A – Number, dates, and street addresses of residential property damage and Fires.

Numbers, dates, and street address of residential property damage and fires by lightning strikes.

Number	Date	Street Address
1	2002 4, June	6913 Kilimanjaro Court
2	2001 10, April	7236 Fitzwilliam Drive
3	2000 23, May	6201 Inverurie Drive E.
4	2000 7, April	6470 Post Road (Commercial residence)
5	2000 7, May	6430 Post Road (Commercial residence)
6	2000 3, January	9309 Lerwick Drive
7	1999 12, June	7659 Wallsend Court
8	1998 10, August	7217 Curragh Court
9	1998 12, June	7217 Starkeys Court
10	1996 15, August	4805 Donegal Cliffs
11	1996 18, July	8798 Killie Court
12	1996 18, July	7688 Brandbury Place
13	1995 26, June	5826 Haddingtshire
14	1995 26, June	6237 Two Notch Court
15	1994 25, July	7401 Avery Road
16	1994 14, June	5545 Adventure Drive
17	2002 11, November	5511 Caplestone Lane
18	2003 8, June	7108 Wendy Trail Lane
19	2003 15, May	9154 Moors Place N.
20	2003 23, July	9321 Muirkirk Drive
21	2003 4, August	9094 Moors Place N.
22	2003 4, August	5537 Kinvarra Court
23	2003 2, August	450 Metro Place (Commercial residence)

Note: The list of numbers, date of incident, and street addresses noted retrieved from WTFPB Fire Investigation Reports from 1994-2003.

Appendix B- Lightning Strike fires as prepared by City of Dublin Division of Information Technology Geographic Information System as of August 2003.



APPENDIX C- Residential Property Damage and Fire Losses from 1994 to 2003

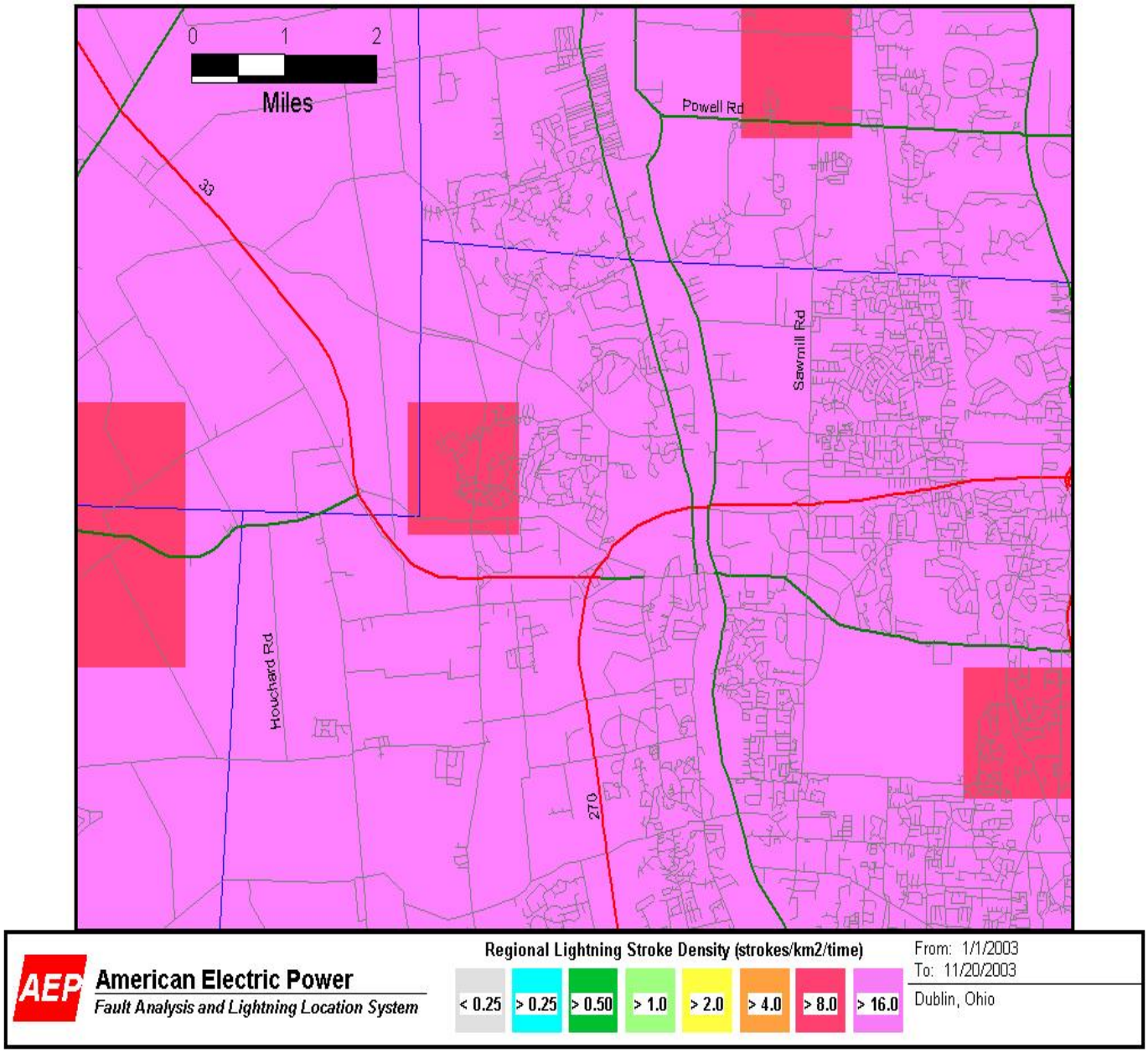
Residential Property Damage and Fire Losses from 1994 to 2003

Year	Number of Residential Lightning Damage Fires [a]	Estimated Lightning and Damage/Fire Losses (b)	Annual Residential Damage/Fire Losses(c)	Percent of Estimated Losses divided by Annual Losses (d)
2003	6	$ 17,100	$ 816,220	2%
2002	2	$ 236,486	$ 370,186	64%
2001	1	$ 250,000	$ 416,390	60%
2000	4	$ 25,000	$ 596,500	4%
1999	1	$ 100,000	$ 459,860	22%
1998	2	$ 57,500	$ 71,500	80%
1997	0	$ N/A	$ 94,133	N/A
1996	3	$ 225,000	$ 456,250	49%
1995	2	$ 105,000	$ 180,972	58%
1994	2	$ 103,000	$ 223,057	46%
Total Amounts	23	$ 1,119,086	$ 3,685,068	30%

Note: Statistics retrieved from Annual Fire Investigation Reports compiled each year for fires investigated by the Fire Prevention Bureau.
[a] Number of Residential Lightning Damage/Fires.
[b] Estimated Lightning and Damage/Fire Losses.
(c)Annual Residential Damage/Fire losses.
(d) In percent (%) estimated losses divided by annual losses.

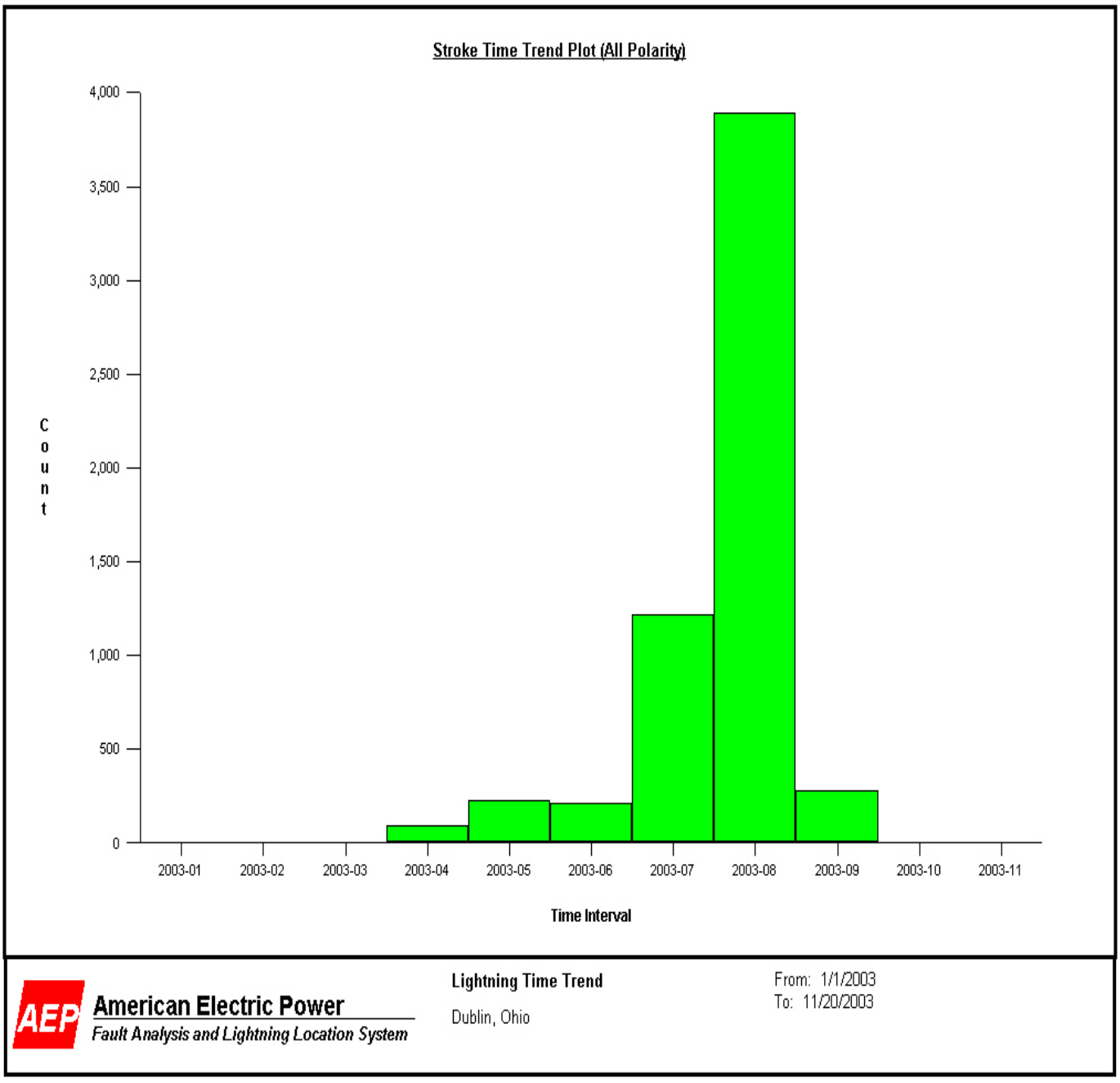
APPENDIX D – FAULT ANALYSIS AND LIGHTNING LOCATION SYSTEM (AEP)

Regional Lightning Stroke Density from 1/1/2003 to 1/20/2003 for Dublin, Ohio



APPENDIX E – FAULT ANALYSIS AND LIGHTNING LOCATION SYSTEM (AEP)

Lightning Time Trend from 1/1/2003 to 11/20/2003 for Dublin, Ohio



APPENDIX F – Hayes, R., (Personal Communications July 11, 2002)

To: rmhayes@aep.com

Subject: Re User or customer inquiry from aep.com

cc: pjtoomey@aep.com

Mr. Hayes,

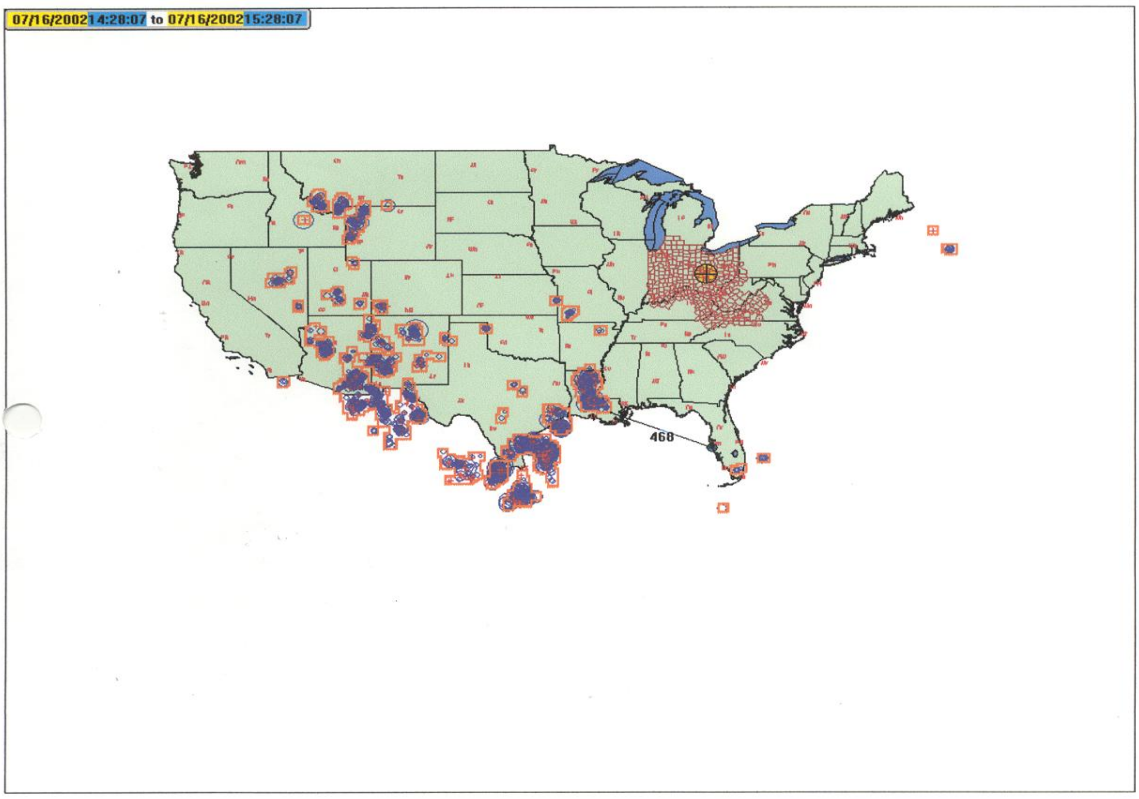
I'm looking for lightning strikes info for the Dublin, Ohio area for a report. I'm researching strike info for a report from the fire department on losses via strikes for the last ten years. Anything you can help me with I'd appreciate.

AEP is a subscriber to the Global Atmospherics, Inc.(GAI) National Lightning Detection Network (NLDN). This is a network of 105 (+/-) sensors all around the Continental United States (U.S.), (Canada and Brazil have their own version also from GAI, as do about 25 other countries around the world). GAI has a software product called Fault Analysis and Lightning Location System (FALLS) that is used to do statistical analyses-for example, the study of long-term lightning activity on several hilltops before sitting a communications tower.

AEP is also the developer of LTraX. This is an archive and display system to save the NLDN data to a database, and to display lightning activity in real time or from the archive. I am the lead developer and supporter of LTraX. There is a sample screen capture (Appendix E) from LTraX, showing the lightning flashes across the U.S. for the last hour.

If your interest is in statistical lightning data, FALLS is probably a better application. You can contact Paul Toomey at AEP (614-223-3441) for FALLS information.

APPENDIX G- Sample screen capture from LTraX



APPENDIX H– QUESTIONNAIRE

I'm doing a research paper for the Ohio Fire Executive Program (OFE) on methods and theories of better protecting Residential structures from lightning strikes. Any statistics/data you have available would be greatly appreciated. Below are a few questions that will help me in my research:

1. Number of residential lightning strikes (Fire response) since 1993:_____.
2. Average (if available) of lightning strike events a year:_____.
3. Number of fires resulting from those strikes_____.
4. Number of just damage:_____.
5. Average fire/damage amounts ($) from lightning in Annual fire losses per year:

   1993_____ 1994_____ 1995_____ 1996_____ 1997_____

   1998_____ 1999_____ 2000_____ 2001_____ 2002_____.
6. Any concentrated areas of lightning activity:
7. Structure type totals:

   Residential_____ Commercial:_____ Other:_____
8. Any Lightning protection in place at time of lightning strike:
9. Fatalities:_____ Where?

You can fax me back results @ 614.766.2507, or e-mail me at Guisinger@aol.com.

Thanks,
Bob Guisinger
Washington Township Fire
Dublin, Oh 43016
614.889.2347