planning handbook
march 1979

TRAVELERS INFORMATION STATION

NATIONAL PARK SERVICE / DENVER SERVICE CENTER

October 31, 1979

ERRATA SHEET

FOR TRAVELER'S INFORMATION STATION PLANNING HANDBOOK, MARCH 1979

Pages 3 & 4: Replace with revision sheets, dated 8-79

Pages 5 & 6: Replace with revision sheet, dated 8-79.

Page 9; Line 2: Change the word "the" to "this".

Page 9; In first line of Section 3.3: Insert "12-watt" after the word "require", and delete the word "overload."

Page 9; Section 3.3, second paragraph, second line: Change the words "the modulating wave" to read "a 12-watt modulated carrier".

Pages 17 & 18: Replace with revision sheets, dated 8-79.

Page 19: Delete first paragraph.

Page 19; Line 7 of first paragraph of Section 4.7: Change the word "capitulating" to "compromising".

Page 19; Section 4.8: Add the following sentence to item "c": "Determine whether it is possible to use 1610 KHz (preferable if interference criteria can be met)."

Page 24; item (4):

First line: change "non-directiona" to "non-directional".
Fifth line: add comma after "instance" and change "9km" to "18 km".
Sixth line: change "must" to "much"
Eight line: change "8 km" to "16 km".
Last line: delete the word "miles".

Pages 37 & 38: Replace with revision sheets, dated 8-79.

Page 39; Third symbol in "Proposed" column of legend, described as NPS TIS-530 and 1610KHz: Add horizontal line, making the symbol into a "plus" enclosed in a circle.

Page 41; add following to Exhibit D: "Note: For conventional antenna systems use 530 KHz only where 1610 KHz is not feasible."

Page 49; reference 4, line 1: Change "strenght" to "strength"

bottlenecks, and the provision of safety messages to the traveling public--all accomplished without large signs or increased staffing.

Because 1610 kHz and 530 kHz are just outside the upper and lower ends of the AM broadcast band, not all car radios can tune in TIS stations. TIS systems engineered in accordance with this manual will usually produce satisfactory signals (see Exhibit A) within the predicted distances (see Exhibit E).

1.2 Description of TIS

The TIS system is a low-power AM radio one-way communications system which is located near the center of the area to be covered.

Basically, a TIS system is a small radio station or group of stations. The stations can provide service using either AC or DC power sources and can be programmed either locally by utilizing tape cartridges or microphones, or from a remote location via telephone lines. Endless tape cartridges are the usual media used. TIS messages can be broadcast from antennas or buried cables--depending on engineering requirements for particular installations. See Chapters 3 and 4 for more information. Because radio signals do not respect boundaries, cooperation between agencies is imperative in engineering, siting, and providing program materials where public contact is desired along contiguous boundaries.

It is currently (1978) estimated that TIS installations will cost approximately $3,500 per site for engineering, equipment, and installation. Increased equipment costs with the passage of time will raise the dollar amounts--sufficient data is not available to estimate the rate of inflation at this time.

Technical people, with the aid of this handbook, will have to serve as consultants to those administrative, interpretive, and planning personnel who propose the installation of TIS units. There are technical characteristics which must be evaluated before it can be determined that TIS facilities can be used in a given situation. The characteristics which must be considered include:

a. Protection of broadcast stations (present and future) from interference;

b. Protection of other TIS systems;

c. IRAC[1] requirements (See Chapter 6);

d. Range limitations of TIS facilities;

These matters are more fully developed in succeeding chapters and are included in Chapters four and six, and in Exhibits A, B, C, and F.

1.3 Historical Background

Beginning under a temporary frequency authorization from the Interdepartment Radio Advisory Committee (IRAC) for a demonstration project, Yellowstone National Park has for several years offered visitors the opportunity to use their own auto radios to listen to messages containing information about the park. There were thirty transmitters located throughout the park. (Originally called "Broadcasters", later they were called "Drivers' Information Service." "Travelers Information Station" is the official IRAC/FCC designation.) There were signs near each transmitter directing motorists to tune their radio to 1606 kHz for information. The intended use of the transmitters was to provide local information to motorists relative to the area they were traveling through. For example, signs at all five entrances of Yellowstone read: "TUNE RADIO TO 1606." Tuning in, a motorist heard a message--usually about a minute in length--conveying information of immediate interest: the entrance fee, current state of accommodations, where to go in the park for interpretive talks, and information on what to see and do to make the visit more enjoyable.

The radio transmitters were located at entrances and at such strategic points as campgrounds, scenic overlooks, and developed areas. Some were intended to reach moving vehicles, others were intended to reach vehicles parked in overlooks, etc. Each message was tailored to its area of use, and dealt with a variety of subjects--such as the exercise of caution during the taking of a scenic walk, or the availability of campsites, etc. The messages gave one the feeling of being escorted through the park with ones own personal guide. This dissemination of information to travelers was accomplished without marring the beauty of the natural surroundings.

A survey was conducted at Yellowstone during the 1973 season when a questionnaire was distributed to every third vehicle leaving

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[1]Interdepartment Radio Advisory Committee (the Government counterpart of the Federal Communications Commission).

the park through all five gates between the hours of 10 a.m. and 2 p.m. The survey indicated that the majority of the visitors listened to the broadcasts and most found them to be valuable during their tour of the park. The broadcasts were most helpful in implementing increased emphasis on safety. For example, the motorists were warned not to approach bears, and were reminded that it is unlawful to feed them.

The survey took place on five different days: June 10 and 22, July 3 and 21, and August 22. The questionnaire was on the back of a postage-free, preaddressed postcard. In all, 2,346 questionnaires were distributed and 996 were returned (a 42.5 percent return rate), 976 of which were usable. The returns indicated that of the vehicles containing radios, 90.8 percent tried to listen to the park broadcasts. The following table is a breakdown of this survey:

Listened to broadcasts without difficulty	598/976	61.2%
Reception not completely satisfactory	155/976	15.9%
Tried to tune in on broadcasts unsuccessfully	96/976	9.8%
Radio available but not aware of broadcasts and did not attempt to tune in	60/976	6.1%
No radio available	20/976	2.0%
Radio available and aware of broadcasts but did not attempt to tune in	28/976	2.9%
Considered information contained in broadcasts as not beneficial	19/976	1.9%

Today's motorists are primarily concerned with three types of information: visitor, commercial, and traffic. The principal existing sources for such information are signs, billboards, commercial radio, and printed matter. TIS is a new system designed to create another media through localized radio for visitor and traffic information. The above-mentioned survey and subsequent observations have proven radio to be a valuable aid to the motorist because it relieves his overtaxed visual sense and utilizes his audio sense.

As of June 30, 1978 TIS facilities have been placed in operation by the Fish and Wildlife Service, Bureau of Land Management, and National Park Service, all within the Department of Interior. Additional users are the Department Agriculture, Federal Highway Administration, the National Aeronautics and Space Administration, the Department of of Defense, and a number of state and local governments.

CHAPTER 2

MESSAGE TYPES AND CONTENTS

2.1 Types of Messages

TIS messages may fall into one or more of the following categories: safety advisory, directional advisory, facilities information (see precautions in Section 2.3), interpretive, historical, or general information.

2.2 Contents and Procedures

Message content should be clear and concise, delivered by a professional-quality voice that is not too "boomy". Pleasantness is desireable; however, flippancy, frivolity, and cuteness are inappropriate.

Care should be used, especially in the wording of safety, directional, and facility messages to use language that will be readily understood by the visiting public. For example, locations should be identified by the same names that are consistent with highway and trail signs and park folders, avoiding locally-known names. Compass directions are not always obvious to the visitor, so it is better to say something like: "if you entered the park from Sweetwater, turn right at the next intersection, but if you entered the park from Buck Hollow, do not turn at the next intersection." (rather then saying "turn east", or "proceed to the second parking lot on your left.")

In those situations where it is intended that the message be heard by travelers that are moving in more than one direction, the text must avoid the terms "left" and "right" to avoid confusion. Distances should not be included unless they are identified with the direction of travel.

Messages should be of such length that they will be heard at least twice while traveling through the coverage area. The maximum length of message can be determined from the formula:

$$(60\ R/S) \text{ minus } 0.125 = L$$

Where R is the maximum usable range in kilometers or miles; and S is the average vehicle speed per hour in the same distance unit as R, and L = length of message in minutes. This assumes that

In discussing separation requirements, (see Table I) it is important to remember that failure to achieve interference-free reception in any one TIS service area, will detract from the creditability of other TIS installations. In other words a poorly-designed TIS at one of the NPS sites in California may discourage motorists from tuning to a Forest Service TIS or a BLM TIS installation in Arizona or Nevada, and vice versa.

It is also necessary to remember that a signal that may be received satisfactorily in one vehicle may not be acceptable in another vehicle with a less-sensitive receiver. As indicated in Section 4.4 and Exhibit A, the useful range predictions are based upon signal strengths that will reach a high percentage of vehicles, day or night.

Table I

Separation Requirements for
Conventional Antenna TIS Installations

	CONDITION	530 kHz TIS	1610 kHz TIS
A.	Distance from Broadcast Stations on second channel removed (550 or 1590 kHz) within about 80 miles.	"The applicant shall certify that he has considered these possible interference effects and, to the best of his knowledge, does not foresee harmful interference occuring to Broadcast Stations operating on 550,560,1580 or 1590 kHz."	
B.	Distance from 500 uV/m daytime contour of adjacent channel Broadcast Stations (540 or 1600 kHz.	15 km (9.3 mi)	15 km (9.3 mi)
C.[4]	Distance from other-agency co-channel TIS contour using conventional antenna	15 km (9.3 mi)	15 km (9.3 mi)
D.[4]	Distance from same or other-agency co-channel TIS using conventional antenna.	Col. 8 or 12 of sheet 2 of Exhibit F[5]	Col. 8 or 12 or sheet 1 of Exhibit F[5]
E.	Distance from other-agency TIS contour using cable antenna.	7.5 km (4.66 mi)	7.5 km (4.66 mi)
F.	Distance from same-agency TIS using cable antenna.	No legal requirement: determine by engineering	
G.	Distance from nearby Broadcast Stations on any frequency	Check for cross-modulations by test, using	

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[4]For separation from other-agency co-channel TIS use C or D, whichever is larger. For separation from same agency use D only.

[5]Note that the radius of the 330 (or 250) uV/M contour of the existing station must be added to Column 8 to obtain D before comparing with C. In the same manner (if applicable) the radius of 330 (or 250) uV/M contour of the proposed station must be added to Column 12 to obtain D before comparing with C.

CHAPTER EIGHT

EXHIBITS

A. REQUIRED FIELD INTENSITIES

B. TRAVELERS INFORMATION STATIONS AND NEAR-CHANNEL BROADCAST STATIONS

C. GROUND CONDUCTIVITY

D. PLANNING CHART (PROCEDURES)

E. MAXIMUM RANGES

F. SEPARATION BETWEEN STATIONS

G. ANTENNA TYPES

EXHIBIT A

REQUIRED FIELD INTENSITIES

The sensitivity of automobile receivers at their upper and lower frequency limits has been found to range from as low as 15 uV/m to as high as 1000 uV/m. Not all receivers that have good sensitivity can tune to 530 and/or 1610 kHz. Because of this, it is not practical to evaluate TIS coverage on the basis of results obtained by a few receivers.

Sampling of automobile receiver sensitivity at 530 and 1610 kHz by DSC engineers, and informal exchange of information with other engineers who have made similar tests, has been used to develop the following criteria, which should assure reaching at least 80% of the visitor vehicles.

Signal Strengths
Microvolts Per Meter

	530 kHz	1610 kHz
1. Required for area coverage	330	250
2. Nearest on-channel station must be less than	130	90
3. Nearest adjacent channel station must be less than	200	160

Note 1: Items 2 and 3 measured at Item 1 coverage-limit contour.

Note 2: This assumes 15 km spacing from 500 uV/m contour of on-channnel Broadcast Stations, and compliance with IRAC/FCC specs on spacing from other TIS units.

TRAVELERS INFORMATION STATION PLANNING HANDBOOK

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Denver, Colorado

Prepared:
December 1978

CONTENTS

FOREWORD

Travelers Information Stations (TIS) are a means of reaching the motoring public with safety, directional, and interpretive information via the motorists' radios.

The contents of this planning handbook are divided into chapters for easy identification of the material that is important to managers/planners and the material that is important to engineers and technicians.

Since there eventually may be more than a thousand TIS installations in this country, operated by at least a dozen agencies and numerous local Government entities; it is important that the traveling public be assured of receiving a clear, succint, useful, undistorted message every time it encounters a "TUNE TO 530 (or 1610) kHz" sign. Equipment breakdown, poor signals, noisy or two-signal reception at any one TIS station will influence the public's willingness to tune in the next TIS station. Thus, a poorly engineered National Park Service TIS installation may reduce the public's dependence upon TIS installations operated by one of the States or other Federal Bureaus and vice versa.

The management of some of the Bureaus who will be using TIS are cooperating with us to assure equipment reliability, avoidance of interference between stations, compliance with existing and proposed FCC rulemaking, and avoidance of interference to or from FCC-licensed Broadcast Stations.

The contents of the technical portions of this handbook may be new to most technicians who have specialized in FM and/or TV transmitters and/or receivers.

> NO TIS INSTALLATION SHOULD BE ATTEMPTED BY NON-TECHNICAL PEOPLE OR TECHNICAL PEOPLE WHO ARE NOT FAMILIAR WITH THE CONTENTS OF THIS HANDBOOK.

It is hoped that users will find this handbook helpful in planning and establishing TIS facilities that will be of real benefit to the public and a credit to the National Park Service.

CHAPTER 1

PURPOSES AND USE OF TRAVELERS INFORMATION STATIONS

1.1 Introduction

Travelers Information Stations (TIS) are unique devices which can be used by public agencies to convey useful information to motorists. The "useful information" may be general or interpretive in nature, or it may be more specific such as safety or directional advice, or traffic-lane control, so long as it complies with the regulations (See Chapter 6). No commercialization or music is permitted.

Travelers Information Stations use licensed low-power AM radio transmitters of limited range, together with tape-players, to provide travelers with repetetive messages via their car radio on 1610 kHz or 530 kHz In cases where these frequencies cannot be used (because of nearby broadcast stations or other co-channel TIS stations), very limited parking-area type coverage can be obtained with restricted radiation devices (hereinafter referred to as RRD) operating on vacant channels in the broadcast band. It is anticipated that RRD will be used only in unusual situations.

Messages are usually of such length that each vehicle can receive the entire message twice while within the area covered by the transmitter. It is also possible to make live broadcasts, but this is not very practical since the message would have to be repeatedly given in order that each vehicle receives the message instead of silence when it reaches the TIS advisory sign ("TUNE TO _____ kHz").

All radio-frequency devices, including TIS and RRD, are governed by the licensing provisions and regulations of the Federal Communications Commission or the Interdepartment Radio Advisory Committee. National Park Service facilities are further governed by the Departmental Manual, Part 313. See Chapter 6 for details.

TIS units are versatile in that they can be utilized along major highways as well as along roads and in parking areas, in such places as parks, historical sites, marinas, tourist information centers, nighway rest stops and campgrounds. Their uses within these areas are described in the opening paragraph above, and in a following section of this chapter.

TIS benefits include improved directional and informational service, interpretive messages, elimination of traffic

bottlenecks, and the provision of safety messages to the traveling public--all accomplished without large signs or increased staffing.

Because 1610 kHz and 530 kHz are just outside the upper and lower ends of the AM broadcast band, not all car radios can tune in TIS stations. However, experience indicates that if properly engineered, more than 80 percent can (because of the field strength standards that have been adopted).

1.2 Description of TIS

The TIS system is a low-power AM radio one-way communications system which is located near the center of the area to be covered.

Basically, a TIS system is a small radio station or group of stations. The stations can provide service using either AC or DC power sources and can be programmed either locally by utilizing tape cartridges or microphones, or from a remote location via telephone lines. Endless tape cartridges are the usual media used. TIS messages can be broadcast from antennas or buried cables--depending on engineering requirements for particular installations. See Chapters 3 and 4 for more information. Because radio signals do not respect boundaries, cooperation between agencies is imperative in engineering, siting, and providing program materials where public contact is desired along contiguous boundaries.

It is currently (1978) estimated that TIS installations will cost approximately $3,500 per site for engineering, equipment, and installation. Increased equipment costs with the passage of time will raise the dollar amounts--sufficient data is not available to estimate the rate of inflation at this time.

Technical people, with the aid of this handbook, will have to serve as consultants to those administrative, interpretive, and planning personnel who propose the installation of TIS units. There are technical characteristics which must be evaluated before it can be determined that TIS facilities can be used in a given situation. The characteristics which must be considered include:

a. Protection of broadcast stations (present and future) from interference;

b. Protection of other TIS systems;

c. IRAC[1] requirements (See Chapter 6);

d. Range limitaitons of TIS facilities;

These matters are more fully developed in succeeding chapters and are included in Exhibit D.

1.3 Historical Background

Beginning under a temporary frequency authorization from the Interdepartment Radio Advisory Committee (IRAC) for a demonstration project, Yellowstone National Park has for several years offered visitors the opportunity to use their own auto radios to listen to messages containing information about the park. There were thirty transmitters located throughout the park. (Originally called "Broadcasters", later they were called "Drivers' Information Service." "Travelers Information Station" is the official IRAC/FCC designation.) There were signs near each transmitter directing motorists to tune their radio to 1606 kHz for information. The intended use of the transmitters was to provide local information to motorists relative to the area they were traveling through. For example, signs at all five entrances of Yellowstone read: "TUNE RADIO TO 1606." Tuning in, a motorist heard a message--usually about a minute in length--conveying information of immediate interest: the entrance fee, current state of accommodations, where to go in the park for interpretive talks, and information on what to see and do to make the visit more enjoyable.

The radio transmitters were located at entrances and at such strategic points as campgrounds, scenic overlooks, and developed areas. Some were intended to reach moving vehicles, others were intended to reach vehicles parked in overlooks, etc. Each message was tailored to its area of use, and dealt with a variety of subjects--such as the exercise of caution during the taking of a scenic walk, or the availability of campsites, etc. The messages gave one the feeling of being escorted through the park with ones own personal guide. This dissemination of information to travelers was accomplished without marring the beauty of the natural surroundings.

A survey was conducted at Yellowstone during the 1973 season when a questionnaire was distributed to every third vehicle leaving the park through all five gates between the hours of 10 a.m. and

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[1]Interdepartment Radio Advisory Committee (the Government counterpart of the Federal Communications Commission).

2 p.m. The survey indicated that the majority of the visitors listened to the broadcasts and most found them to be valuable during their tour of the park. The broadcasts were most helpful in implementing increased emphasis on safety. For example, the motorists were warned not to approach bears, and were reminded that it is unlawful to feed them.

The survey took place on five different days: June 10 and 22, July 3 and 21, and August 22. The questionnaire was on the back of a postage-free, preaddressed postcard. In all, 2,346 questionnaires were distributed and 996 were returned (a 42.5 percent return rate), 976 of which were usable. The returns indicated that of the vehicles containing radios, 90.8 percent tried to listen to the park broadcasts. The following table is a breakdown of this survey:

Listened to broadcasts without difficulty	598/976	61.2%
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Radio available but not aware of broadcasts and did not attempt to tune in	60/976	6.1%
No radio available	20/976	2.0%
Radio available and aware of broadcasts but did not attempt to tune in	28/976	2.9%
Considered information contained in broadcasts as not beneficial	19/976	1.9%

Today's motorists are primarily concerned with three types of information: visitor, commercial, and traffic. The principal existing sources for such information are signs, billboards, commercial radio, and printed matter. TIS is a new system designed to create another media through localized radio for visitor and traffic information. The above-mentioned survey and subsequent observations have proven radio to be a valuable aid to the motorist because it relieves his overtaxed visual sense and utilizes his audio sense.

As of June 30, 1978 TIS facilities have been installed by NPS, BLM, FHWA, NASA, USFS, and some military and local Government establishments.

CHAPTER 2

MESSAGE TYPES AND CONTENTS

2.1 Types of Messages

TIS messages may fall into one or more of the following categories: safety advisory, directional advisory, facilities information (see precautions in Section 2.3), interpretive, historical, or general information.

2.2 Contents and Procedures

Message content should be clear and concise, delivered by a professional-quality voice that is not too "boomy". Pleasantness is desireable; however, flippancy, frivolity, and cuteness are inappropriate.

Care should be used, especially in the wording of safety, directional, and facility messages to use language that will be readily understood by the visiting public. For example, locations should be identified by the same names that are consistent with highway and trail signs and park folders, avoiding locally-known names. Compass directions are not always obvious to the visitor, so it is better to say something like: "if you entered the park from Sweetwater, turn right at the next intersection, but if you entered the park from Buck Hollow, do not turn at the next intersection." (rather then saying "turn east", or "proceed to the second parking lot on your left.")

In those situations where it is intended that the message be heard by travelers that are moving in more than one direction, the text must avoid the terms "left" and "right" to avoid confusion. Distances should not be included unless they are identified with the direction of travel.

Messages should be of such length that they will be heard at least twice while traveling through the coverage area. The maximum length of message can be determined from the formula:

$$(60\ R/S) \text{ minus } 0.125 = L$$

Where R is the maximum usable range in kilometers or miles; and S is the average vehicle speed per hour in the same distance unit as R, and L = length of message in minutes. This assumes that

the TIS is tuned in within 15 seconds after passing the roadside sign at normal driving speeds.

National Park Service personnel should note that messages which are not emergency in nature, which can be planned in advance, are to be "submitted to the Regional Director for approval before sending it to the Harpers Ferry Center or to qualified commercial sources for tape preparation...

"Short-term messages, reflecting local changing situations may be prepared by the parks, using good taste and a professional quality voice" [Special Directive 77-3 (Revised)].

Each message should conclude with the announcement; "This is station _____," using the call sign indicated on the frequency assignment.

2.3 Precautions

The preceding section on contents and procedures contains a number of precautions regarding the message text. The following additional matters should be observed:

Music, sound effects, and commercial promotion are prohibited by regulations (See Chapter 6).

In those parks which have more than one TIS installation, there is the possibility that listeners who leave their receivers on between stations will be disturbed by heterodynes, two-signal reception, or other "garbage". This can be circumvented by including proper instructions in the TIS message, such as, "The next broadcast begins six miles from here. We suggest you check your tuning and increase the volume when you see the sign." This will also reduce the possibility that they will inadvertently hear a message intended for travelers going in the opposite direction (if there is such an installation).

CHAPTER 3

TYPES OF INSTALLATIONS

3.1 Introduction

This chapter describes briefly the types of installations so that the persons proposing and planning TIS facilities will be familiar with the types of facilities that are to be used.

3.2 Types of Installations

Installations may be located to provide information to travelers as they approach highway intersections, and as they approach entrance stations, points of interest, or locations where hazards exist.

TIS provides coverage in all directions; therefore, the transmitter is usally located in the center of the area to be covered. (If it were not, it might not be possible to realize the desired coverage without exceeding FCC limitations. It will also increase the interference potentialities to other TIS stations).

Often there is no building at a suitable site. This is not a problem, since the equipment is in a self-contained vandal-resistant cabinet for pole mounting. See Exhibit G. This type of installation further reduces the possibility of interference to nearby employee-owned radios and/or television. It also avoids the necessity of disturbing the building and/or landscaping in order to bury ground radials.

Each installation is a self-contained entity, consisting of antenna system, transmitter, message player, and power source as shown on Exhibit G. While it might be possible to place the message player in a different location from that shown, it is not desirable to do so. Coordination of audio-levels, ON-OFF controls, power supply connections, and maintenance problems would be detrimental with a separately-located message player.

Exhibit G illustrates the most commonly-used TIS facility. Where mitigating circumstances (usually interference) preclude use of the standard TIS facility, a buried-cable system (RRD or TIS) may be necessary, as further discussed in Chapter 4. Placement of

the transmitter and message player would be determined during design of the type of facility.

All TIS/RRD installations require one or more roadside signs to advise motorists to turn on their vehicle radio. Siting and sign details are covered in Chapter 5.

The power source for most installations is 120 V.A.C. via an underground service. Where AC power is not available, individually-designed DC power sources (solar or thermo-electric) can be used.

3.3 Transmitters

NPS specifications for TIS transmitters require overload capability during acceptance tests, in order to assure reliability when operated continuously at any output up to the legal 10-watt limit.

Modulation capability must be 100 percent, resulting in 48-watts output at the crest of the modulating wave or 22 percent increase in antenna current when modulated with a continuous sine-wave tone. See Chapter 7 (Technical Notes) as to how to confirm this.

"Each transmitter in a Travelers Information Station [System][2] shall be equipped with an audio low-pass filter. Such filter shall be installed between the modulation limiter and the modulated stage. At audio frequencies between 3 kHz and 20 kHz this filter shall have an attenuation greater than the attenuation at 1 kHz by at least:

$$60 \log (f/3) \text{ decibels}$$

where "f" is the audio frequency in kHz and the logarithm is to be the base ten. At audio frequencies above 20 kHz, the attenuation shall be at least 50 decibels greater than the attenuation at 1 kHz." (IRAC/FCC regulations).

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[2]Brackets added.

3.4 Audio Systems

The audio system consists of a continuously-operating tape player, which must be capable of operating for weeks at a time, under adverse temperature and humidity conditions.

There have been requests for a manual override capability. However, where it has been tried it has revealed serious disadvantages which will not be enumerated here. A preferred method is to have spare cartridges loaded with 1, 2, and 3 minutes of tape, upon which any emergency message can be recorded at the time of need.

Drivers must encounter an audio signal in order to tune in on TIS as they enter an area. However, since music is not permitted, and a tone would be objectionable to those who have already tuned to the station, a repeated voice message without long silent intervals is the only way of providing a signal for tuning.

There will be instances where a TIS facility may be many miles from the nearest manned location. If it is anticipated that the message will have to be changed frequently or on short notice, consideration can be given to remoting the tape player via telephone lines.

3.5 Antennas

The antenna system designs of Exhibit G have been optimized. They are governed by technical, legal, and practical constraints which will become more apparent in Chapters 4 and 5 and in Exhibits E and F. The ground system is a very important element in obtaining efficient transfer of energy to the antenna. For maximum range within the legal limitations, each antenna must be properly tuned and resonated at the time of installation.

Regulations limit the antenna height to 15-meters (49.2 feet).

CHAPTER 4

SYSTEM PLANNING

4.1 Introduction

Planning of NPS TIS installation(s) involves management and operational considerations as well as the technical aspects and require active interfacing of the disciplines involved (usually interpretive, maintenance, protection, and technical). The steps are shown on the Planning Chart - Exhibit D.

There has been a prevalent belief that NPS TIS installations must be (a) on park lands, and (b) in, or on, a building. These concepts, if followed, usually do not take full advantage of TIS capability. For instance, a TIS located at an entrance station, which is to convey a message to visitors before they arrive at the entrance station, would be very inefficient: i.e. (a) only half of the usuable range would be utilized, and (b) the transmitter would be working at four times the necessary power to cover the range, thus requiring double the usual geographical separation from the nearest same-channel TIS.

Buildings are not necessary in order to install the TIS at the center of the desired coverage area; see Chapter 3 and Exhibit G.

TIS facilities involve more than the purchase of a unit, and installation on an impromptu basis. While a "system" may include one or more TIS installations, all elements must be properly engineered, taking into account the following factors:

a. Nature and length of message(s).

b. Location of and size of area to be covered by each TIS.

c. Speed of vehicles to be reached.

d. Ground conductivity within the area being covered.

e. Distance from other co-channel TIS installations.

f. Distance from the 500 uV/m daytime contour of adjacent channel broadcast station coverage areas.

g. Environmental considerations at proposed sites.

h. Availability of power at proposed sites.

i. Need for changing messages (either recorded or "live"), on seasonal, periodic, or emergency basis.

The administrator should not make the final decision as to number and location of TIS facilities until the expressed needs have been checked against the technical limitations.

4.2 TIS-Uses

The purpose and intended use of the proposed TIS installation or system (See Chapter 1) must be determined before proceeding with any further planning (See Exhibit D).

Of particular concern should be the type of message (Chapter 2), the vicinity or location at which the visitor should receive the message, whether the message is applicable to traffic traveling in both directions or to traffic along one or more legs of an intersection, location and distance to next NPS TIS installation, and the location and distance to other-agency TIS installations.

4.3 General Geographical Considerations

If there is close cooperation between agencies, one TIS message could be developed that will meet the needs of more than one agency. If there are other-agency TIS stations in the vicinity, it might be desirable or appropriate in the message to call attention to the existence and distance to the other-agency station.

The coverage area for TIS installations should be planned so as to avoid complicated intersections, stop-and-go traffic, winding roads, or other situations where the vehicle driver's full attention should be given to driving.

Further details are described in Chapter 5.

The coverage area should be sufficient to allow 15 seconds for receiver tuning after the driver has read the sign, and extend to a point where the message will have been heard twice (to assure that the driver will have opportunity to hear the entire message, even in those cases where the message is already in progress at the time the TIS is tuned in.). See Section 2.2. The technical constraints will often impose a 1 or 2 minute limitation to the message length. Where the ground conductivity is especially favorable, the range may exceed the limiting criteria described herein.

4.4 Technical Geographical Considerations

Exhibit A shows the result of surveys made to determine the signal-strengths required to reach over 80 percent of all automobile receivers. Not all receivers can tune to 530 kHz and/or 1610 kHz. In order to reach these receivers and to reach other receivers with low band-edge sensitivity, a signal strength of 250 microvolts-per-meter (uV/m) is required at 1610 kHz. 330 uV/m is required for 530 kHz. These levels should be considered as being the outer limit of coverage, even though some vehicles can read TIS messages at 6 db. less than (one-fourth of) these levels. This criteria will be applicable, regardless of the type of antenna used.

The technique for estimating the coverage is described in a following section of this chapter.

Exhibit A also shows that if the nearest co-channel field strength exceeds 90 uV/m, or the nearest adjacent-channel field strength exceeds 160 uV/m, (both measured at the 250 uV/m contour of a 1610 KHz station), interference will be experienced. In the same manner, if the nearest co-channel field strength is more than 130 uV/m or the nearest adjacent-channel field strength exceeds 200 uV/m (both measured at the 330 uV/m contour of a 530 kHz station), interference will be experienced.

With this information available, the first step in TIS system planning is to determine whether the proximity of Broadcast Stations will prohibit use of TIS[3]. Exhibit B indicates the approximate coverage areas of known Broadcast Stations (as of 1977) operating on 540 kHz and 1600 kHz. By inspection of Exhibit B, and reference to more recent allocations for the area under consideration, one can "eyeball" whether a proposed system will be (1) free from broadcast interference, (2) impossible due to broadcast interference, or (3) possible only after more detailed study. The latter would involve the responsible engineering authority obtaining copies of the filed Broadcast Station coverage area and plotting it and the predicted TIS field strength as described elsewhere in this handbook.

After the Broadcast Station and proposed TIS contours have been plotted, it is necessary to determine that the required FCC/IRAC separation and field strength protection to the Broadcast Station(s) and other TIS installations is available. These requirements are as follows:

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[3]See Chapter 6 concerning the secondary status of TIS installations to the Broadcast Service (now or future).

a. Antenna-type TIS installation must be at least 15 km (9.3 mi) from the nearest point on the 500 uV/m daytime contour of the nearest adjacent-channel (540 or 1600 kHz) broadcast station. Exceptions are permitted with a letter of consent from the management of the broadcast station.

b. Antenna-type TIS installations must be at least 15 km (9.3 mi) from the nearest co-channel TIS installation that uses an antenna, or 7.5 km (4.66 mi) from the nearest co-channel TIS installation that uses a cable antenna.

4.5 Estimating Coverage Area

In the following discussion, ground conductivity is frequently referred to. Care should be used in estimating ground conductivity. The map and table of Exhibit C is a generalized guide. However, local conditions can be greatly different. Therefore, it behooves the user to examine local conditions and exercise judgement in deciding what value of ground conductivity to use in estimating useful range and separation requirements. If there are Broadcast Stations or other TIS stations nearby and the soil (or rock) conditions are the same, more accurate ground conductivity estimates can be made by contacting the engineer-in-charge of the Broadcast Station or comparing the measured existing TIS field-strengths with Exhibit E.

4.5a Estimating TIS Coverage with Vertical Antennas

The following discussion is based upon the premise that vertical antennas are essentially non-directional and that with the transmitter located in the center of the desired coverage area, the required range will be equal to the radius of the coverage area.

Coverage from a TIS installation is influenced by (a) antenna height, (b) type of antenna, (c) transmitter power, (d) ground conductivity, (e) ground system configuration, and (f) required field strength.

Required field strengths for proper coverage of the majority of vehicles have been determined to be 330 uV/m for 530 kHz, and 250 uV/m for 1610 kHz as explained in the preceding section. By the application of (a), (b), and (d) to the curves of Exhibit E, it is possible to determine the power necessary to cover the desired distance. In some instances, this may not be possible without exceeding the IRAC limitations: (1) that transmitter power be

limited to 10-watts, and (2) that the field strength at 1.5 km (.93 mi) not exceed 2000 uV/m. In such cases, it will be necessary to shorten the message so that it may be received within the available coverage. See Section 2.2.

Since (a) and (b) are determined for a given type of antenna, and the IRAC limitation on transmitter power is 10-watts, it is possible to tabulate the coverage and interference ranges for the Morad antennas being used in 1977/78 as shown in Exhibits E and F. (Derived from sources listed in References, and correlated with field measurements). It will be seen that the 530A antenna can be relied upon, up to 1.6 km (one mile) distance under average values of ground conductivity (2 to 5 X 10^{-14} emu). In the same manner the 530B antenna cannot be depended upon for distances greater than 2.4 km (1-1/2 miles). The 530C antenna is more efficient so it is possible to exceed the IRAC/FCC limit of 2 uV/m at a distance of 1.5 km from the antenna. This requirement must be met by reducing the transmitter power output, an adjustment which is reflected in Exhibit E and F. Thus the maximum range with good ground conductivity will be about 6.4 km (4 miles), whereas with poor ground conductivity it will be about 5 km (3 mi).

It should be noted that there is no other type antenna which can legally increase 530 kHz range, because of the specified maximum field strength at 1.5 km.

At 1610 kHz the 1610A antenna can be depended upon up to distances of 5 km (3.1 miles). This range can be stretched to 6.4 km (4 miles) if the ground conductivity is greater than 5 and the ground radial length is extended beyond the lengths shown on the drawings. There is no advantage to using larger antennas because the FCC 1.5 km field strength limitation can be reached with the 1610A antenna at any ground conductivity greater than 2.

The required separation between TIS stations under various conditions has been mentioned earlier and is shown in Exhibit F.

4.5b Estimating TIS Coverage Areas with Buried-Wire Antennas

The simplicity and low cost of vertical antenna installations justifies the use of that type of antenna wherever possible. However, it is sometimes desired to install TIS facilities where interference possibilities preclude use of a vertical antenna, and it is then necessary to use a buried-wire antenna. Since the engineering of long (more than 4.8 km) buried-wire antennas is not an exact art, it is preferable to limit buried-wire systems to 4.5 km in length, which would limit the message length to about 3 minutes for 72 km/hr (45 mph) traffic.

At the present time it is not known whether it is possible to obtain coverage from a 4.5 km length of cable without exceeding the IRAC/FCC specified field strength limitations near the feedpoint. Therefore, further technical study is required before actual buried-wire installations can be made.

4.5c Estimating Coverage with Restricted Radiation Devices

Restricted Radiation Devices (RRD) are very similar to TIS with a buried-wire antenna, except that vacant in-band (540-1600 kHz) frequencies are used and the field strength is restricted by IRAC/FCC regulations to:

$$\frac{24{,}000}{\text{Frequency in kHz}} \quad \text{uV/m at 30.5m (100')}$$

This means that the vehicles must be within about ten feet of the buried wire to receive a usable signal. It imposes a requirement that sufficient buried-wire be laid within ten feet of all vehicle locations to be served. However, the difficulties of energizing a buried-wire at levels which will provide a usable signal at all locations, without exceeding the permitted field strength at the feedpoint, may be unsolvable. Therefore, RRD does not offer much usefulness within legal requirements.

4.6 Determining Separation from Other Stations

Since TIS is supplying a service to the public, it is desirable that reception be free from interference due to other TIS or Broadcast Stations. IRAC/FCC rules require that TIS also be engineered in such a way that no interference is caused to reception of Broadcast Stations. In this section, the various legal and technical constraints have been combined to derive criteria for minimum spacing of TIS stations from other TIS stations and from Broadcast Stations.

Typical multi-station TIS operation will usually include in the message of each station a suggestion such as "watch for the next sign to tune in again," or "the next message may be picked up 4 miles ahead, please turn up your volume again when you see the next sign." For this reason, no attempt has been made to avoid or eliminate heterodynes and/or crosstalk which can be heard by more sensitive receivers while driving between coverage areas of multi-station TIS systems.

In discussing separation requirements, (see Table I) it is important to remember that failure to achieve interference-free reception in any one TIS service area, will detract from the creditability of other TIS installations. In other words a poorly-designed TIS at one of the NPS sites in California may discourage motorists from tuning to a Forest Service TIS or a BLM TIS installation in Arizona or Nevada, and vice versa.

It is also necessary to remember that a signal that may be received satisfactorily in one vehicle may not be acceptable in another vehicle with a less-sensitive receiver. As indicated in Section 4.4 and Exhibit A, the useful range predictions are based upon signal strengths that will reach a high percentage of vehicles, day or night.

Table I

Separation Requirements for
Conventional Antenna TIS Installations

	CONDITION	530 kHz TIS	1610 kHz TIS
A.	Distance from Broadcast Stations on second channel removed (550 or 1590 kHz) within about 80 miles.	"The applicant shall certify that he has considered these possible interference effects and, to the best of his knowledge, does not foresee harmful interference occuring to Broadcast Stations operating on 550,560,1580 or 1590 kHz."	
B.	Distance from 500 uV/m daytime contour of adjacent channel Broadcast Stations (540 or 1600 kHz.	15 km (9.3 mi)	15 km (9.3 mi)
C.	Distance from other-agency co-channel TIS contour using conventional antenna	15 km* (9.3 mi)	15 km* (9.3 mi)
D.	Distance from the 330 (or 250) uV/m contour of same or other-agency co-channel TIS using conventional antenna.	Col. 8 or 12 of* Sheet 2 of Exhibit F	Col. 8 or 12 of* Sheet 1 of Exhibit F
E.	Distance from other-agency TIS contour using cable antenna.	7.5 km (4.66 mi)	7.5 km (4.66 mi)
F.	Distance from same-agency TIS using cable antenna.	No legal requirement: determine by engineering	
G.	Distance from nearby Broadcast Stations on any frequency	Check for cross-modulations by test, using several receivers. See Section 5.2, Item 2.	

* For separation from other-agency co-channel TIS use C or D, whichever is larger. For separation from same agency use D only.

Note that the radius of 330 (or 250) uV/m contour must be added to D before comparing to C.

In using Exhibit F it is necessary to estimate the ground conductivity, determine the desired range of the proposed TIS, and relate it to the 330 uV/m (530 kHz) or 250 uV/m (1610 kHz) contour of other TIS installations using conventional antennas.

As indicated elsewhere, the design of cable systems involves so many variable parameters that they must be individually designed. Even so, a certain amount of on-site experimentation may be required before satisfactory results can be achieved.

4.7 General

In some National Park areas (and possibly in domains under joint or other-agency jurisdiction), it is planned to advise the motorist to set their dial once and leave it alone while driving through the coverage area of several TIS stations. Engineering of such systems will require close cooperation between technical and management personnel to determine the system that will most nearly meet managements objectives without capitulating the performance standards.

Details concerning actual selection of the equipment and roadside signs are included in Chapter 5.

4.8 Summary of Planning Steps

Exhibit D is a flow-chart showing the step-by-step procedures for establishing TIS facilities. The following is a summary of the most important steps:

a. Initiate funding (NPS personnel will use Form 10-238).

b. Determine: (a) area in which message is to be received, (b) speed of vehicles and (c) length of message.

c. Determine interference possibilities to or from Broadcast Stations and/or other TIS facilities. Determine whether conventional antenna can be used.

d. Obtain temporary frequency authorization, and select equipment site, roadside-sign site, and determine source of power.

e. Purchase and install equipment, obtain tapes and permanent frequency assignment.

f. Arrange maintenance. (See Chapter Seven)

CHAPTER 5

SITING CONSIDERATIONS

5.1 Introduction

Individuals planning and installing Travelers Information Stations (hereinafter called TIS) may find themselves in an unfamiliar domain. They may have heard "facts" or ideas about TIS which may or may not be true. Much of the information in circulation about TIS is not reliable or accurate. If used, it may not lead to professional-quality results.

So while experimental TIS stations have been installed in the past which give outstanding coverage (as observed in cars with extra-sensitive receivers), they have not been completely reliable or free from interference.

The importance of highly reliable TIS facilities with high-caliber, high-quality messages has been stressed elsewhere in this handbook. Hence it is important that planners and technicians know and use the contents of this handbook.

The contents of this chapter are technical and may be unfamiliar to many technicians who have specialized in FM and/or TV transmitters and/or receivers. NO TIS INSTALLATION SHOULD BE MADE BY NON-TECHNICAL PEOPLE, OR TECHNICAL PEOPLE WHO ARE NOT FAMILIAR WITH THE CONTENTS OF THIS CHAPTER.

All references to proposed FCC-rulemaking are based upon the drafts existing as of July 1977. By the time of issuance of this handbook the draft rules will probably be incorporated within the official IRAC/FCC regulations. If any of the contents of this handbook are in conflict with the finally-issued regulations, the latter will apply.

5.2 Exact Siting

Once the general area for a TIS installation has been determined and the interference criteria met, it will be necessary to carefully examine the area to be covered in order to select the actual site for the transmitter. Those persons making a site selection for the first time should probably follow the criteria listed below step-by-step.

Before looking for a specific site, a preliminary drive-through should be made, observing such things as terrain, roadsigns and road alignment, power lines, overpasses, radio towers, etc. After that the following factors should be investigated more thoroughly:

a. Roadside Signs and Road Alignment (within the TIS Coverage Area): The first 1/4 mile as the driver enters the area is the most important. Note that some TIS installations are intended for reception by visitors traveling from more than one location, requiring more than one sign.

It should be possible to erect the TIS sign within 500 feet after passing the edge of the coverage area, removed enough from other signs to assure its effectiveness. The roadway for the next 1000 feet beyond the roadside sign should be free of intersections, sharp turns or other features which require the attention of the driver (making it a driving hazard to be tuning the radio at the same time). See the following section on Roadside Signs for details of the sign itself.

The terrain in the area to be covered may be moderately rolling, but deep cuts at right angles to the direction of the TIS installation (which would create "shadows") should be avoided. Underpasses, if any, should be in the center of the coverage area, where the signal strength will be strong enough that it will not become unusable to vehicles as they pass through the underpass.

b. Other Radio Stations: Most of today's automobile receivers are susceptible to overload and/or cross-modulation in the presence of strong RF fields. A 1-kW broadcast transmitter on any frequency may break through and override TIS transmissions at distances of 1/2 mile or more. A 50-kW Voice of America (VOA) or broadcast transmitter may intrude on TIS coverage at distances more than 2 or 3 miles, regardless of frequency. Therefore, avoid trying to establish TIS coverage in the vicinity of strong RF fields. If this cannot be avoided, tests should be made while listening to a weak, distant broadcast station, to see if the strong RF field intrudes while traveling in the area to be covered by TIS.

VHF and UHF transmitters rarely constitute a problem with reception in the broadcast band.

c. Power Lines: Since the noise level from power lines may vary, with time and/or climate, do not assume that a line that is quiet during your drive-through will be quiet under other conditions. In some situations dry weather will

increase the noise level; in other instances, rain, snow, wind, or fog may either increase or reduce the level. However, right-angle crossings of transmission lines might not be destructive if the TIS transmitter itself is located within 300-400 feet of the crossing. At this distance the TIS signal should be strong enough to override the transmission-line noise.

Distribution lines are hard to avoid. Usually their noise level is less than the level from transmission lines. When they cannot be avoided, distribution lines will be less harmful if the TIS coverage area is adjusted so that the stronger signal strength (central portion of the coverage area) coincides with the distribution line area.

d. Source of Power: At the time of writing, commercially available TIS units can be operated on either 117 volts AC, or 24 volts DC.

The AC requirements are low and can be supplied from a reliable single-phase source. The service wires should be underground for a distance of at least 25 feet from the installation so they will not detract from the efficiency of the antenna.

DC requirements are 2-amperes at 24 volts. A heavy-duty battery is required to eliminate fluctuations in the power source, which may be a bank of solar cells or a thermo-electric generator. If solar cells are used, the panel and batteries should be large enough to carry over during the night and during cloudy weather. If a thermo-electric generator is used, precautions should be taken to protect intruders, visitors, and personnel from the extreme heat, as well as to provide ready access for delivery and service of fuel.

e. Miscellaneous Factors:

Locating TIS transmitters on a rise in elevation may enhance the coverage possibilities without exceeding FCC limits.

Since there are often requirements to reach travelers before they reach an establishment or entrance gate, siting may require the transmitter to be placed on private or non-agency land. In selecting such a site, the following additional matters should be considered:

(1) Security.

(2) Access.

(3) Land Ownership. Assistance may be required in negotiating for the use of the site.

(4). Since TIS antennas are non-directiona, their coverage is usually circular in pattern, thus there is usually no harm in placing a transmitter off to one side of the roadway to be covered. For instance a transmitter covering 9 km when placed along the road could be placed as must as 4 km to the side of the center of the area to be covered before reducing the coverage by 10 percent (8 km miles, assuming a straight roadway).

The actual site chosen for a TIS transmitter should consider concealment (at TIS frequencies a moderate growth of trees does not greatly reduce coverage) and access for servicing. The installation is quite rugged, but there is no point in inviting vandalism.

The lower part of the antenna is a low impedance point. Therefore, accidental touching of the antenna would not be felt or injurious (voltage to ground would be less than 50 volts).

No attempt should be made to include tunnels within a coverage area. Not only will the signal strength be weaker, but higher ambient audible noise within the tunnel will interfere with reception.

5.3 Antenna Installations

Typical recommended antenna installations are shown in Exhibit G.

The installing technician should note the following hints which have been gleaned from experience and technical literature.

a. Making the ground radials longer than 1-1/2 times the antenna height does not greatly increase the range.

b. There is no real advantage to ground rods at the outer end of the radials (except perhaps where the radials do not make good earth contact).

c. Burial of ground radials at depths greater than 24-30 inches is of no advantage.

d. No. 12 wire has been found to be large enough for ground radials, contrary to earlier advise.

e. Benefits of more than twenty ground radials are questionable.

f. The gap in the ground wire for the 530B and 530C antennas are to prevent the length of the ground wire from absorbing excessive energy from the antenna, without detracting greatly from the effectiveness of the lightning protection.

5.4 Roadside Signs

Signs calling the attention of the motorist to the availability of TIS should be placed near the 250 microvolt (330 microvolt for 530 kHz) contour, taking into account the factors described in Section 5.2, Exact Siting. Of course, if the message is one-way in nature (such as at entrance stations), no sign would be required for traffic traveling in the opposite direction.

At first blush, choosing wording for TIS Roadside Signs should be simple. However, this is not so. For example, how many times have you been misled or frustrated in trying to understand a highway directional sign which the designer was sure would be perfectly clear? How many park visitors stop for directions even though the park signs are "perfectly clear" in the sign committees' minds? For maximum benefit, the correct wording is very important.

Experience to date reveals that most parks would like their signs to read, "Tune 530 (or 1610) kHz for park information" or "Tune 530 (or 1610) kHz for Podunk Hollow information," etc. This would be fine if TIS were only used for interpretive purposes. However, it must be remembered that any interpretive TIS may be pressed into service in emergencies to convey safety or directional advice. In fact, the justifications which were presented to the FCC during its rulemaking process stressed the necessity for TIS as a tool in safety and control of the traveling public.

It should be borne in mind that some visitors are not particularly interested in interpretive information. Having heard one TIS transmitting an interpretive message, such people will probably ignore additional roadside signs where the wording "Park Information" is used. How, then, is the park going to persuade such a person to listen to those TIS units which transmit safety or highway directional information? One solution would be to substitute the words "Safety" "Important" "Visitor Services" for the word "Park". This has the drawback of

requiring a change in the sign each time the type of message is changed.

To circumvent such difficulties as described above, and recognizing that other Federal agencies will also be using TIS facilities, the NPS Sign System Specifications (1978 Rev.) will provide a standard sign reading, "Travelers Information - Tune 530 (or 1610) KHz" which conforms to Federal Highway Administration Sign Standards. These signs will have reflectorized white letters and border on a brown background. The signs can be ordered from Federal Prison Sign Shops. The use of this sign is recommended. If it is necessary to add such words as "SAFETY," "IMPORTANT," "SERVICES," "DIRECTIONAL" ahead of the word "INFORMATION" it can be done on an individual basis; however, the workmanship in preparing the insert should be similar and commensurate with the sign obtained from the Federal Prison Sign Shops.

Standardized signs will work well, once the public becomes familiar with them. They will facilitate traveler recognition and utilization of TIS services available in any area, regardless of whether the TIS unit is sponsored by NPS, BLM, Forest Service or other agency.

CHAPTER 6

LICENSING AND REGULATIONS

6.1 Introduction

All radio-frequency emissions by National Park Service devices and apparatus are regulated and come under the purview of Section 305 of the Communications Act of 1934. Frequency assignments and regulations for Government facilities are promulgated through the Interdepartment Radio Advisory Committee (IRAC) acting through the Chief, Division of Radiocommunications and Frequency Management, Office of the Secretary (Interior). This authority is extended to the National Park Service through authority granted to the NPS Communications Engineer, stationed at DSC.

Since the permitted field strength for Restricted Radiation Devices (RRD) within the 510 - 1600 kHz band is so limited (see DM 313.6.1.3 and Section 4.5 of this handbook) that it is impractical for TIS purposes, it will not be discussed further.

6.2 Licensing Procedures

NPS TIS authorizations follow the procedures outlined in Guideline NPS-15. However, since the frequencies 530 and 1610 kHz are not for exclusive Government use, and are in proximity to broadcast-band frequencies, IRAC must coordinate TIS assignments with the Federal Communications Commission (FCC). The following excerpts from the Secretary's Office (Mr. Baker's memo of 2/21/78 to DSC) are self-explanatory:

"The FCC is now prepared to agree to regular IRAC authorization of our TIS stations that meet provisions of the FCC rules for the service. Federal Government use of TIS frequencies is predicated on the use of the same standards and rules as used by the FCC to regulate this service.

"Frequencies available for TIS use are 530 kHz and 1610 kHz. Existing authorization for use of frequency 1606 kHz must be modified for use of frequency 1610 kHz.

"Because of those rules which provide protection for the service area of certain Standard Broadcast stations, it is possible that some of the Department's existing authorizations for TIS stations

cannot be reissued. This applies to TIS stations operated on any frequency.

"The Department does expect some difficulty in coordinating a few of our TIS requirements with the FCC. It is entirely possible that for certain specific areas we will not be permitted to operate on either TIS frequency, 530 kHz or 1610 kHz. (Due to proximity to other TIS stations or to broadcast stations)."

Therefore, any references in this handbook to the FCC or to "the Commission" refer to regulations that are also applicable to NPS, through the Department, acting under authority of IRAC.

All TIS assignments are made on a secondary basis to the Broadcast Service. Consequently, any TIS authorization may be rescinded by the Department in the event the FCC issues a new Broadcast Station license in an area where conflict could occur (see Section 6.3 Regulations, in this chapter). However, it has been observed that there are relatively few marketing areas in which new licenses could be issued for 540, 550, 1590 and/or 1600 kHz because of the proximity to existing co-channel or adjacent-channel Broadcast Stations. Therefore, it appears that withdrawal of TIS assignments will not occur often, if ever.

The normal Department of Interior form to apply for frequency assignment (Form DI-800) must be supported by predicted or measured signal strength data as outlined in Section 89.1029c) (5) of the FCC regulations, which is quoted in the next section of this chapter.

During the FCC hearings on Docket 20509 the broadcast industry and some other organizations objected to the granting of TIS authority. Some of the protestors' objections were: (a) TIS would duplicate "public service" information provided by broadcasters, (b) TIS would provide information which would discourage advertisers of tourist services from buying commercial broadcast time, resulting in loss of revenue, (c) authorized "public notices" might become political platforms, and (d) the TIS frequencies should be made available for other uses such as minority broadcasters, etc. While the protests have been based upon misconceptions, it behooves all concerned with TIS to adhere closely to the regulations so as to avoid the possibility of the issue being reopened for possible withdrawal of TIS authority.

6.3 Regulations

The NPS authority and regulations pertaining to all radio communications are contained in Part 313 of the Interior

Department Manual. In addition, specific TIS regulations of the FCC which apply to NPS are as follows:

47 CFR 2.1 and 89.3(b), (in part):

"Travelers information Station. A base station in the Local Government Radio Service used to transmit noncommercial voice information pertaining to traffic and road conditions, traffic hazard and travelers advisories, directions, availability of lodging, rest stops and service stations, and descriptions of local points of interest."

47 CFR 2.106, Footnote US221:

"Government and non-Government Travelers Information Stations may be authorized on 530 kHz and 1610 kHz on a secondary basis to all authorized stations operating on a primary basis in the band 510-535 kHz and 1605-1715 kHz, respectively."

47 CFR 89.102(c)(1)(in part):

> "(ii) Travelers Information Stations will be authorized on a secondary, non-interference basis to authorized services operating on a primary basis and must tolerate such interference from those stations as may be necessary.
>
> "(iii) A Travelers Information Station authorization may be suspended, modified, or withdrawn by the Commission without prior notice of right to hearing if necessary to resolve interference conflicts, to implement agreements with foreign Governments, or in other circumstances warranting such action.
>
> "(iv) The transmitting site of each Travelers Information Station shall be restricted to the immediate vicinity of the following specified areas: air, train, and bus transportation terminals, public parks and historical sites, interstate highway interchanges, bridges, and tunnels.
>
> "(v) A Travelers information Station shall normally be authorized to use a single transmitter. However, a system of stations, with each station in the system employing a separate transmitter, may be authorized for a specified area provided sufficient need is demonstrated by the applicant." (Note: Such systems are called multi-station TIS in circumstances where a group of TIS transmitters are clustered as close to the separation requirements of Exhibit F as possible, and in which no nearby 540 kHz or 1600 kHz broadcast stations exist. Where these conditions cannot be met, each transmitter must be considered as a separate TIS.)

47 CFR 89.102(c)(2):

"Travelers Information Stations shall transmit only noncommercial voice information pertaining to traffic and road conditions, traffic hazard and travel advisories, directions, availability of lodging, rest stops and service stations, and descriptions of local points of interest. It is not permissible to identify the commercial name of any business establishment whose service may be available within or outside the coverage area of a Travelers Information Station. However, to facilitate announcements concerning departures/arrivals and parking areas at air, train, and bus terminals, the trade name identification of carriers is permitted."

47 CFR 89.102(c)(3):

"Each application for a station or system shall be accompanied by:

> "(i) A statement certifying that the transmitting site of the Travelers Information Station will be located at least 15.0 km, (9.3 miles) measured orthogonally, outside the measured 0.5 mV/m daytime contour of any AM broadcast station operating on a first adjacent channel (540 kHz or 1600 kHz). If the measured contour is not available, then the calculated 0.5 mV/m field strength contour shall be acceptable. These contours are available for inspection at the concerned AM broadcast station and FCC offices in Washington, D.C.
>
> "(ii) The applicant is advised that cross-modulation and intermodulation interference effects may result from the operation of a Travelers Information Station in the vicinity of an AM broadcast station on the second or third adjacent frequency. Accordingly, the applicant shall certify that he has considered these possible interference effects and, to the best of his knowledge, does not foresee harmful interference occurring to broadcast stations operating on 550 kHz, 560 kHz, 1580 kHz, or 1590 kHz. The Commission reserves the right to reconsider the status of any Travelers Information Station if such interference effects are caused to broadcast stations."

47 CFR 89.102(c)(4):

"Technical Standards

> "(i) The use of 6A3 emission will be authorized, however AØ emission may be used for purposes of receiver quieting, but only for a system of stations employing "leaky" cable atennas.

"(ii) A frequency tolerance of 100 Hz shall be maintained.

"(iii) For a station employing a cable antenna, the following restrictions apply:

"(a) The length of the cable antenna shall not exceed 3.0 km (1.9 miles).

"(b) Transmitter RF output power shall not exceed 50 watts and shall be adjustable downward to enable the user to comply with the specified field strength limit.

"(c) The field strength of the emission on the operating frequency shall not exceed 2 mV/m when measured with a standard field strength meter at a distance of 60 meters (197 feet) from any part of the station."

"(iv) For a station employing a conventional radiating antenna(s) (ex. vertical monopole, directional array) the following restrictions apply:

"(a) The antenna height above ground level shall not exceed 15.0 meters (49.2 feet).

"(b) Only vertical polarization of antennas shall be permitted.

"(c) Transmitter RF output power shall not exceed 10 watts to enable the user to comply with the specified field strength limit.

"(d) The field strength of the emission on the operating frequency shall not exceed 2 mV/m when measured with a standard field strength meter at a distance of 1.50 km (0.93 miles) from the transmitting antenna system.

"(v) Separation Requirements.

"(a) For co-channel stations operating under different licenses, the following minimum separation distances shall apply:

"(1) 0.50 km (0.31 miles) for the case when both stations are using cable antennas.

"(2) 7.50 km (4.66 miles) for the case when one station is using a conventional antennas and the other is using a cable antenna.

"(3) 15.0 km (9.3 miles) for the case when both stations are using conventional antennas.

"(b) For a system of co-channel transmitters operating under a single authorization utilizing either cable or conventional antennas, or bot, no minimum separation distance is required.

"(c) An applicant desiring to locate a station that does not comply with the separation requirements of this section shall coordinate with the affected station."

47 CFR 89.102(c)(5):

"Each application for a station or system of stations for a specified area shall be accompanied by a supplementary statement showing compliance with the technical standards contained in this section and additionally:

"(i) A map showing the geographical location of each transmitter site and an estimate of the strength at the contour of the desired coverage area. For a cable system, the contour to be shown is the estimated field strength at 60 meters (197 feet) from any point on the cable. For a conventional radiating antenna, the estimated field strength contour at 1.5 km (0.93 mile) shall be shown. A contour map comprised of actual on-the-air measurements shall be submitted to the Commission * within 60 days after station authorization or completion of station construction, whichever occurs later. A sufficient number of points shall be chosen at the specified distances (extrapolated measurements are acceptable) to adequately show compliance with the field strength limits.

"(ii) For each transmitter site, the transmitter's output power, the type of antenna utilized, its length (for a cable system), its height above ground, distance from transmitter to the antenna, and the elevation above sea level at the transmitting site."

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*NPS personnel should submit maps to the NPS Communications Engineer for processing through appropriate channels.

47 CFR 89.109(j):

"Each transmitter in a Travelers Information Station shall be equipped with an audio low-pass filter. Such filter shall be installed between the modulation limiter and the modulated stage. At audio frequencies between 3 kHz and 20 kHz this filter shall have an attenuation greater than the attenuation at 1 kHz by at least:

$$60 \log (f/3) \text{ decibels}$$

where 'f' is the audio frequency in kHz and the logarithm is to the base ten. At audio frequencies above 20 kHz, the attenuation shall be at least 50 decibels greater than the attenuation at 1 kHz."

Some areas have expressed the desire for mobile TIS installations, with the thought of a lead-car giving information to a moving caravan of cars. This type of operation is <u>not</u> permitted under IRAC/FCC TIS rules. Neither is the permissible field strength available from a Restricted Radiation Device in a lead-car adequate for this purpose.

In the event that there are special short-term requirements during emergencies involving the safety of the public, it <u>may</u> be possible to obtain an authorization for a temporary TIS station. If such an instance should occur, NPS requests and justification should be directed to the NPS Communication Engineer at DSC.

CHAPTER 7

TIS MAINTENANCE

7.1 Warning

The future credibility of TIS stations (regardless of which bureau operates them) depends upon high reliability of all stations. If the public experiences failure or poor results from one or more TIS facilities, they will be discouraged from tuning to any TIS station. Therefore, ALL TIS UNITS SHALL BE EFFICIENTLY AND PROMPTLY MAINTAINED. If it is not possible to restore a station to service within 4 hours, THE ROADWAY TIS SIGNS SHOULD BE COVERED.

7.2 General

EACH TIS installation consists of five major components:

A. Transmitter

B. Tape deck

C. Antenna

D. Power supply

E. Road signs

Because it is possible for the transmitter to be adjusted outside of the license restrictions, the transmitter cabinet has a separate locked housing to prevent access by other than qualified technicians. The tape deck should be locked with a different lock so as to be accessible to operating personnel. The antenna and loading coil can be damaged by lightning or other means. Moisture within the coil housing can greatly reduce performance.

All elements of each installation should be fully checked (including field strength measurements) twice a year. As of the date of writing, it has not been determined whether this check will be made by an FCC-licensed contractor or by NPS technical personnel.

7.3 Procedures

All plans for servicing and maintaining TIS facilities must seriously consider the following points:

1. High reliability of the facility and prompt correction of troubles is essential to the credibility of the nationwide TIS system.

2. The minimum apparatus required to test and install a TIS station would cost up to $2,500 and includes:

   a. A "Grid-dip" meter tunable to 530 kHz and 1610 kHz (for resonating antennas).

   b. A test tape (with tones) and an oscilloscope with RF pickup (for measuring and adjusting modulation).

   c. A frequency meter for measuring 530 and 1610 kHz frequencies within five cycle accuracy.

   d. A field strength meter, tunable to 530 and 1610 kHz, capable of measuring signal intensities as low as 20 microvolts per meter.

   e. An RF ammeter or obsortion-type RF meter (See Technical Notes).

3. Most two-way radio service organizations are not familiar with the required techniques and do not have the equipment for low-frequency, amplitude-modulated transmitters. It is unrealistic to anticipate that this situation would ever change since there are only a few specialists in this field in most large metropolitan centers to take care of the limited needs for this capability (mostly broadcast stations).

4. IRAC/FCC regulations require adjusting transmitter power to limit the field strength at 1.5 kilometers to 2 mV per meter. Periodic verification of this (and plotting of field strengths) is required.

NPS Special Directive 77-3 assigns the area superintendent responsiblity for reporting equipment failures and/or malfunctions. Except for certain designated areas, the trouble report will be made to the NPS Communication Engineer, who is located at the Denver Service Center, for action. The designated areas will make their reports to their Regional Radio Coordinator. The Denver Service Center and Regional Radio

Coordinators for the Western and Rocky Mountain Regions have qualified personnel or contract personnel to perform the work.

The area Superintendent, or his designated employee must make a special effort to conceal the roadside signs during any period that a TIS is inoperative. This requirement is stressed to assure the credibility of the TIS system (Would you appreciate motorists who do not tune to your station, because of a bad experience at some other park's defective TIS?)

Due to the unique qualifications and test equipment required, and the fact that other nearby agencies may be in need of the same capabilities, consideration is being given to inter-agency cooperation in a preventive maintenance program. To date it has not materialized.

Since the Denver Service Center Communications Engineers are continuously involved in the development of TIS equipment, it is important that they be appraised of any unusual problems or suggested improvements. In the same way, they will endeavor to pass along any useful hints or information to the field.

7.4 Technical Notes

It is possible for a problem to exist with amplitude modulation which is not readily apparent during listening tests. Some transmitters can modulate "downward" if not properly adjusted, which greatly reduces useful range, and sometimes produces distortion. To determine that proper modulation is being achieved, observe an antenna RF ammeter or absorption-type field intensity meter (the field strength meter, item d under Procedures, is unsatisfactory for this purpose) to observe "kicks" due to modulation, which should be upward for proper operation. Downward deflection indicates faulty operation. Another method is to observe the modulation envelope with an oscilloscope.

CHAPTER EIGHT

EXHIBITS

A. REQUIRED FIELD INTENSITIES

B. TRAVELERS INFORMATION STATIONS AND NEAR-CHANNEL BROADCAST STATIONS

C. GROUND CONDUCTIVITY

D. PLANNING CHART (PROCEDURES)

E. MAXIMUM RANGES

F. SEPARATION BETWEEN STATIONS

G. ANTENNA TYPES

EXHIBIT A

REQUIRED FIELD INTENSITIES

The sensitivity of automobile receivers at their upper and lower frequency limits has been found to range from as low as 15 uV/m to as high as 1000 uV/m. Not all receivers that have good sensitivity can tune to 530 and/or 1610 kHz. Because of this, it is not practical to evaluate TIS coverage on the basis of results obtained by a few receivers.

Sampling of automobile receiver sensitivity at 530 and 1610 kHz has been conducted by a number of agencies and by engineers of the NPS Denver Service Center. Analysis of the results of these surveys, with the objective of reaching at least 80 percent of visitor vehicles, have resulted in the following criteria:

Signal Strengths
Microvolts Per Meter

	530 kHz	1610 kHz
1. Required for area coverage	330	250
2. Nearest on-channel station must be less than	130	90
3. Nearest adjacent channel station must be less than	200	160

Note 1: Items 2 and 3 measured at Item 1 coverage-limit contour.

Note 2: This assumes 15 km spacing from 500 uV/m contour of on-channnel Broadcast Stations, and compliance with IRAC/FCC specs on spacing from other TIS units.

EXHIBIT B

TRAVELERS INFORMATION STATIONS
AND NEAR-CHANNEL BROADCAST STATIONS

DATA DETERMINED FROM VARIOUS SOURCES BY NPS-DSC-MPG
(INCLUDES TEMPORARY ASSIGMENTS)

LEGEND

PROPOSED	EXISTING	DESCRIPTION
	○	NATIONAL PARK AREA
◐	◑	NPS TIS-530KHz
⊖	⊖	NPS TIS-1610KHz
◍	●	NPS TIS-530 & 1610KHz
◫	◨	NON-NPS TIS 530KHz
⊟	⊟	NON-NPS TIS 1610KHz
⊞	■	NON-NPS TIS 530 & 1610KHz
		1600KHz BROADCAST STA.- CIRCLE SIZE INDICATES APPROXIMATE COVERAGE
		1590KHz BROADCAST STA.- SIZE NOT RELATED TO COVERAGE
		540KHz BROADCAST STA.- APPROXIMATE COVERAGE
		550KHz BROADCAST STA.- SIZE NOT RELATED TO COVERAGE

○ NATIONAL PARK SERVICE AREAS

971 | 41,059
SHEET | 1 OF 4
DSC | MAR. 79

PREPARED BY GRAPHICS SERVICES / DENVER SERVICE CENTER / JULY 1, 77

TERRAIN	DIFFERENCE IN ELEVATION, FEET	SOIL TYPE	REMARKS	CONDUCTIVITY IN 10^{-14} EMU	DIELECTRIC CONSTANT IN EMU
SEA WATER	0	N. A.		1,000 – 4,000	80
FRESH WATER	0	N. A.		100 – 500	80
MARSH	0	LOAM & SILT		10 – 100	
PASTORAL, ROLLING	100	RICH SOIL	TYPICAL OF DALLAS TEX; LINCOLN NEB;	30	
FLAT, OR ROLLING GENTLY	50	BLACK LOAM	TYPICAL OF OHIO & ILLINOIS	10 – 20	15
ROLLING	50 – 100	LOAMS & SANDY LOAMS		8 – 10	
ROLLING	100 – 500	MOSTLY SANDY LOAMS		6 – 8	
WOODED, DAMP	FLAT	MARSHY	TYP. OF LOUISIANA NEAR MISS. RIVER	7	
HILLY	500 – 800	GRAVELLY SANDY & ROCKY LOAMS	PASTORAL, WITH OR WITHOUT FOREST	4 – 6	
SUBURBS & SMALL TOWNS				3 – 4	
HILLY	600 – 1,000	GRAVELLY SANDY & ROCKY LOAMS		3 – 4	
FLAT OR HILLY		SAND & SHALE		2½ – 4	
VERY BROKEN	300 – 1,000	GRAVELLY, STONY LAND	RAVINED BUT NOT NECESSARILY HIGH	2 – 3	
RESIDENTIAL SECTIONS & TOWNS			NOT FOR HIGH STEEL BUILDINGS	2 – 3	5
MOUNTAINS	1,000 – 1,500	STONY LAND	TYPICAL OF NEW ENGLAND	1 – 2	10
BROKEN MTNS.	1,000 – 8,000	STONY LAND		¾	5
COASTAL	FLAT	DRY SANDY		2	10
FORESTED, FLAT	30	MARSHY		8	12
INDUSTRIAL AREAS				1/10	3

NOTE:
1. WHERE TABLE VALUES APPLY TO TERRAIN, AVERAGE TABLE VALUE WITH MAP VALUE.
2. MAP VALUES x 10^{-14} EMU

○ NATIONAL PARK SERVICE AREAS

ESTIMATING GROUND CONDUCTIVITY
EXHIBIT "C"

971 | 41,059
SHEET | 20F4
DSC | MAR.79

PREPARED BY GRAPHICS SERVICES DENVER SERVICE CENTER JULY 1977

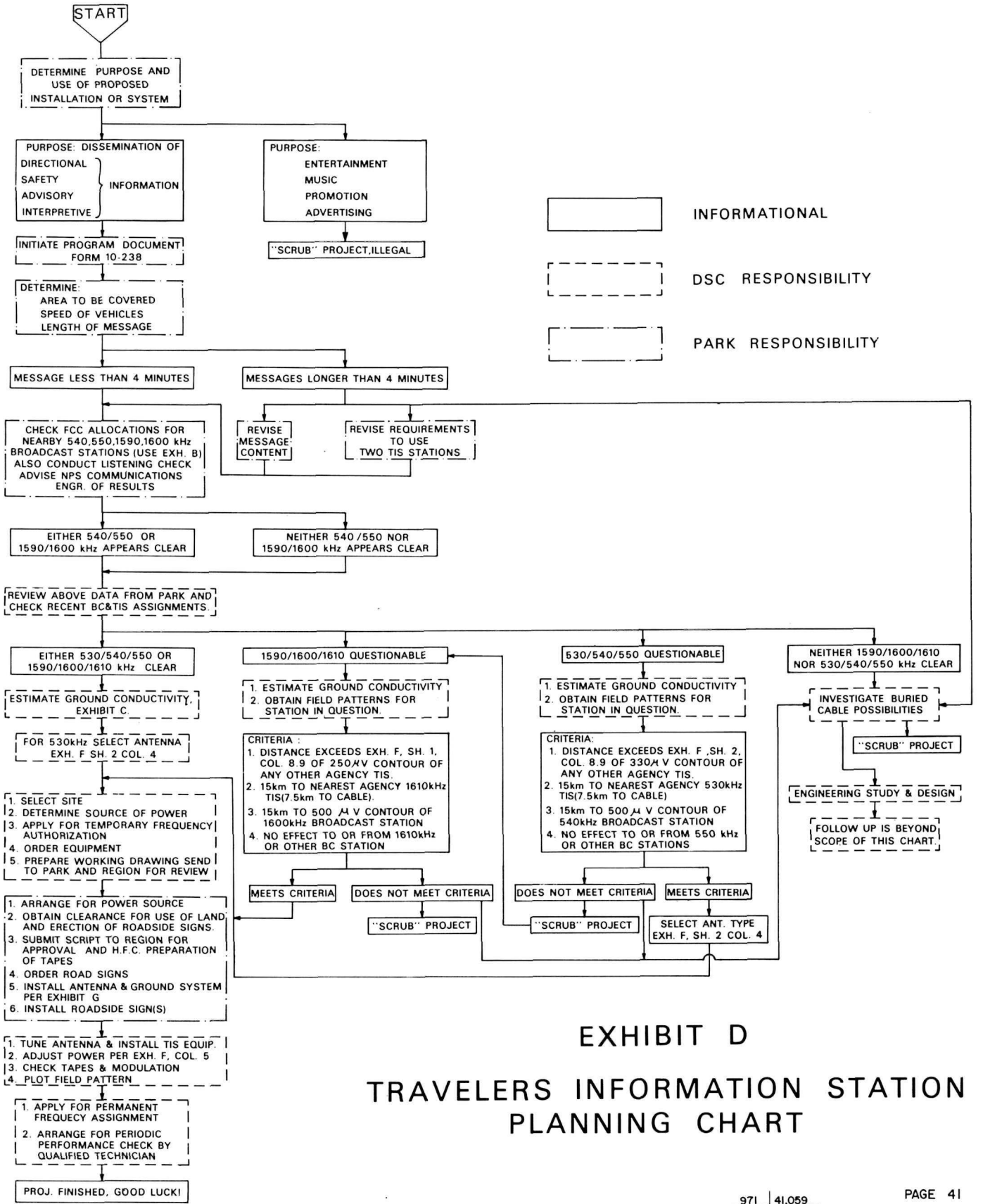

EXHIBIT D

TRAVELERS INFORMATION STATION PLANNING CHART

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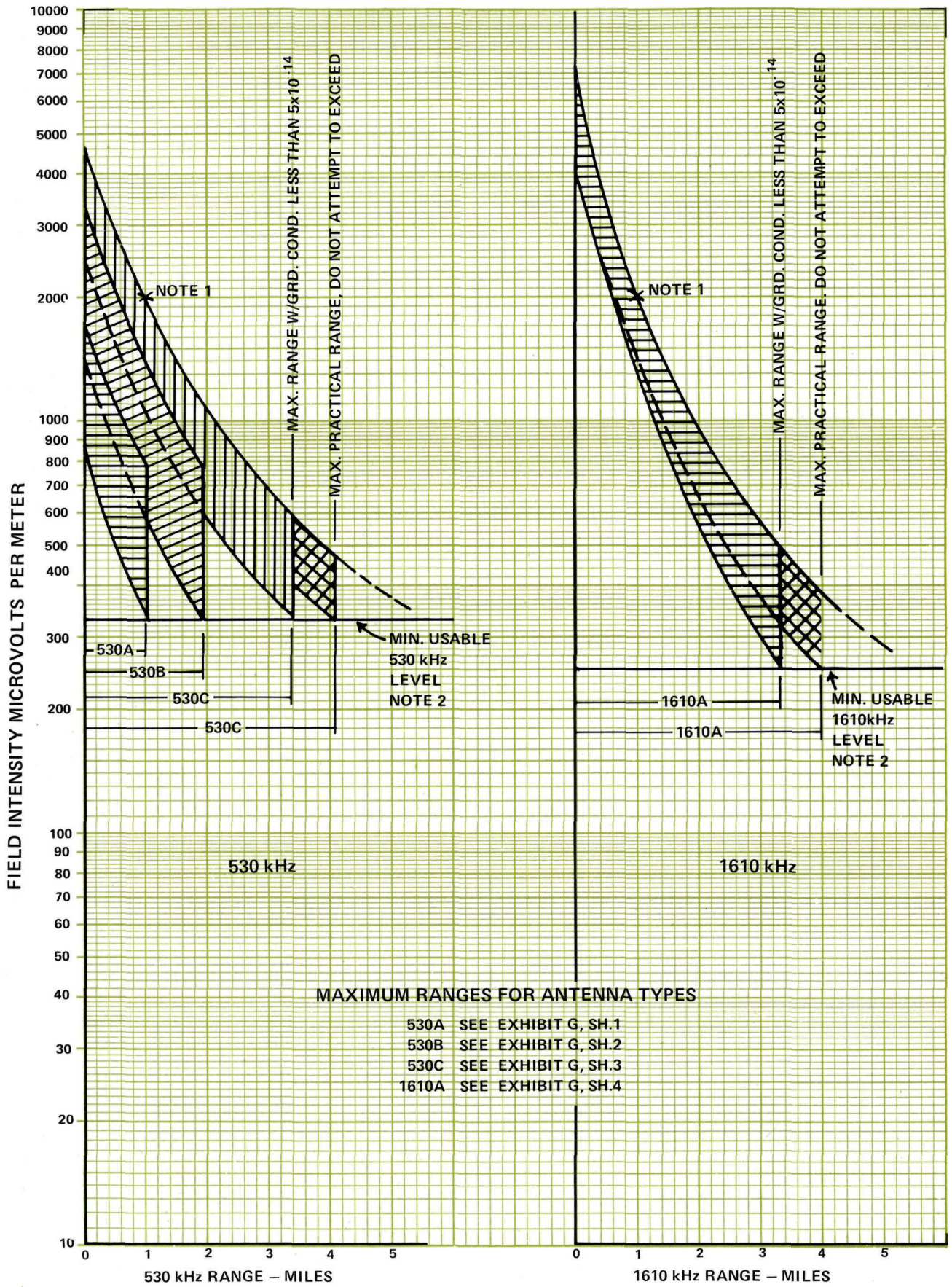

LEGEND

SPREAD OF POSSIBLE FIELD STRENGTHS UPPER LIMIT BASED ON 10×10^{-14} EMU GROUND CONDUCTIVITY AND GOOD GROUND SYSTEM. LOWER LIMIT BASED ON 2×10^{-14} EMU GROUND CONDUCTIVITY AND FAIR GROUND SYSTEM.

SAME AS ABOVE, EXCEPT LOWER LIMIT IS BASED ON 5×10^{-14} EMU GROUND CONDUCTIVITY AND FAIR GROUND SYSTEM

NOTES

1. FIELD STRENGTH AT 1.5 kM (0.93 MI) LIMITED BY FCC TO 2000 μV/M
2. WHILE IT IS CLAIMED THAT SOME TIS INSTALLATIONS WILL SERVE GREATER DISTANCES, THEY WILL NOT RELIABLY SERVE ALL VEHICLES. SEE CHAPTER 3
3. "530C" ANT. IS AT MAX. LEGAL HEIGHT
4. LEGAL LIMIT AT 1.5 kM (SEE NOTE 1) DETERMINES MAX. 1610kHz RANGE. HIGHER ANTENNA WOULD EXCEED NOTE 1 LIMIT

EXHIBIT E

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SHEET	4 OF 4
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NEW STATION							IF RANGE OF EXIST. STA. IS LESS THAN NEW STA.-DISTANCE FROM 250μv OF EXIST. STA.		IF RANGE OF EXISTING STATION IS GREATER THAN NEW STATION						DIST. FROM OTHER-AGENCY TIS OR 500μv CONTOUR OF 1600 kHz B.C.	
COVERAGE RADIUS		GND COND 10^{-14} EMU	ANT TYPE	ADJUST POWER FOR					EXIST. STA RANGE		DIST. FROM EXIST. STA. TO 250μv CONTOUR OF NEW				DIST. BETW NEW & EXIST			
				μv/M	AT													
KM	MI				KM	MI	KM	MI	KM	MI	KM	MI			KM	MI	KM	MI
1	2	3	4	5	6	7	8	9	10	11	12	13			16	17	18	19
1	.6	2	A	180	1.5	.9	2.3	1.5	2	1.2	3.4	2.1			4.4	2.7	15	9.3
									5	3.1	8.5	5.3			9.5	5.9	15	9.3
1	.6	5	A	180	1.5	.9	2.5	1.6-	2	1.9	3.8	2.4			4.8	3.0	15	9.3
									5	3.1	9.0	5.6			10.0	6.2	15	9.3
									7	4.3	12.0	7.5			13.0	8.1	15	9.3
1	.6	10	A	180	1.5	.9	2.6	1.6+	2	1.2	4.8	2.8			5.8	3.4	15	9.3
									5	3.1	10.5	6.5			11.5	7.1	15	9.3
									10	6.2	18.0	11.2			19.0	12.2	15	9.3
2	1.2	2	A	360	1.5	.9	3.4	2.1	5	3.1	8.5	5.3			10.5	6.7	15	9.3
2	1.2	5	A	350	1.5	.9	3.8	2.4	5	3.1	9.0	5.6			11.0	6.8	15	9.3
									7	4.3	12.0	7.5			14.0	8.7	15	9.3
2	1.2	10	A	300	1.5	.9	4.5	2.8	5	3.1	10.5	6.5			12.5	7.7	15	9.3
									10	6.2	18.0	11.2			20.0	12.4	15	9.3
3	1.9	2	A	800	1.5	.9	5.5	3.4	4	2.5	7.0	4.4			10.0	6.3	15	9.3
3	1.9	5	A	650	1.5	.9	6.2	3.9	5	3.1	9.0	5.6			12.0	7.5	15	9.3
									7	4.3	12.0	7.5			15.0	9.4	15	9.3
3	1.9	10	A	560	1.5	.9	7.0	4.4	5	3.1	10.5	6.5			13.5	7.4	15	9.3
									10	6.2	18.0	11.2			21.0	13.1	15	9.3
4	2.5	2	A	1200	1.5	.9	7.0	4.4	5	3.1	8.5	5.3			12.5	7.8	15	9.3
4	2.5	5	A	1000	1.5	.9	7.5	4.7-	5	3.1	9.0	5.6			13.0	7.6	15	9.3
									7	4.3	12.0	7.5			11.0	10.0	15	9.3
5	3.1	2	A	2000	1.5	.9	8.5	5.3	NOT APPLICABLE - 5 KM IS MAX. RANGE AT G.C.=2									
5	3.1	5	A	1500	1.5	.9	9.0	5.6	7	4.3	12.0	7.5			13.0	10.6	15	9.3
5	3.1	10	A	1100	1.5	.9	10.5	6.5	7	4.3	13.8	8.6			18.8	11.7	15	9.3
									10	6.2	18.0	11.2			23.0	14.3	15	9.3
7	4.3	2	A	EXCEEDS IRAC/FCC LIMIT. DO NOT USE														
7	4.3	5	A	2000	1.5	.9	12.0	7.5	NOT APPLICABLE - 7 KM IS MAX RANGE AT G.C = 5									
7	4.3	10	A	1600	1.5	.9	13.8	8.6	10	6.2	18.0	11.2			25.0	15.5	15	9.3
10	6.2	2		EXCEEDS IRAC/FCC LIMIT DO NOT USE														
10	6.2	5		EXCEEDS IRAC/FCC LIMIT. DO NOT USE														
10	6.2	10	A	2000	1.5	.9	18.0	11.2	NOT APPLICABLE - 10 KM IS MAX RANGE AT G.C. = 10									

EXHIBIT-F

SEPARATION BETWEEN STATIONS

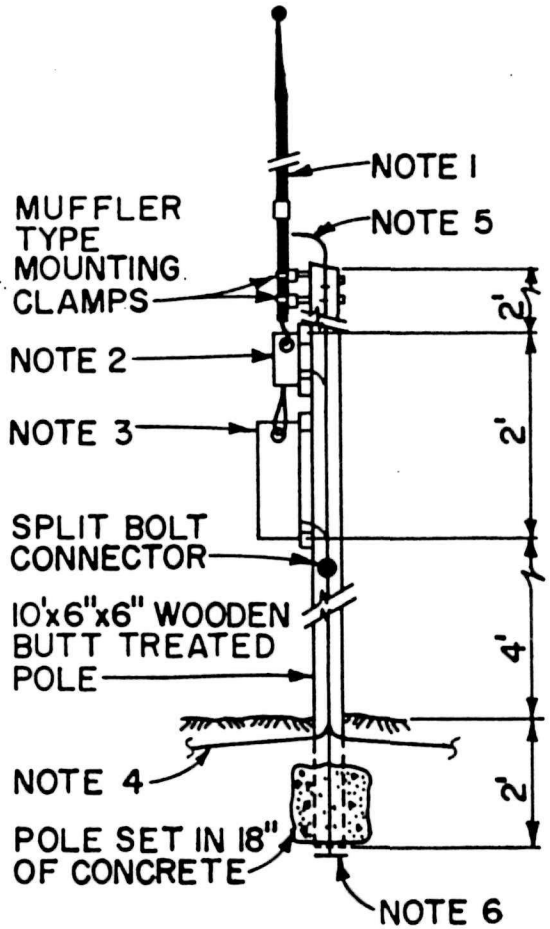
1610 kHz

NEW STATION							IF RANGE OF EXIST. STA IS LESS THAN NEW STA. - DISTANCE FROM 330μv OF EXIST. STA.		IF RANGE OF EXISTING STATION IS GREATER THAN NEW STATION						DIST. FROM OTHER-AGENCY TIS OR 500μv CONTOUR OF 540 kHz B.C.	
COVERAGE RADIUS		GND COND 10^{-14} EMU	ANT TYPE	ADJUST POWER FOR					EXIST. STA. RANGE		DIST. FROM EXIST'G STA. TO 330μv/M CONTOUR OF NEW				DIST. BETW. NEW & EXIST.	
KM	MI			μv/M	AT KM	AT MI	KM	MI	KM	MI	KM	MI	14	15	KM	MI	KM	MI
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	.6	2	A	230	1.5	.9	2.5	1.6-	3	1.9	6.8	4.2			7.8	4.8	15	9.3
									7	4.3	13.5	8.4			14.5	9.0	15	9.3
1	.6	5	A	220	1.5	.9	2.6	1.6-	3	1.9	7.6	4.7			8.6	5.3	15	9.3
									5	3.1	9.5	5.9			10.5	6.5	15	9.3
									9	5.6	17.0	10.6			18.0	11.2	15	9.3
1	.6	10	A	210	1.5	.9	2.7	1.7	3	1.9	7.8	4.8+			8.8	5.4	15	9.3
									5	3.1	11.3	7.0			12.3	7.6	15	9.3
									10	6.2	21.0	13.1			22.0	13.7	15	9.3
2	1.2	2	A	400	1.5	.9	4.4	1.7	5	3.1	9.5	5.9			11.5	7.1	15	9.3
									7	4.3	13.5	8.4			15.5	9.6	15	9.3
2	1.2	5	A	395	1.5	.9	4.8	3.0-	5	3.1	10.5	6.5			12.5	7.7	15	9.3
									9	5.6	17.0	10.6			19.0	11.8	15	9.3
2	1.2	10	A	390	1.5	.9	4.9	3.0	5	3.1	11.3	7.0			13.3	8.2	15	9.3
									10	6.2	21.0	13.1			23.0	14.3	15	9.3
3	1.9	2	B	700	1.5	.9	6.8	4.2	5	3.1	9.5	5.9			12.5	7.8	15	9.3
									7	4.3	13.5	8.4			16.5	10.3	15	9.3
3	1.9	5	A	650	1.5	.9	7.6	4.7	15	3.1	10.5	6.5			13.5	8.4	15	9.3
									7	4.3	15.0	9.3			18.0	11.2	15	9.3
									9	5.6	17.0	10.6			20.0	12.5	15	9.3
3	1.9	10	A	620	1.5	.9	7.8	4.8+	5	3.1	11.3	7.0			14.3	8.9	15	9.3
									7	4.3	14.0	8.7			17.0	10.6	15	9.3
									10	6.2	21.0	13.1			24.0	15.0	15	9.3
4	2.5	2	B	880	1.5	.9	8.5	5.3	5	3.1	9.5	5.9			13.5	8.4	15	9.3
									7	4.3	13.5	8.4			17.5	10.9	15	9.3
4	2.5	5	B	850	1.5	.9	9.5	5.9	5	3.1	10.5	6.5			14.5	9.0	15	9.3
									7	4.3	15.0	9.3			19.0	11.8	15	9.3
									9	5.6	17.0	10.6			21.0	13.1	15	9.3
4	2.5	10	B	760	1.5	.9	10.0	6.2	5	3.1	11.3	7.0			15.3	9.5	15	9.3
									7	4.3	14.0	8.7			18.0	11.2	15	9.3
									10	6.2	21.0	13.1			25.0	15.6	15	9.3
5	3.1	2	B	1100	1.5	.9	9.5	5.9	7	4.3	13.5	8.4			28.5	18.5	15	9.3
5	3.1	5	B	1000	1.5	.9	10.5	6.5	7	4.3	15.0	9.3			20.0	12.4	15	9.3
									9	5.6	17.0	10.6			22.0	13.7	15	9.3
7	4.3	2	C	1700	1.5	.9	13.5	8.4	NOT APPLICABLE- 7 KM IS MAX RANGE AT G.C.= 2								15	9.3
7	4.3	5	C	1550	1.5	.9	15.0	9.3	9	5.6	17.0	10.6			24.0	14.9	15	9.3
7	4.3	10	B	1700	1.5	.9	14.0	8.7	10	6.2	21.0	13.1			28.0	17.4	15	9.3
10	6.2	2	C	EXCEEDS IRAC/FCC LIMIT. DO NOT USE														
9	5.6	5	C	2000	1.5	.9	17.0	10.6	NOT APPLICABLE- 9 KM IS MAX RANGE AT GC= 5									
10	6.2	10	C	2000	1.5	.9	21.0	13.1	NOT APPLICABLE- 9 KM IS MAX RANGE AT GC=10									

EXHIBIT-F

SEPARATION BETWEEN STATIONS

530 kHz

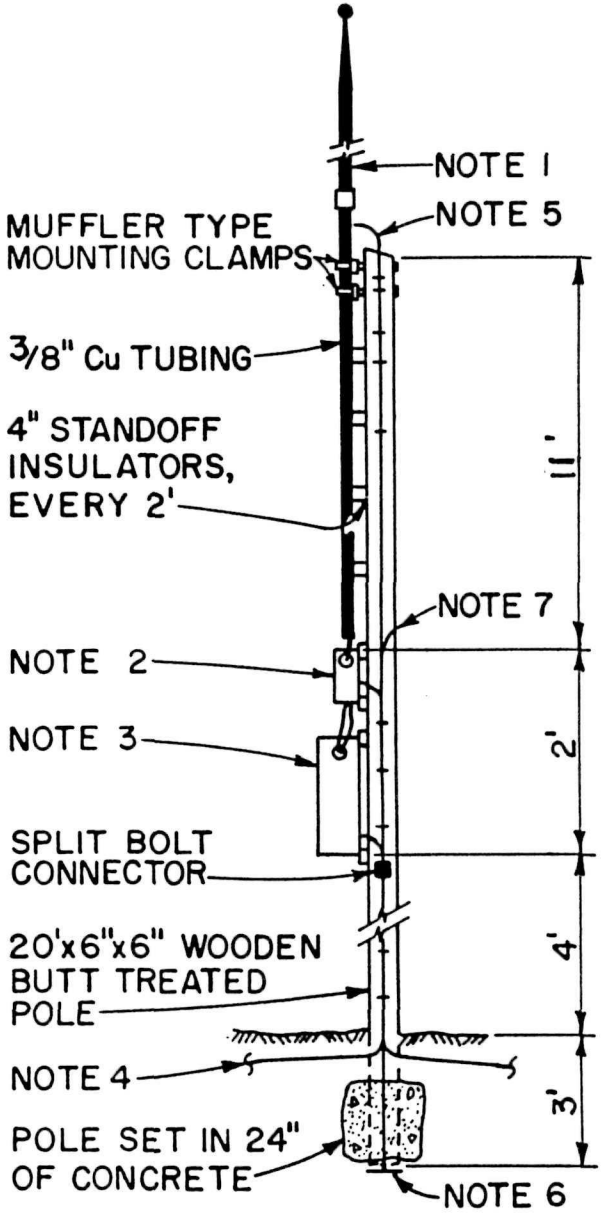


NOTES:

1. 530 KHz ANTENNA WITH LOADING COIL & TUNING STUB. LATTER MUST BE ADJUSTED BY INSTALLING ENGINEER.
2. TRANSMITTER UNIT (SECURITY BOX ACCESSIBLE ONLY TO FCC LICENSED PERSONNEL).
3. TAPE PLAYER & TRANSMITTER POWER SUPPLY (SECURITY BOX ACCESSIBLE TO PARK PERSONNEL).
4. INSTALL COUNTERPOISE CONSISTING OF EIGHT 50' EQUALLY-SPACED RADIALS OF #12 (MIN.) BARE COPPER WIRE BURIED 18" WHERE POSSIBLE (6" MIN. OR TO SOLID ROCK). SOLDER ALL RADIALS TO #6 COPPER GROUND WIRE. EXTEND ONE RADIAL TO ALL WATER LINES, METAL FENCES, POWER SYSTEM GROUNDS AND FUEL TANKS LYING LESS THAN 200' FROM POLE.
5. BEND 1/2"x6' COPPERWELD GROUND ROD WITH 6" RADIUS TO FORM LIGHTNING GAP. POINTED TIP SHALL BE 1/4" FROM ANTENNA. FASTEN TO POLE & CONNECT TO #6 BARE COPPER GROUND WIRE BONDED TO CABINET & GROUND RADIALS RUNNING TO POLE BUTT. STAPLE GROUND WIRE TO POLE EVERY 2'.
6. SPIRAL 4' LENGTH OF #6 BARE COPPER WIRE & STAPLE TO BUTT END OF POLE.

530A ANTENNA

NO SCALE

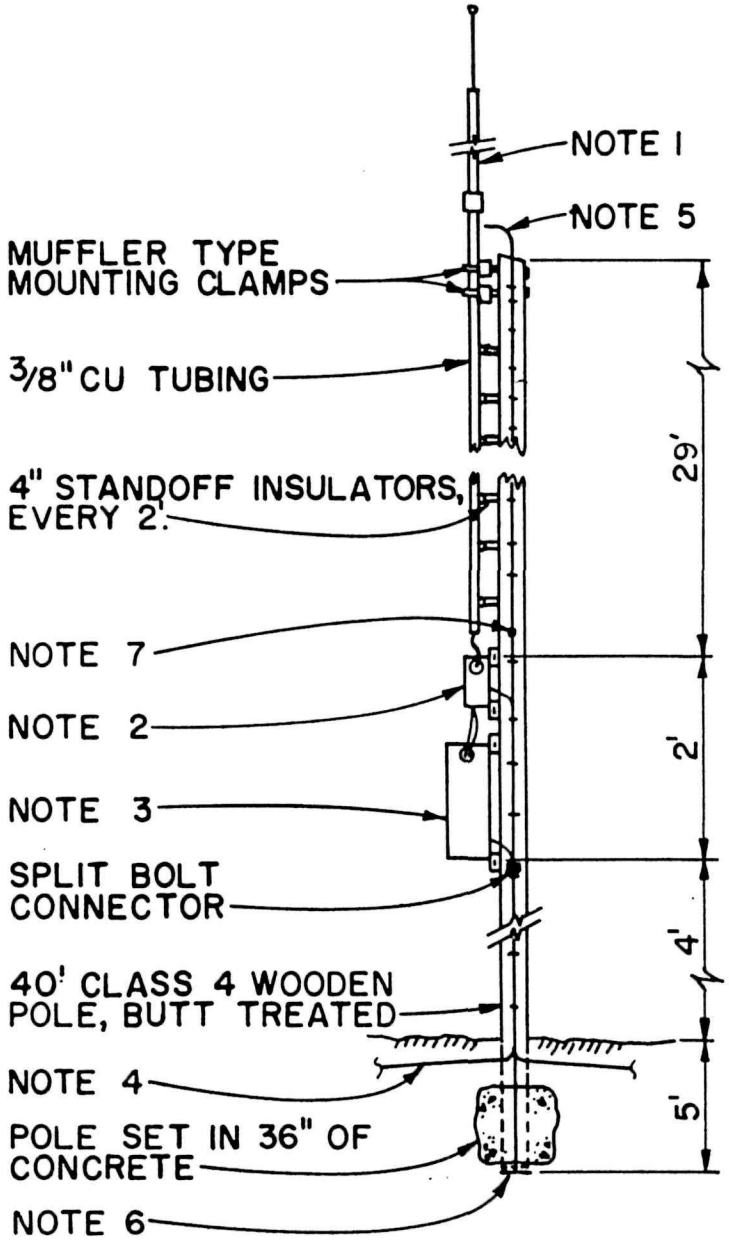


NOTES:

1. 530 KHz ANTENNA WITH LOADING COIL & TUNING STUB. LATTER MUST BE ADJUSTED BY INSTALLING ENGINEER.
2. TRANSMITTER UNIT (SECURITY BOX ACCESSIBLE ONLY TO FCC LICENSED PERSONNEL).
3. TAPE PLAYER & TRANSMITTER POWER SUPPLY (SECURITY BOX ACCESSIBLE TO PARK PERSONEL).
4. INSTALL COUNTERPOISE CONSISTING OF EIGHT 60' EQUALLY SPACED RADIALS OF #12 (MIN.) BARE COPPER WIRE BURIED 18" WHERE POSSIBLE (6" MIN. OR TO SOLID ROCK). SOLDER ALL RADIALS TO #6 COPPER GROUND WIRE. EXTEND ONE RADIAL TO ALL WATER LINES, METAL FENCES, POWER SYSTEM GROUNDS AND FUEL TANKS LYING LESS THAN 300' FROM POLE.
5. BEND 1/2"x6' COPPERWELD GROUND ROD WITH 6" RADIUS TO FORM LIGHTNING GAP. POINTED TIP SHALL BE 1/4" FROM ANTENNA. FASTEN TO POLE & CONNECT TO #6 BARE COPPER GROUND WIRE BONDED TO CABINETS & GROUND RADIALS RUNNING TO POLE BUTT. STAPLE GROUND WIRE TO POLE EVERY 2'.
6. SPIRAL 4' LENGTH OF #6 BARE COPPER WIRE & STAPLE TO BUTT END OF POLE.
7. FORM 1/8" GAP IN GROUND WIRE ON SIDE OF POLE WHERE INDICATED.

530B ANTENNA

NO SCALE

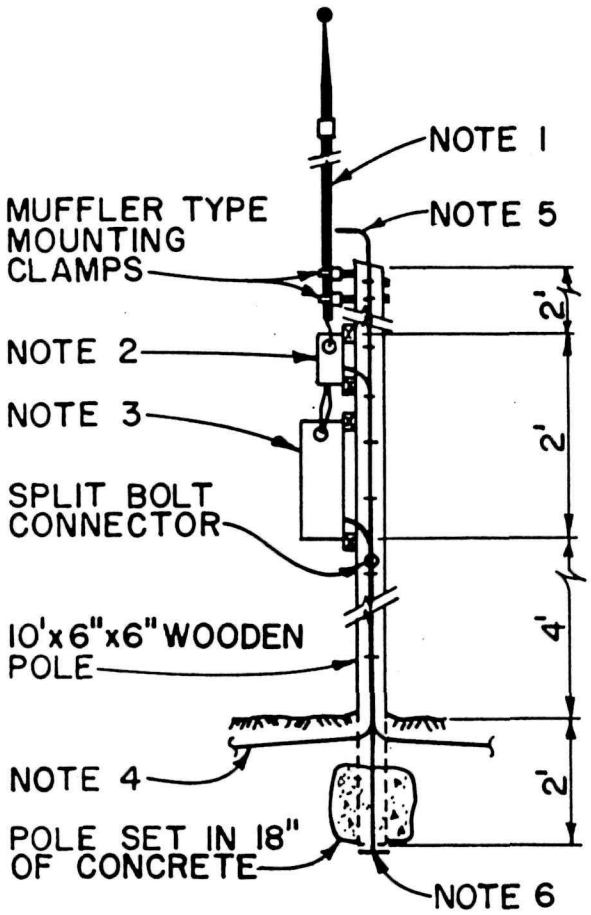


NOTES:

1. 530 KHz ANTENNA WITH LOADING COIL AND TUNING STUB. LATTER MUST BE ADJUSTED BY INSTALLING ENGINEER.
2. TRANSMITTER UNIT (SECURITY BOX ACCESSIBLE ONLY TO FCC LICENSED PERSONNEL).
3. TAPE PLAYER AND TRANSMITTER POWER SUPPLY (SECURITY BOX ACCESSIBLE TO PARK PERSONNEL).
4. INSTALL COUNTERPOISE CONSISTING OF EIGHT 100' EQUALLY-SPACED RADIALS OF #12 (MIN) BARE COPPER WIRE BURIED 18" WHERE POSSIBLE (6" MIN. OR TO SOLID ROCK). SOLDER ALL RADIALS TO #6 COPPER GROUND WIRE. EXTEND ONE RADIAL TO ALL WATER LINES, METAL FENCES, POWER SYSTEM GROUNDS AND FUEL TANKS LYING LESS THAN 400' FROM POLE.
5. BEND 1/2"x6' COPPERWELD GROUND ROD WITH 6" RADIUS TO FORM LIGHTNING GAP. POINTED TIP SHALL BE 1/4" FROM ANTENNA. FASTEN TO POLE AND CONNECT TO #6 BARE COPPER GROUND WIRE BONDED TO CABINETS AND GROUND RADIALS RUNNING TO POLE BUTT. STAPLE GROUND WIRE TO POLE EVERY 2'.
6. SPIRAL 4' LENGTH OF #6 BARE COPPER WIRE AND STAPLE TO BUTT END OF POLE.
7. FORM 1/8" GAP IN GROUND WIRE ON SIDE OF POLE WHERE INDICATED.

530C ANTENNA

NO SCALE



NOTES:

1. 1610 KHz ANTENNA WITH LOADING COIL & TUNING STUB. LATTER MUST BE ADJUSTED BY INSTALLING ENGINEER.
2. TRANSMITTER UNIT (SECURITY BOX ACCESSIBLE ONLY TO FCC LICENSED PERSONNEL.)
3. TAPE PLAYER & TRANSMITTER POWER SUPPLY (SECURITY BOX ACCESSIBLE TO PARK PERSONNEL.)
4. INSTALL COUNTERPOISE CONSISTING OF EIGHT 50' EQUALLY SPACED RADIALS OF #12 (MIN.) BARE COPPER WIRE BURIED 18" WHERE POSSIBLE (6" MIN. OR TO SOLID ROCK). SOLDER ALL RADIALS TO #6 COPPER GROUND WIRE. EXTEND ONE RADIAL TO ALL WATER LINES, METAL FENCES, POWER SYSTEM GROUNDS AND FUEL TANKS LYING LESS THAN 150' FROM POLE.
5. BEND 1/2" x 6' COPPERWELD GROUND ROD WITH 6" RADIUS TO FORM LIGHTNING GAP. POINTED TIP SHALL BE 1/4" FROM ANTENNA. FASTEN TO POLE & CONNECT TO #6 BARE COPPER GROUND WIRE BONDED TO CABINETS & GROUND RADIALS RUNNING TO POLE BUTT.
6. SPIRAL 4' LENGTH OF #6 BARE COPPER WIRE & STAPLE TO BUTT END OF POLE.

1610 ANTENNA

NO SCALE

CHAPTER 9

REFERENCES

The following were used as sources of information in deriving Exhibits E and F.

1. F.E. Terman, Radio Engineers Handbook, First Edition. Figure 26 (p. 793). (Used to estimate radiation resistance.)

2. (Source unknown). "Smith and Johnson; Performance of Short Antennas." Figure 13. Theoretical radiation resistance for various degrees of lop loading. (Used to corroborate radiation resistance obtained from reference 1).

3. Denver Service Center (National Park Service) tests of Morad antennas.

4. Vir James (1973) "Engineering Exhibit, Field Strenght, Ground Conductivity Measurements, Coverage and Allocation Survey." Report to DSC August 1973. (Measurements of selected Yellowstone 1606 kHz TIS installations).

5. F.E. Terman, Radio Engineers Handbook, First Edition. Equation (25) page 795.

6. CFR Title 47, Part 73.184, Graph 1 (540 kHz) and Graph 19 (1600 kHz).

7. Federal Highway Administration, Report No. FHWA-RD-74-73, December 1974, "Study and Development of Highway Advisory Information Radio". Chapter 5.0 (survey of automobile receiver characteristics).

CHAPTER 10

ABBREVIATIONS USED IN THIS HANDBOOK

AC	Alternating current
AM	Amplitude modulation
BLM	Bureau of Land Management
DC	Direct current
DM	Departmental Manual (Department ofthe Interior)
DSC	Denver Service Center
emu	Electromagnetic units
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FM	Frequency Modulatin
IRAC	Interdepartment Radio Advisory Committee
kHz	Kilohertz (measurement of radio frequency)
km	Kilometer (measurement of distance)
kw	Kilowatt
mph	Miles per hour
mV/m	Millivolts per meter (measurement of field strength)
NASA	National Aeronautical and Space Administration
NPS	National Park Service
RRD	Restricted Radiation Device (sometimes referred to as a "Rule 15" device)

TIS	Travelers Information Station
TV	Television
USDI	United States Department of the Interior
USFS	United States Forest Service
uV/m	Microvolts per meter (measurement of field strength).
UHF	Ultrahigh frequency
VHF	Very high frequency

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