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Severe Weather Impact Analysis

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Severe Weather Impact Analysis for Military Construction Projects

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Some construction delays caused by severe weather are inevitable, and evaluating the weather severity and resultant impact to construction activities can be difficult. The U.S. Army Corps of Engineers (USACE) attempts to give contractors a reasonably accurate estimate of anticipated severe weather impact before construction begins, to build normal delays into construction schedules and contract durations. This report develops a concept for an improved method to estimate and evaluate the impact of severe weather on Corps military construction projects.

This improved approach will provide: (1) accurate preconstruction estimates of anticipated severe weather, and (2) a fair and reasonable way to evaluate delays during construction due to severe weather.

The proposed method helps to estimate and evaluate the impact of severe weather on Corps construction projects by analyzing historical weather data along with severe weather limitations of specific construction activities as the basis for analysis. This interim report focuses on the principal components of the proposed method, including: (1) location of an appropriate source of historical weather data, (2) development of an approach for performing data analysis, and (3) definition of severe weather parameters and criteria for various construction activities.

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13. ABSTRACT (Maximum 200 words)

Some construction delays caused by severe weather are inevitable, and evaluating the weather severity and resultant impact to construction activities can be difficult. The U.S. Army Corps of Engineers (USACE) attempts to provide contractors with a reasonably accurate estimate of anticipated severe weather impact before construction begins, in order to build normal delays into construction schedules and contract durations. This report develops a concept for an improved method to estimate and evaluate the impact of severe weather on Corps military construction projects.

This improved approach will provide: (1) accurate preconstruction estimates of anticipated severe weather, and (2) a fair and reasonable mechanism for evaluating delays during construction due to severe weather.

The proposed method helps to estimate and evaluate the impact of severe weather on Corps construction projects by analyzing historical weather data along with severe weather limitations of specific construction activities as the basis for analysis. This interim report focuses on the principal components of the proposed method, including: (1) location of an appropriate source of historical weather data, (2) development of an approach for performing data analysis, and (3) definition of severe weather parameters and criteria for various construction activities.

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FOREWORD

This study was conducted for the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Project 4A162734AT41, "Military Facilities Engineering Technology"; Task SA; Work Unit AF0, "Construction Control Knowledge Schedule." The HQUSACE technical monitor was Mr. James Jones, CEMP-CP.

This research was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USACERL). The principal investigator was Mr. Diego Echeverry. Dr. Michael J. O'Connor is Chief, USACERL-FS. The USACERL technical editor was Mr. William J. Wolfe, Information Management Office

COL Everett R. Thomas is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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SEVERE WEATHER IMPACT ANALYSIS FOR MILITARY CONSTRUCTION PROJECTS

1 INTRODUCTION

Background

Most construction projects are affected to some degree by adverse weather. Typical U.S. Army Corps of Engineers (USACE) policy is to attempt to provide contractors with a reasonably accurate estimate of the anticipated severe weather impact before construction begins so that normal delays can be built into construction schedules and contract durations. After construction begins, the government is obligated to evaluate delays due to occurrences of unusually severe weather and issue modifications for time extensions. Such action must be taken in a timely manner to prevent acceleration of the contractor's work and the resultant costs of acceleration.

The Corps presently uses several methods to perform weather impact analysis. While these methods attain some degree of success, it is not unusual for military construction projects to experience contract time growth due to severe weather impact. An improved and uniform approach to severe weather impact analysis on Corps military construction projects will minimize this type of delay.

Objective

The objective of the initial stage of study reported here is to develop an improved method to: (1) estimate the anticipated normal severe weather impact before construction begins; and (2) evaluate the actual impact of severe weather during construction.

The final phase of this study will: (1) survey construction industry field experts to determine reasonable and fair severe weather limitations for construction activities, (2) field test the proposed severe weather impact analysis methods using an actual construction project to develop and refine these concepts. Corps personnel currently performing severe weather impact analysis for military construction projects will participate in testing of the proposed methods.

Approach

Weather data sources were contacted by telephone and mail correspondence to identify an accessible and reliable source of historical weather data, and to develop a procedure for data analysis. A site visit was made to Scott Air Force Base (AFB), Belleville, IL, to investigate the U.S. Air Force Environmental Technical Applications Center (USAFETAC). Later, data from a hypothetical construction project was submitted to the selected source to test its ability to provide and process the desired weather information.

An electronic keyword search was done through the Corps of Engineers Guide Specifications (CEGS) to locate all references to weather requirements and limitations for specific types of construction activities. Relevant sections were tagged and imported into word-processing format for later analysis.

Scope

CEGS were reviewed for explicitly stated weather requirements and limitations. Implied weather requirements or limitations were not within the scope of this study.

Mode of Technology Transfer

It is anticipated that this report will be made part of the material of Huntsville division courses. Further issues regarding the dissemination of proposed concepts and practices will be addressed during field testing.

2 DETERMINING AND APPLYING SEVERE WEATHER LIMITATIONS

Anticipated Adverse Weather Impact - The Estimation Process

To provide a fair and reasonable administration of its construction contracts, the Corps normally provides contractors with an estimate of anticipated adverse weather impact as part of the contract documents. The number of anticipated weather delay days in each month of the year is included in a special weather clause within the project manual. This clause states that the contractor's schedule must reflect the anticipated adverse weather delays on all weather-dependent activities.

This report proposes a method to develop a fair and reasonable estimate of anticipated adverse weather impact for inclusion in the contract documents of Corps construction projects. The method involves analysis of historical weather data for a given construction site to determine the extent of normal adverse weather impact. The analysis is based on the severe weather limitations of the activities planned for the project. Since different activities have different weather requirements, the extent of impact must be estimated for each weather sensitive activity. Figure 1 shows the proposed estimation process.

It should be noted that estimation of impact (anticipated delay) upon individual construction activities is not presently a requirement for Corps construction contracts. Impacts are usually indicated in the special weather clause as the monthly impact or delay for the project in general. The delays are not linked to specific activities, and the severe weather criteria used to define a weather delay day is the same for all construction activities that occur on the project regardless of the activity's degree of sensitivity to weather.

The method of analysis proposed in this report is based on the premise that no single set of severe weather parameters and criteria can accurately reflect the impact on all construction activities; rather, various activities will have unique weather sensitivities that should be accounted for during severe weather impact analysis. Weather conditions considered severe for one activity, may have no impact on another less sensitive activity.

Time Extensions for Unusually Severe Weather - The Evaluation Process

In addition to providing an estimate of the anticipated severe weather, the weather clause describes the process of evaluating delays due to unusually severe weather during construction. The anticipated adverse weather (the estimated weather delay days) constitutes the base line for monthly weather time evaluations. If it is shown that the actual weather experienced during construction was more severe than the base line estimate of anticipated adverse weather indicated in the weather clause, and that the resultant delays critically affected the construction schedule, then the contractor may be granted a contract time extension.

The first step is to determine whether or not unusually severe weather has occurred. This requires analysis of data representing the actual weather experienced during construction. The analysis is based on the severe weather limitations of the activities thought to have been delayed. If the weather experienced was more severe than the base line estimate for the activities being evaluated, then the contractor may be granted a time extension. The second part of the evaluation involves an analysis of the contractor's schedule to determine if work scheduled to be performed was actually delayed, and if such delay was on the "critical path," thereby delaying overall completion. Even if unusually severe weather has occurred, a time extension is not granted unless overall completion is delayed. Figure 2 illustrates the proposed evaluation process.

ESTIMATION PROCESS

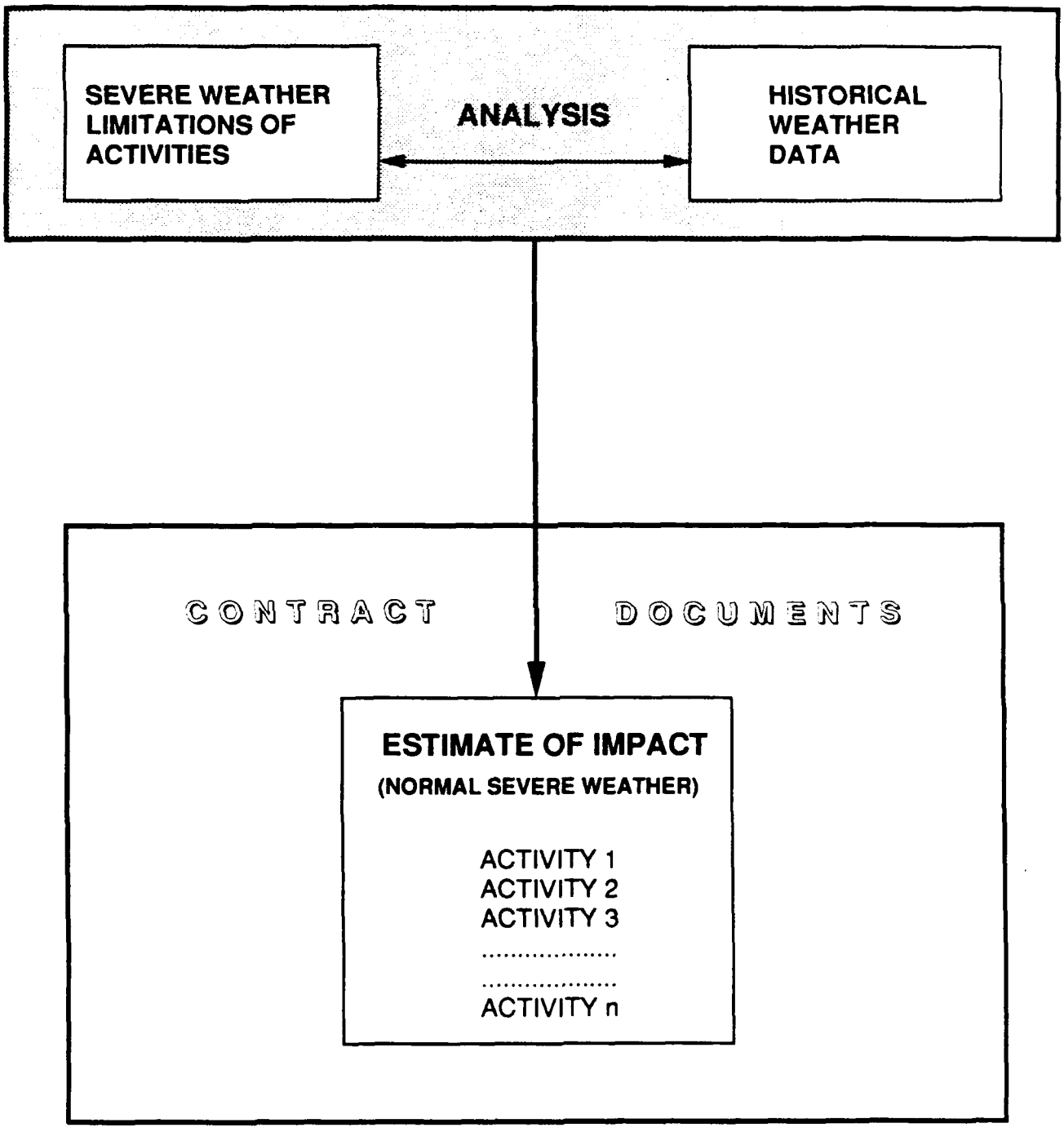

Figure 1. Schematic diagram of proposed severe weather impact estimation process.

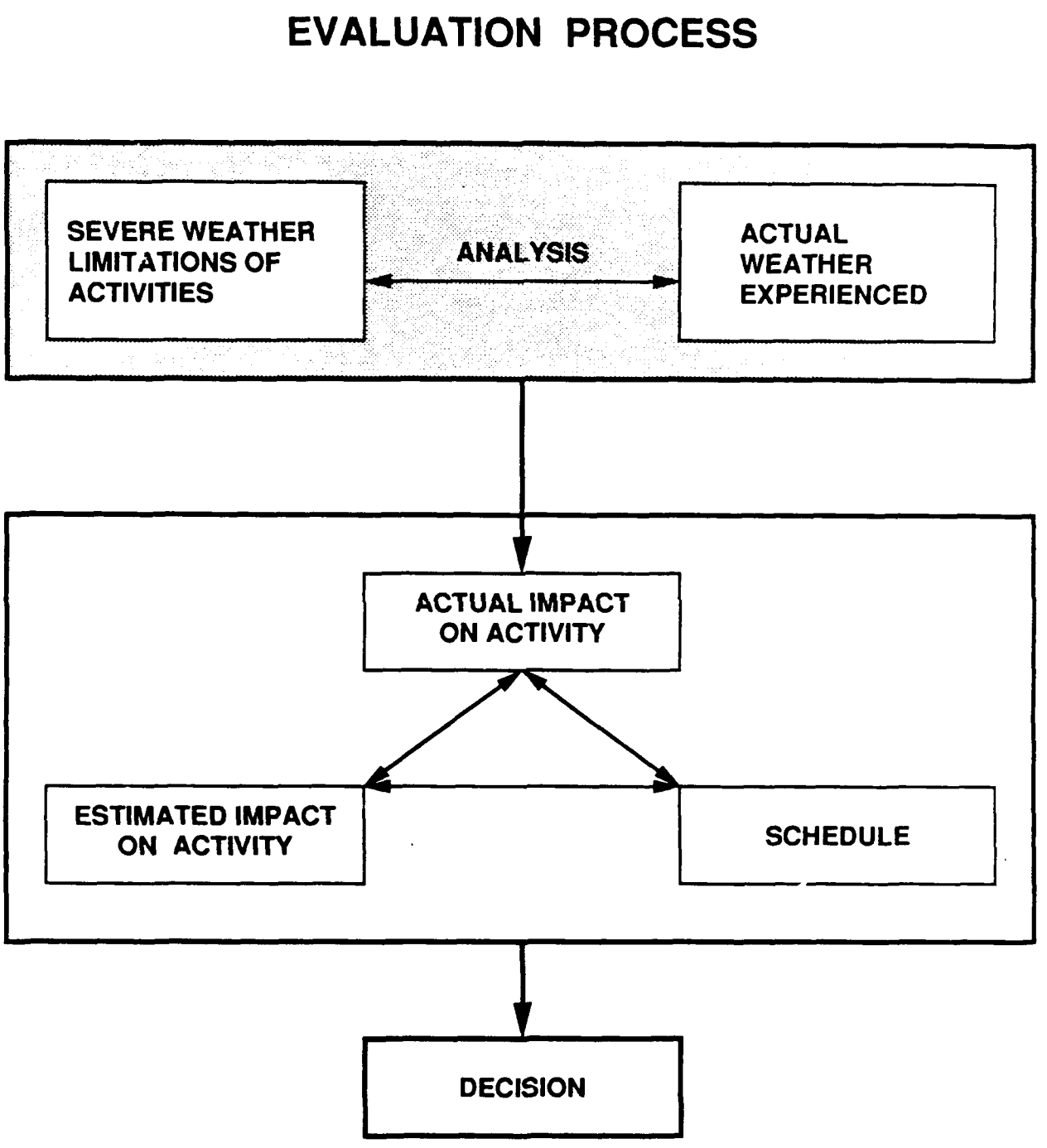

Figure 2. Schematic diagram of proposed severe weather impact evaluation process.

Principal Components of Weather Impact Analysis Procedures

The estimation and evaluation procedures above are similar in two respects. First, each process requires the analysis of weather data. The estimation process uses historical data for the construction site under consideration, and the evaluation process uses data representing the actual weather experienced during the period of delay. The use of documented weather occurrences validates the analysis procedures and the decision to allow or disallow the time extension.

Second, both estimation and evaluation procedures require that the unique severe weather limitations of the construction activities planned to occur (estimation procedure) or that have already occurred (evaluation procedure) be considered in the analysis. This is an important aspect since some types of construction are extremely sensitive to weather, while others are not affected at all.

The analysis of historical weather data and the use of severe weather parameters and criteria of specific activities under consideration represent the two basic elements of this approach. They are indicated within the shaded boxes of Figures 1 and 2.

Defining Severe Weather Limitations of Construction Activities

Since both estimation and evaluation procedures account for the unique weather requirements of the activities anticipated to occur (or which have already occurred) during the project, the identification of the respective severe weather parameters and criteria of specific construction activities comprises a crucial aspect of the research. This process was begun with a comprehensive review of CEGS.

CEGS

CEGS for military construction are a master specification tool. They serve as a basis for Corps construction project specifications, and provide a vehicle for compilation, elaboration, and refinement of specification data.[1] CEGS include items of work normally encountered during Corps construction projects. Specifiers edit selected CEGS sections to suit particular projects and their unique requirements.

CEGS are organized according to the Construction Specification Institute (CSI) 16-division format "which establishes broad categories of construction information so that specification sections of a similar nature can be grouped together."[2] Each division of CEGS is subdivided into "sections." Each section within divisions 2 through 16 generally corresponds to a specific construction activity (section 02210-grading, section 05300-steel decking, section 07920-caulking and sealants, etc.). Each CEGS section, once edited and included in the contract documents, defines the qualitative requirements for performing an activity. Weather limitations (sometimes referred to as "environmental limitations") are often indicated within CEGS master specification sections. Although the specifier may edit CEGS sections to fit a particular project, the weather requirements or limitations within this master specification provide guidelines for the normal requirements for the specific activity of the section. A comprehensive review of CEGS was undertaken to identify the normal severe weather requirements prescribed by the guide specifications for activities typically encountered on Corps construction projects.

[1] *Manual of Practice* (Construction Specifications Institute [CCI], Alexandria, VA, October 1985).
[2] *Manual of Practice*.

Scope Limitations

CEGS contain a large volume of text, much of which is extraneous to the goals of this research. Since the objective of the review was to identify CEGS weather requirements for various construction activities, the CEGS review was limited to those activities normally affected by weather. The following divisions include types of construction activities potentially sensitive to adverse weather, and were selected for review:

- Division 2 - Sitework
- Division 3 - Concrete
- Division 4 - Masonry
- Division 5 - Metals
- Division 6 - Wood and Plastics
- Division 7 - Moisture and Thermal Protection
- Division 8 - Doors and Windows
- Division 9 - Finishes.

CEGS Divisions 10 through 16 include activities that normally occur after the building construction has been substantially "closed-in." These divisions were not selected for review since for them weather impact is not normally considered a critical factor:

- Division 10 - Specialties
- Division 11 - Equipment
- Division 12 - Furnishings
- Division 13 - Special Construction
- Division 14 - Conveying Systems
- Division 15 - Mechanical
- Division 16 - Electrical.

CEGS frequent use of reference standards resulted in another limitation on the scope of the research. The CSI manual of practice defines reference standards as: requirements set by authority, custom, or general consensus that are established as accepted criteria. When a standard is incorporated by reference into the specification, the provisions of the standard "become part of the project manual just as though included in their entirety."[3] CEGS sections were reviewed only for explicit statements of weather requirements within the text of the master specification. Implicit weather requirements inherent in referenced standards were not within the scope of this research. It should also be noted that although CEGS occasionally state the weather requirements for performing a construction activity under extreme conditions, only the "normal" weather limitations were documented. This included only the weather requirements stated for performing the activity without the use of special enclosures, materials, or techniques. Although CEGS occasionally permit the use of nontypical means and methods in the event of severe weather conditions, they are not necessarily required by the specification, and are usually implemented only at the contractor's option. This scope limitation was imposed to maintain a fair and reasonable expectation of the contractor's willingness, financial ability, and legal responsibility for performing construction activities outside the "normal" weather limitations prescribed by CEGS.

CEGS Review Procedures

Compact Disk-Read Only Memory (CD-ROM) technology was used to review CEGS, to identify activity weather limitations prescribed by the master specification sections. A CD-ROM system is essentially an electronic database. The use of this technology enables rapid access to any part of the

[3] *Manual of Practice.*

database with full-text search and retrieval capabilities.[4] CEGS are available on the *Construction Criteria Base*—a CD-ROM system developed by the National Institute of Building Sciences (NIBS) in conjunction with the Corps and other federal agencies. Full-text word search capabilities of the CD-ROM were used to identify those sections within CEGS having text which specifies the weather limitations and requirements for the performance of construction activities. The following key words were typically used to conduct the search:

• Weather	• Rain	• Freeze	• Cold
• Environment	• Snow	• Ice	• Hot
• Temperature	• Wind	• Frost	• Application
• Precipitation	• Humidity	• Degree	• Installation.

Sections of text containing one or more of the search words were reviewed, "tagged" (if applicable to the research), and imported into a word processing format (WordPerfect 5.0 or 5.1).[5] These sections were transferred to 5-1/4-in. diskettes for further scrutiny of weather requirements explicitly stated within their texts. The requirements were then cataloged and compiled in tabular format (Appendix A).

Historical Weather Data Sources and Data Analysis

Both the estimation and evaluation procedures of weather impact analysis require access to a source of historical weather data. The data source should produce reliable, periodic documentation to "establish a history of weather conditions in the vicinity of the project and provide records of daily weather conditions during construction."[6] Careful analysis of this data can provide information useful for: (1) producing a baseline estimate of expected severe weather at the project site for inclusion in the special weather clause of the project manual; (2) performing evaluations of delays due to unusually severe weather; and (3) estimating original project durations.

Alternative Weather Data Sources

Several important considerations in the selection of a weather data source are:

- Availability/accessibility of relevant data
- Cost of data
- Size and manageability of data base
- Logistics of data analysis
- Updating and maintenance requirements of data base.

Several sources were investigated. The National Oceanic and Atmospheric Administration (NOAA) has extensive data for many continental U.S. (CONUS) and out-of-continental U.S. (OCONUS) sites. However, there were several problems with the NOAA weather data:

1. Although raw data is available for many sites, it must be selected from among many NOAA data bases. It is difficult to determine exactly what type and how much data to request.

2. Requested data must be purchased, resulting in a considerable initial cost to the Corps.

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[4] Jerry McFaul, "CD-ROM, The Information Machine for A/E Firms," *The Construction Specifier* (June 1990).

[5] *WordPerfect* is a registered trademark of the WordPerfect Corporation, Orem. UT, 84057.

[6] Draft Engineer Regulation (ER) 415-1-15, *Construction Time Extensions for Weather* (U.S. Army Corps of Engineers [USACE], 21 October 1989).

3. Data base analysis procedures must be developed to derive meaningful information from the raw data bases. Even "summary of the day" data (available from NOAA for many sites) does not provide weather information readily usable for performing weather impact analysis.

4. Weather data bases are often quite large and difficult to manage.

5. Considerable update and maintenance of the data bases would be required.

USAFETAC is a second weather data source. The mission of USAFETAC is "to assess the natural environment from a historical perspective and advise the United States Air Force, the United States Army, and other agencies as directed, on its effects."[7] A meeting with USAFETAC officials at Scott AFB in April 1990 revealed several advantages to this source of weather data information:

1. Comprehensive weather data is available for many military bases and nonmilitary weather bureau sites.

2. USACE is authorized to receive USAFETAC support on a nonreimbursable basis.

3. USAFETAC presently has weather data analysis capabilities and expertise, and upon Corps request, will perform the necessary statistical analyses on their resident data bases to provide requested weather information. This eliminates the need for transfer of large quantities of data, and for development of in-house Corps data analysis techniques.

4. Data bases are managed, updated, and maintained entirely by USAFETAC since data is not transferred.

The primary disadvantage of USAFETAC as a source of data analysis is the possibility of nonimmediate response to Corps requests. Although the formal request to USAFETAC for climatological support includes the date that information is required, response time ultimately depends on the request priority level and the current USAFETAC work load.

Test of USAFETAC Weather Data Analysis Capabilities

The U.S. Army Construction Engineering Research Laboratory (USACERL) conducted a test to evaluate the weather data analysis capabilities of USAFETAC. A hypothetical construction project was conceived involving five hypothetical construction activities, each with a unique set of severe weather parameters and criteria. USACERL submitted a formal request for climatological support according to Department of the Army (DA) and Air Force guidelines,[8] and as prescribed by USAFETAC. The submittal requested an estimate of severe weather impact, during any month of the year, for each of the hypothetical construction activities given their specific severe weather limitations. The request identified the construction site location as Scott AFB. (Appendix B)

It should be noted that the test used unrealistically severe weather parameters and criteria for the hypothetical activities. The intent was to test USAFETAC's flexibility and responsiveness in analyzing weather data involving a wide variety of severe weather parameters and criteria.

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[7] USAFETAC Pamphlet 105-3, *An Introduction to USAFETAC* (Department of the Air Force, 15 February 1990).

[8] Army Regulation (AR) 115-10, and Air Force Regulation (AFR) 105-3, *Climatic, Hydrological, and Topographic Services—Meteorological Support for the U.S. Army* (Department of the Army [DA], and Department of the Air Force [DAF], 15 September 1980).

3 RESULTS AND ANALYSIS

Definition of Severe Weather Limitations for Construction Activities

While many activities have generally acknowledged severe weather limitations, others have ambiguous or nonexistent limitations. Moreover, severe weather criteria for any given construction activity should be inherently flexible. Allowing the specifier latitude in defining severe weather requirements for construction activities balances quality control against cost. Setting very strict requirements for acceptable conditions under which an activity can be performed ensures high quality, but increases the cost of construction.

While flexibility in defining severe weather criteria for any given construction activity is desirable, it is the intent of this research to develop reasonable and fair weather limitations to guide Corps personnel during weather impact analysis. Definite severe weather parameters and criteria for specific construction activities will help provide a basis to estimate and evaluate severe weather impact upon that activity. The procedures proposed in this report illustrate that, since specific activities have unique weather limitations and requirements, no single set of severe weather parameters and criteria can represent all activities in a typical military construction project. Specific severe weather criteria must be built for each weather-sensitive activity.

CEGS

Appendix A gives the result of investigations into the weather requirements stated within Divisions 2 through 9 of the CEGS master specification in a tabular format. Supplementary "notes" have been included to clarify weather requirements.

Of the 153 CEGS sections reviewed, 71 sections (about 46 percent) provide the specifier with an explicit statement regarding the conditions under which the work may proceed. No sections from divisions 5, 6, or 8 (metals, wood and plastics, and doors and windows, respectively) contained explicit weather requirements. This does not imply that these activities have no weather limitations. CEGS may warn that certain work is affected by weather, but that specific parameter ranges and severe weather criteria are not provided for that particular section (cf. entries noted with asterisks [*] in Appendix A).

The CEGS review located severe weather limitations for almost half of the construction activities found within this master specification. The absence of clearly stated weather requirements for slightly more than half of the sections reviewed suggests that more research is required to specify severe weather limitations and requirements for all construction activities under consideration during Corps weather impact analysis procedures.

One important consideration is that the CEGS review may address an unreasonably high level of detail. Each CEGS section represents a very specific construction activity. While small construction projects may involve a relatively small number of these activities, larger projects may involve several hundred (or more) of these activities. Therefore, weather impact analysis procedures performed at this high level of detail may ultimately be unrealistic. In these cases, it may be useful to develop a set of severe weather limitations for more general types of construction activity (e.g., sitework, concrete, masonry, carpentry, roofing, etc.).

Weather Data Analysis

Investigations into alternative weather data sources have shown USAFETAC to be the preferred source of historical weather data for a Corps weather impact analysis. Two significant Army benefits resulting from the use of USAFETAC as a data source: (1) that comprehensive data is available through USAFETAC, and (2) that USAFETAC support of Corps activities is provided on a nonreimbursable basis.

Furthermore, since no transfer of data is involved, the Corps will benefit by avoiding the logistical problems associated with the procurement, storage and maintenance of unwieldy quantities of weather data.

Perhaps the strongest argument for selecting USAFETAC as a weather data source is the Corps' opportunity to use this organization's expertise to ensure the relevancy of data analysis. USAFETAC was able to successfully demonstrate its weather data analysis capabilities in a USACERL test. (Appendix B)

Although it is not obliged to prioritize Corps requests, USAFETAC has expressed confidence in its ability to provide weather impact analysis in a timely manner. Furthermore, they are currently refining the data analysis techniques initially developed during the test conducted for this project.

Appendix B gives the results of the weather impact analysis performed by USAFETAC. Included is an estimate of the monthly anticipated adverse weather impact for each of the five hypothetical construction activities at Scott AFB, and a description of the procedures used by USAFETAC in analyzing their resident data bases to obtain the impact estimates shown.

Proposed Method for Estimating Adverse Weather Impact

This method involves the analysis of historical weather data for the geographical location of the construction site. Severe weather parameters and criteria for the types of construction activities planned serve as the basis for the analysis. The following steps outline the proposed method to estimate the monthly severe weather impact on Corps military construction projects:

1. Determine the geographic location of the construction site.

2. Review the construction documents (plans and technical specifications) to determine the weather sensitive construction activities that are planned to occur.

3. Assign severe weather parameters and criteria to each weather sensitive construction activity identified in step 2 using the following alternative procedures:

a. Carefully review the technical specification relating to each weather sensitive activity to determine the weather requirements and limitations stated for the performance of the activity.

b. Select severe weather limitations from a comprehensive list of weather requirements associated with various construction activities. Appendix A represents a first step toward the development of this type of list. Care should be taken so that the weather requirements obtained from this list are not in conflict with weather requirements stated (or referenced) in the technical specification for any given project.

4. Prepare and submit a formal request for climatological support of Army activities to USAFETAC at Scott AFB. This request should adhere to the guidelines of Army Regulation/Air Force Regulation 115-10/105-3. It should indicate that analysis of historical weather data is to be performed for the geographical location of the military construction site in question using the severe weather parameters and criteria which have been assigned to the weather sensitive activities anticipated to occur on the project. The result of this analysis will be an estimate of the normal monthly severe weather impact upon each weather sensitive construction activity. The necessary information required for the completion of this request for USAFETAC data analysis is obtained in steps 1, 2, and 3 above. An example of this type of request is found on pages 1 and 2 of Appendix B.

5. Include the estimate (provided by USAFETAC following step 4) of normal monthly severe weather impact for each weather sensitive construction activity within the construction documents. The contractor should be instructed to include this estimate of normal severe weather impact for each weather sensitive activity in the construction schedule as weather delay days. The severe weather parameters and criteria assigned to the weather sensitive activities, and those used by USAFETAC as the basis for estimating the normal severe weather impact, should also be indicated within the construction documents. Figure 3 illustrates a possible format for presenting the impact estimates for various activities (along with the specific parameters and criteria used to obtain them) within the special weather clause of the project manual.

Proposed Method for Evaluating Impact Due to Adverse Weather During Construction

The following steps outline a proposed method for evaluating the impact of weather during construction. As in the impact estimation process, the evaluation process uses the severe weather parameters and criteria for the construction activities that have occurred as the basis for the analysis. The following steps outline the proposed evaluation method.

1. Determine the specific activity (activities) to be evaluated.

2. Determine the actual severe weather impact on the activities being evaluated. This may be accomplished using one of the following procedures:

a. Prepare and submit a formal request for climatological support of Army activities to USAFETAC (similar to step 4 of the estimation process above). This submittal should request an analysis of the actual weather experienced during the period under consideration using the severe weather parameters and criteria of the activity (activities). The severe weather parameters and criteria should be the same as those used during the estimation process and those included in the special weather clause of the project manual (see steps 3 and 5 of the estimation process above).

b. Obtain actual weather data for the time period in question from: (1) local weather sources, (2) daily logs of the project, or (3) USAFETAC (by request). Determine the extent of actual weather impact on the activity by using the severe weather parameters and criteria (previously assigned to the activities in question) to analyze the actual weather experienced during each day that the activity was being performed. This analysis will determine if any given day qualifies as a weather-impact delay day for the activity. Figure 4 shows a logic flowchart showing this type of analysis. It shows how the actual weather experienced during each day of the period may be analyzed to determine if it should be considered a severe weather impact day for any given activity. The hypothetical activity under consideration in Figure 4 has been assigned three severe weather parameters: temperature, precipitation and wind. The criteria associated with these parameters are 40 °F (minimum), 0.2 in. (maximum) and 20 mph (maximum), respectively.[9] These parameters and criteria are for illustrative purposes only.

[9] °C = 4.55 (°F - 32); 2 in. = 25.4 mm; 1 mi = 1.61 Km.

ACTIVITY	PARAMETER	CRITERIA	ESTIMATED ADVERSE WEATHER IMPACT DAYS											
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
#1	Temperature:													
	Precipitation:													
	Wind:													
	Relative Humidity:													
#2	Temperature:													
	Precipitation:													
	Wind:													
	Relative Humidity:													
#3	Temperature:													
	Precipitation:													
	Wind:													
	Relative Humidity:													
#4	Temperature:													
	Precipitation:													
	Wind:													
	Relative Humidity:													

Figure 3. Possible format for presenting estimate of anticipated adverse weather within the construction documents.

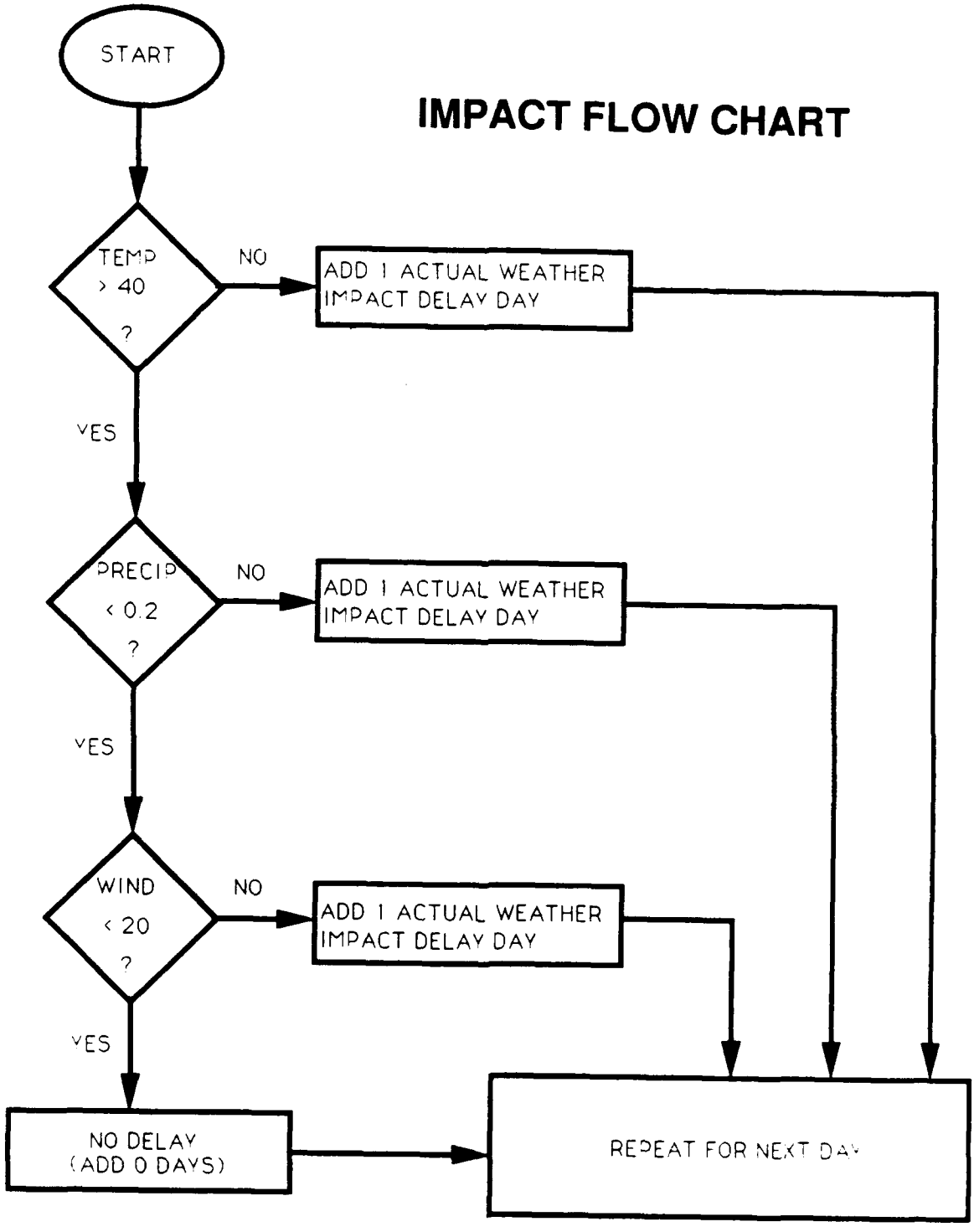

Figure 4. Actual impact analysis flow chart for activity with severe weather requirements as follows: Temperature > 40 °F, Precipitation < 0.2 in., and Wind < 20 mph.

3. The result of step 2 above will represent the actual severe weather impact upon the activities in question during the period being evaluated. Compare the actual severe weather impact with the estimated impact indicated in the special weather clause for each activity in question:

a. If the estimated impact exceeds the actual impact for a given activity, notify the contractor that a time extension will not be granted for the performance of the activity.

b. If the actual impact exceeds the estimated impact for a given activity, then by definition, unusually severe weather has occurred for the activity and the analysis should proceed to step 4 below.

4. A careful review of the contractor's construction schedule must be performed for each activity where the actual impact is greater than the estimated severe weather impact for the activity. If it can be demonstrated that the actual impact critically affected the overall construction schedule such that delays were incurred, then the contract time should be adjusted accordingly. This aspect of the evaluation is likely to require a critical path method (CPM) network analysis. The intricacies associated with this type of analysis are beyond the scope of this research.

4 CONCLUSIONS AND RECOMMENDATION

Conclusions

This interim report has proposed a method that combines the analysis of historical weather data with the unique severe weather requirements of types of construction activities under consideration for any given military construction project.

Access to and analysis of historical weather data are essential to the proposed approach to severe weather analysis. This study concludes that the best source available to the Corps for weather data and analysis is the U.S. Air Force Environmental Technical Applications Center (USAFETAC) at Scott AFB. It can provide both historical weather data and an alternative to in-house weather data management and analysis.

Weather requirements for specific construction activities were located in divisions 2 through 9 of the Corps of Engineers Guide Specifications (CEGS).

The feasibility of estimating or evaluating the weather impact upon an individual construction activity by analyzing historical weather data for a given geographical location was tested by USACERL and USAFETAC. From this test, it was concluded that it is possible to estimate the normal severe weather impact upon an individual activity if the severe weather parameters and criteria of the activity are defined.

The methods outlined in this interim report represent initial efforts to estimate and evaluate severe weather impact on Corps construction projects. The termination of this project will:

1. Survey construction industry field experts to determine reasonable and fair severe weather limitations for construction activities.

2. Field test the proposed severe weather impact analysis methods using an actual construction project to develop and refine these concepts. Corps personnel currently performing severe weather impact analysis activities for military construction projects will participate in testing phases of the proposed methods.

Recommendation

Because construction durations are substantially affected by the severity of weather impact, it is recommended that the analytical concepts of this research be merged with current USACERL research development of a prototype system for computer-supported duration estimation.[10]

[10] Ruofei N. Sun, *A Prototype Construction Duration Estimating System (CODES) for Mid-Rise Building Construction*, Draft Interim Report (U.S. Army Construction Engineering Research Laboratory [USACERL], January 1991).

CITED REFERENCES

Army Regulation (AR) 115-10, and Air Force Regulation (AFR) 105-3, *Climatic, Hydrological, and Topographic Services—Meteorological Support for the U.S. Army* (Department of the Army [DA], and Department of the Air Force [DAF], 15 September 1980).

Draft Engineer Regulation (ER) 415-1-15, *Construction Time Extensions for Weather* (U.S. Army Corps of Engineers [USACE], 31 October 1989).

Manual of Practice (Construction Specifications Institute [CSI], Alexandria, VA, October 1985).

McFaul, Jerry, "CD-ROM, The Information Machine for A/E Firms," *The Construction Specifier* (June 1990).

USAFETAC Pamphlet 105-3, *An Introduction to USAFETAC*, (U.S. Air Force [USAF] Environmental Technical Applications Center, Scott AFB, IL, 15 February 1990).

UNCITED REFERENCES

Adrian, James J., "Productivity and the Environment," ch. 8 of *Construction Productivity Improvement* (Elsevier Science Publishing Co., N.Y., 1987), pp. 169-183.

Grimm, Clayton T., and Norman K. Wagner, "Weather Effects on Mason Productivity," *Journal of the Construction Division: Proceedings of the American Society of Civil Engineers*, vol. 100, No. C03 (American Society of Civil Engineers [ASCE], September 1974), pp. 319-335.

Hinze, Jimmie, and James Couey, "Weather in Construction Contracts," *Journal of Construction Engineering and Management*, vol. 115, No. 2 (ASCE, June 1988), pp. 270-283.

Koehn, Enno, and Gerald Brown, "Climatic Effects on Construction," *Journal of Construction Engineering and Management*, vol. 111, No. 2 (ASCE, June 1985), pp. 129-137.

Kuipers, Edward J., *A Method of Forecasting the Efficiency of Construction Labor in Any Climatological Conditions*, Ph.D. Dissertation (University Microfilms International, Ann Arbor, MI, 1976).

APPENDIX A: CEGS Weather Requirements for Divisions 2 Through 9

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
02 SITE WORK				
	2050	DEMOLITION	*	
	2110	CLEARING AND GRUBBING	*	
	2201	EXCAVATION, FILLING BACKFILLING FOR BUILDINGS	*	
	2210	GRADING	*	
	2222	EXCAVATION, TRENCHING, BACKFILLING FOR UTILITIES SYSTEMS	*	
	2225	EARTHWORK FOR ROADWAYS, RAILROADS AND AIRFIELDS	*	
	2232	SELECT-MATERIAL SUBBASE COURSE	TEMP. > 35° F	No damage allowed by freezing or rainfall.
	2233	GRADED-CRUSHED- AGGREGATE BASE COURSE	TEMP. > 35° F	No damage allowed by freezing or rainfall.
	2234	SUBBASE COURSE	TEMP. > 35° F	No damage allowed by freezing or rainfall.
	2235	LIMEROCK BASE COURSE	*	No damage allowed by freezing temperatures or other adverse weather conditions.

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2236	DRY-BOUND MACADAM BASE COURSE	*	No damage allowed by freezing temperatures, rainfall or other weather conditions.
	2237	WATER-BOUND MACADAM BASE COURSE	TEMP.> 32° F	No damage allowed by freezing, rainfall or other weather conditions.
	2238	BITUMINOUS-STABILIZED BASE COURSE, SUBBASE OR SUBGRADE	TEMP. ≥ 50° F	
	2239	PORTLAND CEMENT-STABILIZED BASE OR SUBBASE COURSE	TEMP. ≥ 40° F	No damage allowed by freezing, rainfall or other weather conditions.
	2240	LIME-STABILIZED BASE COURSE, SUBBASE OR SUBGRADE	TEMP. ≥ 40° F	No damage allowed by freezing, rainfall or other weather conditions.
	2241	STABILIZED-AGGREGATE BASE COURSE	TEMP. ≥ 35° F	
	2242	BITUMINOUS BASE COURSE	TEMP. ≥ 40° F (surface temperature)	No surface water allowed on underlying course.
	2360	STEEL H-PILES	*	
	2361	ROUND TIMBER PILES	*	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2362	PRESTRESSED CONCRETE PILING	*	
	2363	CAST-IN-PLACE CONCRETE PILES,STEEL CASING	*	
	2365	PILING: COMPOSITE, WOOD & CAST-IN-PLACE CONCRETE	*	
	2366	PRECAST CONCRETE PILING	Defers to CEGS division 03 CONCRETE, section 03300.	FABRICATION: TEMP. > 50° F for 7 days (regular portland cement) and > 50° F for 3 days (high early strength).
	2371	AUGER-PLACED GROUT PILES	*	
	2377	CONTRACTOR OPTION FOR PRESSURE INJECTED CONCRETE FOOTINGS	*	
	2383	DRILLED FOUNDATION CAISSONS (PIERS)	*	
	2450	RAILROADS	*	
	2511	CONCRETE SIDEWALKS AND CURBS AND GUTTERS	TEMP. > 40° F (air temperature) and < 85° F (concrete temperature)	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2515	CONCRETE PAVEMENT FOR ROADS AND AIRFIELDS	TEMP. > 40° F (air temperature) and < 90° F (concrete temperature)	
	2520	ROLLER COMPACTED CONCRETE (RCC) PAVEMENT FOR AIRFIELDS, ROADS, STREETS, AND PARKING LOTS	TEMP. > 40° F (air temperature) and < 90° F (concrete temperature)	
	2530	PLAYING SURFACES FOR OUTDOOR SPORTS FACILITIES	TEMP. ≥ 40° F, (dry weather)	No damage allowed by freezing temperatures, rainfall or other weather conditions. Special surfaces as per manufacturer.
	2546	AGGREGATE SURFACE COURSE	TEMP. ≥ 35° F	No damage allowed by freeze, rainfall or other weather conditions.
	2551	BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS	TEMP. ≥ 40° F (surface temperature)	
	2552	BITUMINOUS BINDER AND WEARING COURSES (CENTRAL-PLANT COLD-MIX)	TEMP. ≥ 60° F, no fog, no rain	
	2553	BITUMINOUS MACADAM WEARING COURSE (PENETRATION METHOD)	TEMP.> 60° F (temperature in shade), no fog, no rain	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2554	BITUMINOUS ROAD-MIX SURFACE COURSE	TEMP. ≥ 40° F , no rain	
	2555	BITUMINOUS SURFACE TREATMENT	TEMP. ≥ 50° F (air temperature, in shade) and ≥ 70° F (pavement temperature), dry surface	
	2556	BITUMINOUS INTERMEDIATE AND WEARING COURSES FOR AIRFIELDS, HELIPORTS AND HEAVY DUTY PAVEMENTS (CENTRAL-PLANT HOT-MIX)	TEMP. ≥ 40° F (existing pavement surface or base course temperature)	
	2557	TAR AND RUBBERIZED-TAR CONCRETE PAVEMENTS	TEMP. ≥ 50° F (existing pavement surface or base course)	
	2558	BITUMINOUS TACK COAT	TEMP. ≥ 50° F (in shade), dry surface	Temperature ≥ 35° F for 12 hours prior to application.
	2559	BITUMINOUS PRIME COAT	TEMP. ≥ 50° F (in shade)	Temperature ≥ 35° F for 12 hours prior to application. Requirement for "dryness" of subgrade, subbase or base course.
	2560	BITUMINOUS SEAL COAT, SPRAY APPLICATION	TEMP. ≥ 60° F (in shade) and ≥ 50° F (pavement surface temperature), no rain, no fog, wind velocity not to prevent uniform application	Dry surface required.

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DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2561	ASPHALT SLURRY SEAL	TEMP. ≥ 60° F (air or pavement temperature)	
	2562	POROUS FRICTION COURSE FOR AIRFIELDS AND ROADS	TEMP. ≥ 60° F (existing pavement surface temperature)	
	2563	RECYCLED ASPHALT CONCRETE INTERMEDIATE AND WEARING COURSES	TEMP. ≥ 40° F (existing pavement surface or base course temperature)	
	2564	COLD MIX RECYCLING	TEMP. ≥ 50° F (in shade), no rain	
	2577	PAVEMENT MARKINGS	PAINT: TEMP. > 40° F and < 95° F (air and pavement temperatures), dry surface required THERMOPLASTIC: TEMP. ≥ 40° F (pavement surface temperature), dry surface required PREFORMED TAPE: TEMP. ≥ 60° F (ambient and pavement surface temperature)	
	2579	PATCHING OF RIGID PAVEMENTS	TEMP. ≥ 40° F (in shade) and ≤ 90° F	

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DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2580	JOINT SEALING IN CONCRETE PAVEMENTS FOR ROADS AND AIRFIELDS	TEMP. > 50° F , dry surface	
	2581	RESEALING OF JOINTS IN CONCRETE PAVEMENTS FOR ROADS AND AIRFIELDS	TEMP. > 50° F (atmospheric and surface temperature), dry surface	
	2593	PREFORMED ELASTOMERIC JOINT SEALS FOR CONCRETE PAVEMENTS	TEMP. ≥ 35° F (ambient and pavement temperature), dry surface.	
	2596	HEATER-PLANING OF BITUMINOUS PAVEMENTS	TEMP. > 60° F (pavement surface temperature), dry surface	
	2597	HEATER-SCARIFYING OF BITUMINOUS PAVEMENTS	TEMP. > 60° F (pavement surface temperature), dry surface	
	2598	COLD MILLING OF BITUMINOUS PAVEMENTS	no snow, no ice on pavements	
	2599	BITUMINOUS REJUVENATION	TEMP. ≥ 50° F (atmospheric temperature in shade), dry surface	
	2660	WATER LINES	*	
	2666	UNDERGROUND DISTRIBUTION SYSTEM [CHILLED WATER] [HOT WATER] [DUAL TEMP]	*	
	2670	WATER WELLS	*	

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DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2685	GAS DISTRIBUTION SYSTEM	*	
	2695	UNDERGROUND HEAT DISTRIBUTION SYSTEMS (PREAPPROVED SYSTEMS)	*	
	2697	ABOVEGROUND HEAT DISTRIBUTION SYSTEMS	*	
	2710	SUBDRAINAGE SYSTEM	*	("suitable" conditions required)
	2711	FOUNDATION DRAINAGE SYSTEM	*	
	2720	STORM-DRAINAGE SYSTEM	*	("suitable" conditions required)
	2730	SANITARY SEWERS	*	
	2732	FORCE MAINS AND INVERTED SIPHONS; SEWER	*	
	2751	PNEUMATIC SEWAGE EJECTORS	*	
	2752	SIPHONS, DOSING	*	
	2831	FENCE, CHAIN-LINK	*	
	2835	VEHICLE BARRIERS	*	
	2935	TURF	*	Wind velocity must not prevent uniform seed distribution.

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	2950	TREES, SHRUBS, GROUND COVERS AND VINES	ground must not be frozen, snow-covered or "unsuitable" for planting	
03 CONCRETE				
	3100	STRUCTURAL CONCRETE FORMWORK	*	
	3200	CONCRETE REINFORCEMENT	*	
	3250	EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS	Dry surface	
	3300	CONCRETE FOR BUILDING CONSTRUCTION General	Sun, heat, and wind must not prevent proper consolidation, finishing, and curing.	
		Cold-Weather Concreting	TEMP. ≥ 50° F and ≤ 75° F (Concrete temperature) TEMP. ≥ 40° F (Ambient temperature	
		Hot-Weather Concreting	TEMP. ≤ 85° F (maximum concrete temperature without retarder)	Referenced: Hot Weather Concreting-ACI 305R-77 (Revised 1982 Hot Weather Concreting).

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	3300 (cont.)	Curing	TEMP. > 50° F (ambient air temperature)	Temperature maintained for 3 days after placing, and temperature > 32° F maintained for the remainder of the curing period.
		Finishing	TEMP. ≥ 50° F (air temperature adjacent to surface)	Temperature maintained 24 hours prior to, and 48 hrs. after application
		Repair of Surface Defects	TEMP. > 50° F (concrete and mortar patching material temperature; and ambient air temperature)	
	3301	CONCRETE FOR BUILDING CONSTRUCTION (MINOR REQUIREMENTS)	No frost, no ice, and no water on placement surfaces	Concrete protected from freezing throughout the curing period.
	3330	CAST IN PLACE ARCHITECTURAL CONCRETE	*	
	3414	PRECAST ROOF DECKING	*	
	3450	PRECAST ARCHITECTURAL CONCRETE	*	
	3510	ROOF DECKING, CAST-IN-PLACE LOW DENSITY CONCRETE	TEMP. ≥ 40° F (ambient air temperature during placement)	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	3550	PRECAST/PRESTRESSED CONCRETE FLOOR AND ROOF UNITS	*	
04 MASONRY				
	4200	MASONRY Cold Masonry Construction	TEMP. > 32° F (ambient temperature); TEMP. ≥ 40° F (masonry units temperature); TEMP. ≥ 40° F and ≤ 120° F (mortar and grout temperature)	
		Hot Masonry Construction	TEMP. ≤ 99° F (ambient temperature, in shade), and Relative Humidity ≥ 50 %	
05 METALS				
	5055	WELDING, STRUCTURAL	*	
	5061	ULTRASONIC INSPECTION OF WELDMENTS	*	
	5062	ULTRASONIC INSPECTION OF PLATES	*	
	5120	STRUCTURAL STEEL	*	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	5210	STEEL JOISTS	*	
	5300	STEEL DECKING	*	
	5500	MISCELLANEOUS METAL	*	
06 WOOD and PLASTICS				
	6100	ROUGH CARPENTRY	*	
	6200	FINISH CARPENTRY	*	
07 THERMAL and MOISTURE PROTECTION				
	7111	ELASTOMERIC MEMBRANE WATERPROOFING	TEMP. > 40° F (ambient surface temperature), no rain	
	7112	BITUMINOUS WATERPROOFING	TEMP. ≥ 40° F	
	7140	METALLIC OXIDE WATERPROOFING	TEMP. > 40° F	
	7160	BITUMINOUS DAMPPROOFING	TEMP. > 40° F	
	7220	ROOF INSULATION	TEMP. > 40° F, no ice, no frost and no moisture	

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DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	7240	EXTERIOR INSULATION AND FINISH SYSTEM	TEMP. ≥ 40° F	Temperature must be >40° F for 24 hours after application. Relative humidity as per manufacturer's specifications.
	7265	SPRAY-APPLIED FIREPROOFING	TEMP. >40° F	Temperature must be >40° F for 24 hours before and after application.
	7270	FIRESTOPPING	*	
	7311	ROOFING, STRIP SHINGLES	*	
	7413	METAL ROOFING AND SIDING, PLAIN	*	
	7415	METAL ROOFING AND SIDING, FACTORY-COLOR-FINISHED	*	
	7510	BUILT-UP ROOFING	TEMP. > 40° F , no ice, no frost and no moisture	
	7530	ELASTOMERIC ROOFING (EPDM)	*	
	7540	ELASTOMERIC ROOFING, FLUID APPLIED	*	
	7550	PROTECTED MEMBRANE ROOFING	*	
	7555	POLYVINYL CHLORIDE (PVC) ROOFING	*	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	7600	SHEET METALWORK, GENERAL	*	
	7720	ROOF VENTILATORS, GRAVITY-TYPE	*	
	7920	CAULKING AND SEALANTS	TEMP. > 40° F and < 90° F	
08 DOORS and WINDOWS				
	8110	STEEL DOORS AND FRAMES	*	
	8120	ALUMINUM DOORS AND FRAMES	*	
	8201	WOOD DOORS	*	
	8312	SLIDING METAL DOORS	*	
	8313	ALUMINUM SLIDING GLASS DOORS	*	
	8318	SECURITY-VAULT DOORS	*	
	8325	COLD STORAGE DOORS AND FRAMES	*	
	8330	OVERHEAD COILING DOORS	*	
	8331	METAL COILING COUNTER DOORS	*	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	8353	ACCORDION DOORS AND PARTITIONS, AND OPERABLE PARTITION	*	
	8360	SECTIONAL OVERHEAD DOORS	*	
	8365	VERTICAL LIFT DOORS	*	
	8510	STEEL WINDOWS	*	
	8520	ALUMINUM WINDOWS	*	
	8521	ALUMINUM ENVIRONMENTAL CONTROL WINDOWS	*	
	8610	WOOD WINDOWS	*	
	8615	CLAD WOOD WINDOWS	*	
	8620	POLYVINYL CHLORIDE (PVC) WINDOWS	*	
	8700	HARDWARE; BUILDERS' (GENERAL PURPOSE)	*	
	8701	HARDWARE: PRISON-LOCKING DEVICES	*	
	8810	GLASS AND GLAZING	*	
	8840	PLASTIC GLAZING	*	

* CEGS provides either no explicit reference to weather requirements or indicates that the work is affected by weather, but does not provide specific weather parameter ranges.

DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
09 FINISHES				
	9200	LATHING AND PLASTERING	*	
	9215	VENEER PLASTER	*	
	9225	STUCCO	TEMP. > 40° F	Ambient temperature maintained for 48 hours after application.
	9250	GYPSUM WALLBOARD	*	Application allowed only after structure is weathertight.
	9310	CERAMIC TILE	TEMP. ≥ 50° F	Ambient temperature shall be maintained at least 3 days after application
	9411	BONDED TERRAZZO	TEMP. > 50° F	Temperature shall be maintained 24 hours prior to application and maintained until mixture is cured
	9421	TERRAZZO TILE	TEMP. ≥ 70° F	Maintain temperature ≥ 55° F after installation.
	9431	CONDUCTIVE RESINOUS TERRAZZO FLOORING	TEMP. > 60° F	Temperature maintained 2 days prior to and 7 days after installation
	9433	CONDUCTIVE SPARKPROOF INDUSTRIAL RESINOUS FLOORING	TEMP. > 60° F	Temperature maintained 2 days prior to and 7 days after installation

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DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	9445	RESINOUS TERRAZZO FLOORING	TEMP. > 60° F	Temperature maintained 2 days prior to and 7 days after installation
	9510	ACOUSTICAL CEILING	TEMP. ≥ 60° F and ≤ 80° F. Relative Humidity < 70 %	Weather requirements shall be maintained before, during, and after installation
	9560	WOOD STRIP FLOORING	TEMP. ≥ 65° F and ≤ 85° F, dry surfaces	Temperature maintained 3 days prior to and continuing throughout the remainder of the contract period
	9570	HARDWOOD PARQUET FLOORING	TEMP. = 70° F	Temperature maintained for 5 days before, during and after installation
	9650	RESILIENT FLOORING	TEMP. > 70° F	Temperature maintained 2 days before, during, and 2 days after application. Temperature maintained at 55° F thereafter.
	9655	RESILIENT ATHLETIC FLOORING	dry surface	
	9675	CONDUCTIVE VINYL FLOORING	TEMP. > 70° F	Temperature maintained 2 days before, during, and after application. Temperature maintained at 55° F thereafter.

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DIVISION	SECTION NUMBER	SECTION TITLE	WEATHER REQUIREMENTS	NOTES
	9680	CARPET	TEMP. > 60° F	Temperature maintained 2 days before, during, and 2 days after application. Temperature maintained at 55° F thereafter.
	9706	INDUSTRIAL RESINOUS FLOORING	*	
	9900	PAINTING, GENERAL	TEMP. ≥ 45° F and ≤ 95° F, no frost, no ice, dry surface required	
		WATER-THINNED COATINGS	TEMP. ≥ 50° F and ≤ 90° F	Relative humidity ≥ 30 % for moisture-cure polyurethane.
		EPOXY, MOISTURE-CURE POLYURETHANE AND LIQUID GLAZE COATING	*	As per manufacturer's requirements.
	9960	VINYL-COATED WALL COVERING	TEMP. > 50° F , dry surface required	Temperature maintained 3 days before, during, and after application.

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APPENDIX B: USACERL/USAFETAC Correspondence

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORY, CORPS OF ENGINEERS
P.O. BOX 4005
CHAMPAIGN, ILLINOIS 61820-1305

REPLY TO
ATTENTION OF:

APR 17 1990

CECER-FS (70-1y)

MEMORANDUM FOR Commander, USAF Environmental Technical Applications Center, ATTN: ETAC/DO, Scott AFB, IL 62225

SUBJECT: Request for Climatological Support Services

1. References:

a. AR 115-10/AFR 105-3, Weather Support to the U.S. Army, 15 Feb 90.

b. Meeting, Ms. Snelling and staff, Scott A.F.B., 6 April 90, with Mr. Stephen Steen (USACERL).

2. Request climatological support services be provided to the U.S. Army research, development, test, and evaluation (RDTE) project listed below:

a. Unit and Project Support, if applicable: Weather Impact Analysis Project, U.S. Army Construction Engineering Research Laboratory (USACERL), Champaign, Il.

b. Support Priority: FAD IV

c. Mailing Address: ATTN: Stephen Steen
USACERL
FS Division
P.O. Box 9005
Champaign, IL
61826-9005

d. Message Priority/Security classification: NA/Unclassified

e. Point of Contact: Mr. Stephen Steen
217/352-6511, ext.651

Message Address: N/A

f. Statement of Operational Problem: U.S. Army Corps of Engineers requires an improved method of weather impact analysis on its construction projects.

CECER-FS (70-1y)
Subject: Request for Climatological Support Services

g. Environmental Factors Affecting Problem: Temperature, Precipitation, Relative Humidity and Wind impact construction activities to varying degrees often resulting in contract time growth (delays). Request analysis of historical weather data for Scott A.F.B. assessing monthly severe weather impact upon the following activities based on the specific weather parameters, criteria and qualifying factors listed below.

ACTIVITY NO. 1: temp.>or= 40 degrees fahrenheit (consider daytime only - 6:00 am to 6:00pm), precip.= 0 inches (consider daytime only)

ACTIVITY NO. 2: temp.>or= 32 degrees fahrenheit (consider full 24 periods), precip.<0.1 inches (24 hour period), wind <20m.p.h. (24 hour period)

ACTIVITY NO. 3: temp.> or = 50 degrees fahrenheit (consider daytime only), precip. < 0.2 inches (24 hour period), wind< 10 m.p.h. (24 hour period, relative humidity <or= 75% (24 hour period).

ACTIVITY NO. 4: temp.>or= 55 degrees fahrenheit and <or= 95 degrees fahrenheit (daytime only), precip. <0.1 (24 hour period), wind < 15 m.p.h. (24 hour period), relative humidity <95% (24 hour period)

ACTIVITY NO 5: temp.>or= 60 degrees fahrenheit and <or=80 degrees fahrenheit (daytime periods only), precip. = 0 inches (daytime only), wind <or= 5 m.p.h.(daytime periods only), relative humidity < 80% (24 hours periods).

h. Date required: 31 MAY 1990

i. Other remarks: Monthly impacts requested in text format (ascii file with PC DOS compatibility) and hardcopy. This request supersedes previous request dated 8 March 1990.

3. If you need any further information regarding our requests, please feel free to contact Mr. Stephen Steen at 800-USA-CERL, ext. 651 or me at (217) 373-7269.

FOR THE COMMANDER:

Thomas R. Napier, FOR

SIMON KIM
Construction Management Team Leader

Encl

CF:
CEMP-CP/Mr. Jim Jones

DEPARTMENT OF THE AIR FORCE
USAF ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER (MAC)
SCOTT AIR FORCE BASE, ILLINOIS 62225-5438

REPLY TO ATTN OF: ECE (MSgt Canter, DSN 576-3641) 10 Aug 90

SUBJECT: Weather Impact Analysis for Army Construction (USAFETAC Project 900440)

TO: USACERL
FS Division
ATTN: Mr. Steen
P.O. Box 4005
Champaign, IL 61824-4005

1. We are enclosing the requested monthly impacts, activities 1 through 5, for Scott AFB in text format (ASCII file with PC DOS compatibility) and hardcopy. The weather impact data was calculated using the period of record from 1 Jan 38 through 30 Nov 89. We have provided a detailed description of each activity and how we obtained the corresponding impact days.

2. We realize that future requests may have different criteria depending on the type of construction and/or the site location. With the basic procedures already developed, we should have no problem in providing you weather impact analysis in a timely manner. We are currently involved in doing additional quality control of the data and techniques we have developed. If needed, we will send you an update.

3. This closes project 900440. If you have any questions concerning the data enclosed, please call.

David S. Ladwig

DAVID S. LADWIG, Lt Col, USAF
Chief, Environmental Applications Branch

3 Atch
1. Wx Impact Floppy Disk
2. Wx Impact Hard Copy
3. Act 1-5 Descriptions

MONTH	ACT. 1	ACT. 2	ACT. 3	ACT. 4	ACT. 5
JANUARY	29	28	31	31	31
FEBRUARY	26	24	28	28	28
MARCH	25	23	31	30	31
APRIL	16	17	30	28	30
MAY	11	13	30	25	31
JUNE	10	11	30	19	29
JULY	8	9	30	18	31
AUGUST	7	8	31	17	31
SEPTEMBER	8	8	29	22	30
OCTOBER	13	10	31	28	31
NOVEMBER	24	20	30	29	30
DECEMBER	28	26	31	31	31

For the relative humidities, winds, and the daytime, temperatures we used hourly data. For the precipitation and the temperature (in Activity 2) we used daily data.

How we obtained the impact day(s) for each activity is as follows:

Activity 1: Anytime the temperature fell below 40 F during 0600 and 1800 local (using the hourly data), that day was considered an "impact" day and was set aside in a file. Using the daily data we checked to see if any precipitation had occurred that day, if it did that day was considered an "impact" day and was set aside in its' own file. Then the two files were merged. The final file shows the mean number of days each month that EITHER the temperature went below 40 F (during the daytime) OR precipitation occurred (anytime in a 24 hour period).

Activity 2: Using the daily data we checked the minimum temperature and the daily precipitation amounts. If the minimum temperature was below 32 F OR the precipitation amount was equal to or greater than .10", that day was considered an "impact" day and was set aside in a file. We used hourly data to check the winds. If the winds equalled or exceeded 20 mph at anytime in a 24 hour period, that day was considered an "impact" day, and was put in a file. The two files we merged with the resultant file showing the mean number of days each month that EITHER the temperature was below 32 F, OR the precipitation was equal to or greater than .10", OR the winds were equal to or greater than 20 mph.

Activity 3: Using the daily data we checked to see if the total precipitation equalled or exceeded .20", if so then that day was considered and "impact" day and was set aside. Using the hourly data we checked the winds to see if they were equal to or greater than 10 mph and checked to see if the relative humidity was equal to or greater than 75%, if either occurred, that day was an "impact" day and was set aside. We used the hourly data and checked only the hours between 0600 and 1800 inclusive to see if the temperature went below 50 F, if so that day was an "impact" day and was also set aside. Then all three files were merged. The resultant file showed the mean number of days each month when EITHER the daytime temperature was below 50 F, OR the total precipitation was equal to or greater than .20", OR the winds were equal to or greater than 10 mph that day, OR the relative humidity was equal to or greater than 75% that day.

Activity 4: Using the daily data we checked to see if the total daily precipitation was equal to or greater than .10", if so, that day was an "impact" day and was set aside. Using the hourly data we checked to see if the winds were equal to or greater than 15 mph or the relative humidity was equal to or greater than 95% at anytime that day. Then we used the hourly data to check only the hours between 0600 and 1800 inclusive to see if the temperature went either below 55 F or above 95 F, if so, that day was an

"impact" day. All files were merged and the resultant file showed the mean number of days per month that EITHER the daytime temperature was below 55 F OR above 95 F, OR the relative humidity was equal to or greater than 95%, OR the winds were equal to or greater than 15 mph, OR the precipitation was equal to or greater than .10".

Activity 5: Using the daily data we checked to see if any precipitation had occurred, if so, the "impact" days were placed in a file. Using the hourly data we checked to see if the relative humidity was equal to or greater than 80% during a 24 hour period, if so, that "impact" day was placed in a file. Also using the hourly data we checked to see if either the daytime winds were equal to or greater than 5 mph OR the daytime temperature either went below 60 F or above 80 F, if so, these "impact" days were placed in a file. All files were then merged. The resultant file showed the mean number of days each month when EITHER the daytime temperature went below 60 F OR above 80 F, OR the daytime winds were equal to or greater than 5 mph, OR the 24 hour relative humidity was equal to or greater than 80%, OR any precipitation occurred.

NOTE: For the TEST station of SCOTT AFB, Ill, every day of the year would be considered an "impact" day for activity 5. This means that either the daytime temperature will drop below 60 F OR go above 80 F, OR the daytime winds will equal or exceed 5 mph, OR the relative humidity will be equal to or greater than 80% at sometime during the 24 hour period, OR that precipitation will occur at sometime during a 24 hour period.