The Federal Energy Regulatory Commission

Safety Signage at Hydropower Projects

October 2001

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Division of Dam Safety and Inspections
Office of Energy Projects
Federal Energy Regulatory Commission
Washington, DC 20426

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ACKNOWLEDGMENTS

Safety signage at Hydropower Projects **was developed by compiling existing information on signage and safety issues, extracting those elements that related to hydropower projects, and applying the knowledge and experience of many Commission staff members and project owner representatives who, through their day-to-day activities, have developed practical expertise in this area. We gratefully acknowledge the following for their direct and indirect assistance in producing this document.**

***Hydro Public Safety Issues Group**

***Hydro Users Group Public Safety Committee**

National Water Safety Congress

U. S. Army Corps of Engineers

U. S. Bureau of Reclamation

U. S. Coast Guard

National Park Service

Occupational Safety and Health Administration

Tennessee Valley Authority

Other contributors of materials and examples

In addition, our thanks to those organizations listed in the "Web Links" section. By accessing *Safety Signage at Hydropower Projects* on the hydropower page of the Commission's internet site (https://www.ferc.gov) users will also be able to link to many safety related internet resources.

***This document has been developed with the help of HPSIG and HUG. HPSIG is a group of FERC hydropower project owners interested in maintaining the highest level of public safety at their projects through, (1) promoting open communication on these issues; (2) facilitating technical assistance and providing expert resources; (3) reviewing public safety issues; and (4) participating in cooperative efforts with FERC (such as the development of this document). HUG is a coalition of hydropower project owners, operators and affiliated interests in the Midwest that emphasizes consistency in signage,**

increased knowledge and cooperation among its members. Both groups are leaders in safety around dams and reservoirs.

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Adobe Reader

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LIST OF ACRONYMS

ADAAG	American with Disabilities Act Guidelines for Buildings and Facilities
ANSI	American National Standards Institute
ASDSO	Association of State Dam Safety Officials
FERC or Commission	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
GIS	Geographic information systems
GPS	Global positioning systems
GSA	General Services Administration
HAGL	Height above ground level
HDO	High density overlay
HPSIG	Hydro Public Safety Issues Group
HUG	Hydro Users Group
ISO	International Organization for Standardization
MDF	Medium density fiberboard
MDO	Medium density overlay
NPS	National Park Service
OSHA	Occupational Safety and Health Administration
PWC	Personal water craft
USACE	United States Army Corps of Engineers

USBR	United States Bureau of Reclamation
USCG	United States Coast Guard
USWMS	Uniform State Waterway Marking System

I. FERC's ROLE IN PROMOTING EFFECTIVE SAFETY SIGNAGE

One of the Federal Energy Regulatory Commission's (FERC or Commission) roles is to provide regulatory oversight to help project owners create and maintain safe hydropower projects. The potential for drownings, and other accidental deaths and injuries on project lands and waters is of concern to the Commission and project owners. Licensees and exemptees identify and address public safety issues at their projects, and the Commission staff reviews these activities to help project owners ensure that the operation of these projects does not endanger the public.

Commission staff inspects approximately 2,600 hydro facilities each year. These inspectors are vigilant in watching for unsafe conditions during their inspections. The objective is to identify potential hazards and require that appropriate safety measures be in place, before accidents occur. This review and assessment must be conducted on a project-specific basis. As each project has its unique configuration of hydropower facilities, reservoir size and use, topography, and recreational uses and sites, the potential dangers vary widely as well. Accordingly, each project's plan to address these potential dangers, through the use of signs and other devices, is unique.

The Commission's role is not to set signage standards for uniform applicability, but rather to require that each project owner takes the appropriate actions, including placing the appropriate signage, to safeguard the public from harm at and around its hydropower project. To this end, FERC requires that a Public Safety Plan be developed by the owner of any project where public safety measures are necessary. The plan includes a list of each safety device at the project and a schematic drawing showing the location of each device. Such safety devices, include fences, signs, boat barriers, buoys, log booms, audible devices, night illuminations, and warning lights. The plan is kept current by the project owner and reviewed by Commission staff during each operation inspection for accuracy and adequacy.

This "Safety Signage at Hydropower Projects" document was developed by FERC to provide hydropower project owners with easy-to-access information and examples of safety signage suitable for use at their facilities. Although general information on safety signs is available, information specific to hydropower projects can be difficult to locate. Such specific information is often interspersed within larger, more general texts. This document presents the most relevant generally available information, and directs interested individuals to more detailed references and resources. Providing FERC licensees and exemptees with a central location for safety sign information is one step toward helping project owners to create the safest environment possible at these hydroelectric projects.

This document contains:

1 an overview of safety signage concepts and current standards (section III);
2 examples of possible dangers associated with hydroelectric projects that require signage (section IV);
3 annotated signage examples (section V);
4 a safety bibliography (section VI.A);
5 an internet resource list with links to safety web sites (section VI.B); and
6 supporting safety documents (appendices A through D).

II. INTRODUCTION

Recreational use of Commission-licensed hydropower facilities has increased in past decades and is projected to continue to increase in the future. This increase is primarily due to two factors: increased popularity of water-based activities and increased overall population of the United States. The U.S. population is projected to expand by 30 percent over the next 20 years. In addition, recreation participation is anticipated to continue growing at high levels. In particular, water-based recreation has increased dramatically over recent years, and the trend is for continued growth. For example, the number of individuals participating in motor boating increased from 33.6 million to 51.4 million from 1983 to 1999, an increase of 53 percent in just 16 years (NSRE, 2000).

The percent of the population taking part and the types of water-based recreation activities also have been changing. One extreme example of this is the use of personal water craft (PWC). The jet water propulsion technology for PWCs was originally developed in the late 1960s, but they have only been available commercially since the mid-1970s. PWCs and jet boats can be used in water not formerly accessible to conventional propeller-driven boats: river rapids, ocean surf, shallows, and narrow reaches of rivers and reservoirs (Cordell, 1999). According to the USCG, PWC numbers in the United States have increased from about 100,000 in 1987 to approximately 1,100,000 in 1998. Along with this increase in the number of PWCs in use, the number of associated accidents, injuries, and fatalities also has increased. The manner in which PWCs are operated differs from conventional motor boats. They tend to be operated in a more erratic or circular motion, as opposed to the standard linear motion of other motor boats. This change in activity patterns of recreational users may affect the signage that is necessary at a given hydropower dam and associated reservoir.

These changes in population, use, and recreation types have changed the landscape of safety issues that project owners face at hydropower projects. Different recreation activities often compete for the same space at a site (e.g., use of PWCs and use by swimmers). This creates direct safety risks, such as collisions, or indirect risks, such as overcrowding, which may encourage recreators to use other project areas that, historically, were unused. Dam owners and operators need to be aware of these safety risks and address associated safety concerns. Bresnahan et al. (1993) adapted the work of previous researchers Barnett and Brinkman to create a "current consensus" on how to develop a safety hierarchy to address such changing

concerns (table 1). The "safety hierarchy" identifies priorities and options for eliminating or reducing risks once they have been identified.

Table 1. Adaptable Safety Priority Hierarchy (Bresnahan et al., 1993, as modified by the staff).

Priority	Action	Hydropower project examples
First	Eliminate the hazard and/or risk	Raising high voltage electric lines to heights above where sailboat masts and anglers' fishing lines and tackle may come close enough to create an electric current to ground through sailboaters or anglers. Designing deep water intake structures versus surface intakes. Moving/designing beach or marina areas to a safe distance from the dam crest or intakes. Modifying ramping rates to increase reaction time of downstream users.
Second	Apply safeguarding technology	Installing fences, gates, escape ladders, safety rings, boat barriers, warning sirens, strobe lights and other physical protective measures.
Third	Use warning signs	Providing conspicuous signage denoting non-obvious safety hazards.
Fourth	Train and instruct	Conduct public outreach meetings with user groups or other safety officials.
Fifth	Prescribe personal protection	Require personal flotation devices, hard hats, boots or operator certifications.

Most projects have had safety design modifications put into place over the life of the project. Fencing, gates, and even video cameras have been incorporated to increase safety at hydropower projects. However, safety signage continues to be a critical part of maintaining safe conditions, in part because of the hidden nature of many of the potential hazards at hydropower projects. Signs that effectively warn, inform, and educate the public about potential safety hazards are an integral part of a comprehensive safety plan.

III. KEY CONCEPTS IN PLANNING, DESIGN, CONSTRUCTION, AND MAINTENANCE OF SAFETY SIGNS

What is a safety sign? For the purposes of this document, we include any form of signage that has a potential impact on public safety. These include not only the prohibitive and warning signs commonly recognized as having a direct safety message, but also other sign genres including directional signs, informational signs, interpretive signs, and those signs that specifically denote areas where activities are allowed. Signs with symbols or messages that mark swimming areas, inform the public of portage routes or even parking signs serve a public safety purpose in that they encourage use of safe areas over areas where there are potential risks or hazards. Safety signage should address not only activities or actions that are prohibited but should also guide and encourage viewers to make safe activity choices.

The first rule of safety signage is to identify potential safety hazards and determine the existence of information and regulations that govern safety. A variety of agencies and organizations have researched safety signs and their design and provided guidance in this area. National, international and regional agencies and organizations include: the Occupational Safety and Health Administration (OSHA), the American National Standards Institute (ANSI), the International Organization for Standardization (ISO), the Federal Highway Administration (FHWA), the General Services Administration (GSA), the United States Army Corps of Engineers (USACE)(see appendix A for USACE Signage Guidelines), the United States Bureau of Reclamation (USBR), the United States Coast Guard (USCG), the Association of State Dam Safety Officials (ASDSO), the Hydro Public Safety Issues Group (HPSIG), Hydro Users Group (HUG) and FERC (see appendix B). Many of these organizations and agencies have published information regarding the concepts and principles of proper safety signage and produced regulatory or suggested guidelines for sign planning and production. Another national source of sign design guidance is the Americans with Disabilities Act Guidelines for Buildings and Facilities (ADAAG). The complete guidelines are available on the Access Board website (see web links in section VI.B). The ADAAG include specific requirements for various aspects of signage, and these requirements are discussed in the appropriate sections of this document (ADAAG, 1998).

A dam owner should know of any state or local regulations regarding safety signage or dam safety. It is an important part of properly assessing signage needs and possible design requirements. For example, in Pennsylvania, legislation is proposed that may require the posting of specialized signage at non-power producing dams (see web links in section VI.B). Other states, such as Oregon, have published guidelines regarding safety signs at specific types of site. The Oregon guidelines entitled "Uniform Sign Guidelines for Recreational Boat Launching and Transient Tie-Up Facilities" (see appendix C) was prepared by the Oregon State Marine Board (OSMB) in 1997. The guidelines include specific information on capitalization, text size, arrows, abbreviations, sign shapes, materials and even enforcement information. All of this information may have an impact on how a dam owner assesses, designs, places and maintains signs at their project. Section VI.B of this document (Safety Signage at Hydropower Projects) contains web links to several of the groups and web sites mentioned above, providing further safety information.

While the specific approach of each agency or group to safety may vary, the basic elements of an effective safety signage program are the same:

- conduct a thorough needs assessment;
- develop an effective design;
- standardize format and message;
- properly place and locate signs;
- and perform regular maintenance.

All of the elements together form a complete and comprehensive safety signage plan. Without properly assessing the need for signs, effective signage is never developed; a poorly worded sign will not be effective; if poorly placed, even a well designed sign will not be effective; and effectiveness decreases in areas where sign maintenance is neglected. In the following section, we examine each of these elements, describe associated pitfalls, and identify the most important components of each aspect of an effective safety signage plan.

A. Assessing the Need for Signage

When developing or updating the safety signs at a project, the dam owner or operator must inventory the potentially hazardous areas at the project and identify the users affected by dangerous areas. Because each hydropower project has site-specific characteristics that may pose unique hazards to the public, each project owner must examine all of the areas affected by the dam. In many cases, however, the issues at a number of different facilities are similar enough that some uniformity among projects is possible.

Each hydropower project has some features in common with others, but also many project-specific features that may require specialized signage not available in an "off the shelf" format. A comprehensive site review should be conducted if a current safety plan is not available. The USACE Sign Standards Manual Volumes I and II (last updated in 1995) provide detailed guidance on how to conduct a thorough sign inventory (publications EP 310-1-6A and EP 310-1-6B are available at no cost). Contact the USACE via its web site (see web links in section VI.B) to request these documents.

Include the following steps when assessing signage needs:

- document existing signs, including construction materials, text, placement, condition, and projected replacement times;
- review local, state, and federal signage regulations, as well as any signs specifically required by license articles;

- assess any recreational/project changes that may require new signs such as creation of a new access area, increased PWC traffic, use of fishing tubes or other new technology, operational changes, or trail construction;

- review any recent accidents or safety issues at the project or nearby facilities to identify possible problem areas;

- examine any public safety concerns received in the form of phone calls, letters, or email; and

- identify any planned project changes or events that may require permanent or temporary signage (e.g., fishing tournaments, canoe portage construction, and sale or subdivision of project lands or lands adjacent to project lands that would increase reservoir use).

The review also should identify any new signage needs, modifications, replacements, and removals. For example, the change from a peaking mode to run-of- river operation may necessitate a change in signage and, in some cases, sign removal.

A note about technology: Technological advances in the past several years have made digital cameras and electronic documentation of signage much more affordable for even small dam owners. Electronic record keeping of both text and graphics, including site maps and photos, is highly recommended. Reordering signs, copying examples of other signs in use, and analyzing standards all may be completed much more easily using electronic methods. Computer applications using three-dimensional modeling and global positioning/ global information systems (GPS/GIS) technologies can be used to identify exact sign positions, schedule maintenance, and help determine the site of future signs.

Key Concepts

- Typical safety signage may not address site-specific safety issues.

- Identify any federal, state, and local regulations that may apply.

- Reviews should include existing signage, project history, public concerns and public safety hazards.

- Review any project changes for impacts on signage needs.

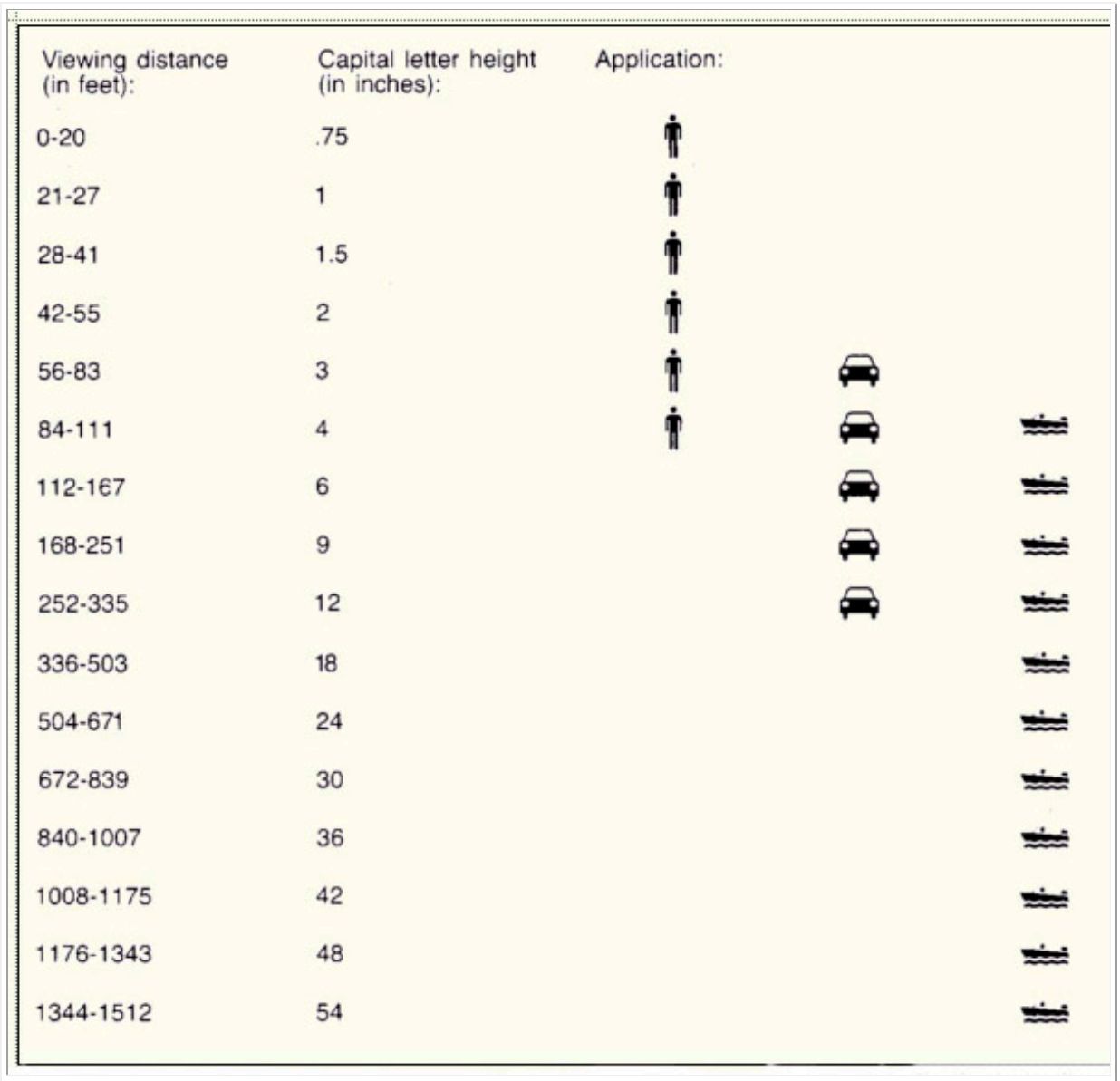
B. Effective Design

A number of factors influence a sign's effectiveness. The text height, sign size, typography (font style), color, symbols used, shape, phrasing, and the message conveyed all have an impact on how a sign will be perceived. Generally, signs should be designed for the first time viewer assuming no prior knowledge. An OSHA report "Hazard Communication: A Review of the Science Underpinning the Art of Communication for Health and Safety" (OSHA, 1997) reviewed studies conducted to determine factors affecting labels and signage. This report, while primarily about product labeling, provides summary information on general safety signage design concepts. A web link to this report is contained in section VI.B of this document.

1. Text Height and Sign Proportions

Text height is generally a function of two factors: the intended viewer's distance from the sign and the priority of that line of text within the total sign legend. All the text on a sign (known as the legend) should be sized based on the distance from which it is to be viewed, the speed of the viewer, and the manner of movement (e.g., foot, car, or boat). [1] In compliance with FHWA standards, letter height is calculated for people with at least 20/40 vision. Figure 1 illustrates the calculated letter height for signs and their intended application. The USACE defines the calculated text height as "A," where "A" is the height of the first capital letter in the main body or "Bond Copy" of the sign legend.

1. Text height guidelines vary slightly. See FERC, 1992; USBR, 2000, USACE, 1995, and FHWA, 2000, for suggested letter heights. Individual site characteristics vary, and individuals should use available information to determine the standard that is most appropriate for their situation.



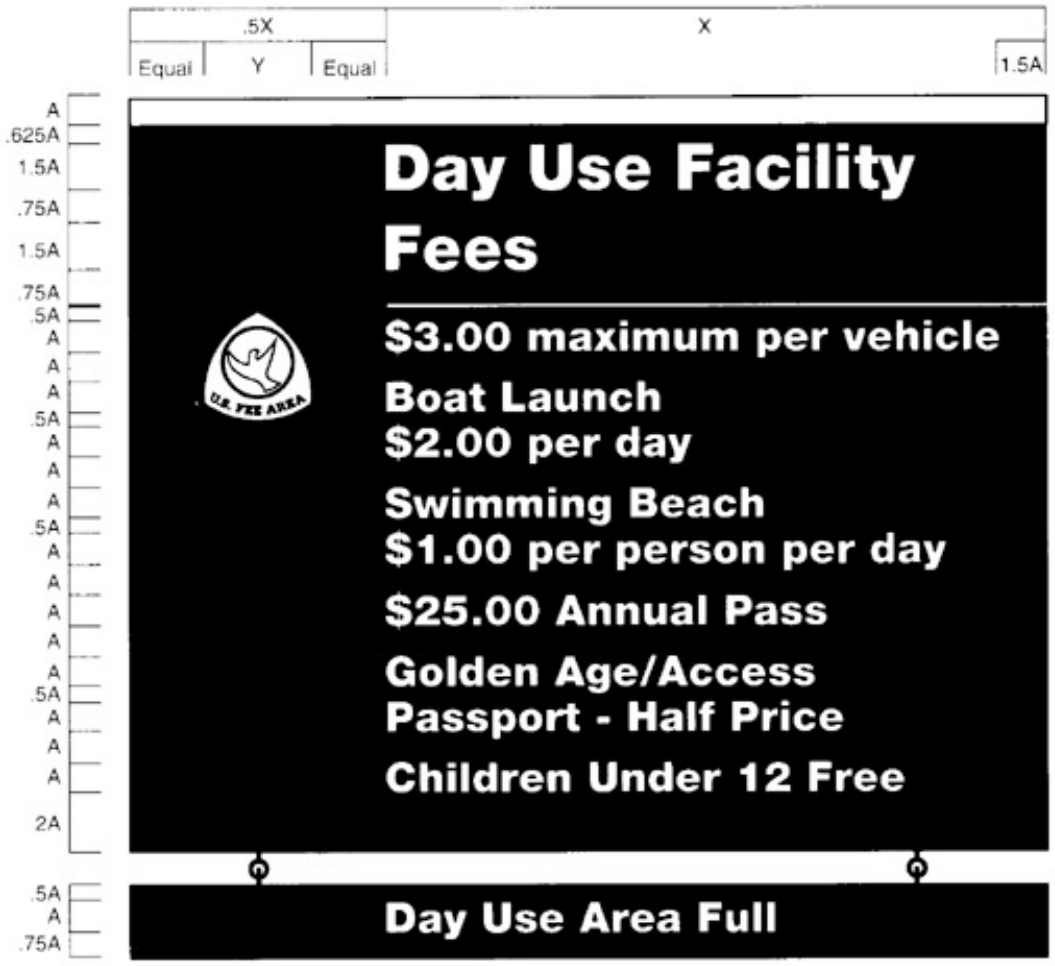
For distances greater than 1,512 feet, the first capital letter height of a sign legend (A) is calculated by dividing the viewing distance by 28 and rounding up to the nearest inch.

Figure 1. FHWA standard for sign font height (Source: USACE, 1995, as modified by the staff)

"A" is used as the base measurement for proportioning other text, borders, and spacing on the sign panel. For example, the headline (top line or highest priority phrase such as "Danger") size is 1.5A or 1.5 times the height of the first capital letter in the main body of the sign. Use of a ratio or proportioning method such as this allows the designer to determine the way a sign will ultimately be perceived. Text height, spacing between lines, the distance to the sign edge, arrow or symbol sizes, and logos or graphics can all be properly scaled using a method similar to this one. Proportioning is an important part of creating effective, readable signs.

Figure 2 shows the relative ratio of the font height, line spacing, and borders for a USACE site sign. The distance "X" is equal to the length of the longest legend line plus 1.5A. Also included are the measurements for the sign size, posts, and mounting height in Height Above Ground Level (HAGL). Mounting method, height, and sign size vary with text height. The USACE sign proportion regulations are designed to increase the readability, clarity, and effectiveness of the signage for the viewer. The border provides a visual separation between the text on the sign and the environment, while line spacing groups associated text together allowing the reader to visually prioritize the information being given. In relation to sign size, the HUG Public Safety Committee recommends a minimum size of 2 feet by 2 feet for "Dam" and "Thin Ice" warning signs, as well as for "Take Out" and "Canoe Portage" signs. They also recommend a minimum of 4 feet by 4 feet for other message and warning signage. Appendix D contains a copy of HUG recommendations for font size, coloration, sign lighting, sirens, strobes, and other safety issues.

Font proportions also are important to capture the viewer's attention, give prioritized information, and set up a hierarchy of concepts. In its 1997 report on product labeling, OSHA reports that a 2 point increase in font size from 10 to 12 point text (a 20 percent increase) between the bond copy and the headline drew the viewer's attention to the heading and increased the labeling effectiveness. Although this differs from the USACE proportion of 150 percent of bond copy height, the concept of differing font height for emphasis is well accepted. A combination of suitable text height and properly proportioned sign components ensures that signs are readable and effective.



Sign Type	Legend Size (A)	Panel Size*	Symbol Size (Y)	Post Size	Spec. Code	Mounting Height	Color Bkg/Lgd
ENT-05	1"	33.25" x 24.25"	4"	4"x 4"	HDO-5/6	60"	BR/WH
ENT-05	1.5"	49.875" x 36.375"	6"	4"x 4"	HDO-3/6	48" - 60"	BR/WH
ENT-05	2"	66.5" x 48.5"	8"	4"x 4"	HDO-3	48" - 60"	BR/WH

The panel height shown is without the "Day Use Area Full" attachable panel.

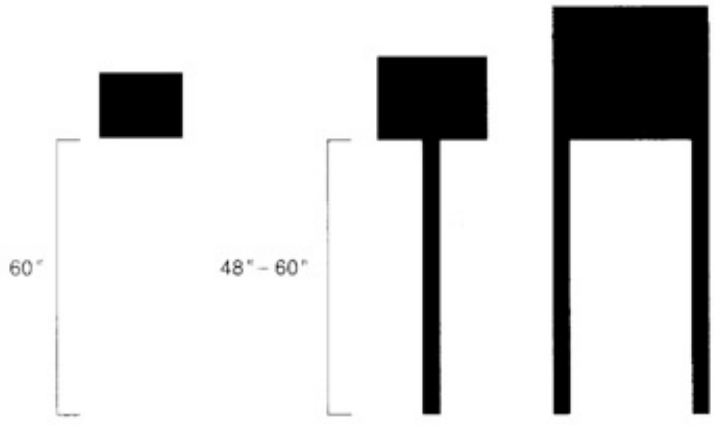


Figure 2. An example of USACE sign design with text heights given in A (the height of the first capital letter in the copy body of the legend text) (Source: USACE, 1995, as modified by the staff)

The ADAAG require that letters and numbers on signs shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10 (Section 4.30.2). Further, characters and numbers on signs shall be sized according to the viewing distance from which they are read. The minimum ADAAG height is measured using an uppercase X. Lower case characters are permitted. The absolute minimum height for characters is 3 inches (Section 4.30.3). For mounting location and height, other ADAAG requirements may apply.

Key Concepts

- Design sign and text size for viewing at appropriate distances.
- Account for mode of viewing (foot or vehicle) during design.
- Determine a standard minimum size for any signage.
- Proper proportioning of text and borders increases effectiveness.
- Increased headline font size compared to bond copy prioritizes message.

2. Sign Shape

FHWA has developed shape-based traffic signage in use across the United States: octagons for stop, inverted triangles for yield, diamonds for warning, and rectangles for information. Warning signs and labels are often rectangular in shape but include symbols within the sign that reflect the standard safety shapes to gain prompt user attention. ANSI Z535.3 (1991) standards state that the perimeter of the label panels may take on the surrounding shape of safety symbols, although justifications for this allowance are not specified. Safety shapes recommended by ANSI Z535.3 (1991) and ISO 9186, along with their associated meanings are as follows:

- Equilateral triangle resting on base: Warning and hazard alerting;
- Circle: Mandatory action;

- Circle with 45 degree slash from upper left to bottom right: Prohibited action; and

- Square or oblong as necessary to accommodate text: information.

The HUG Public Safety Committee recommendations advise that warning signs used for "Dam" and "Thin Ice" be diamond shaped, and that informational signs should be square. They also recommend using a 2- or 4-inch minimum width border of international orange (similar to the Uniform State Waterway Marking System [USWMS] [see section III.C.2]).

Key Concepts

- Use pre-existing sign shape standards to increase viewer recognition.
- A shape standard is effective when printed on a sign of a differing shape (e.g., a prohibition circle on a square sign).

3. Panel Planning

There are three common panel types used for safety signage applications: one, two, and three panel signs (figure 3). A one panel sign can have a signal word, a message, or a symbol/picture. A two panel sign has combinations of signal word, message, and symbol/picture. A three panel sign uses all three combinations. It is important to prioritize any signal words (trigger words) so that they are larger than other message text and located at the top of the sign (ISO Recommendation No. 3864, Safety Colors and Safety Signs contains more information on panels and is available for purchase from the ISO; see web link in section VI.B)

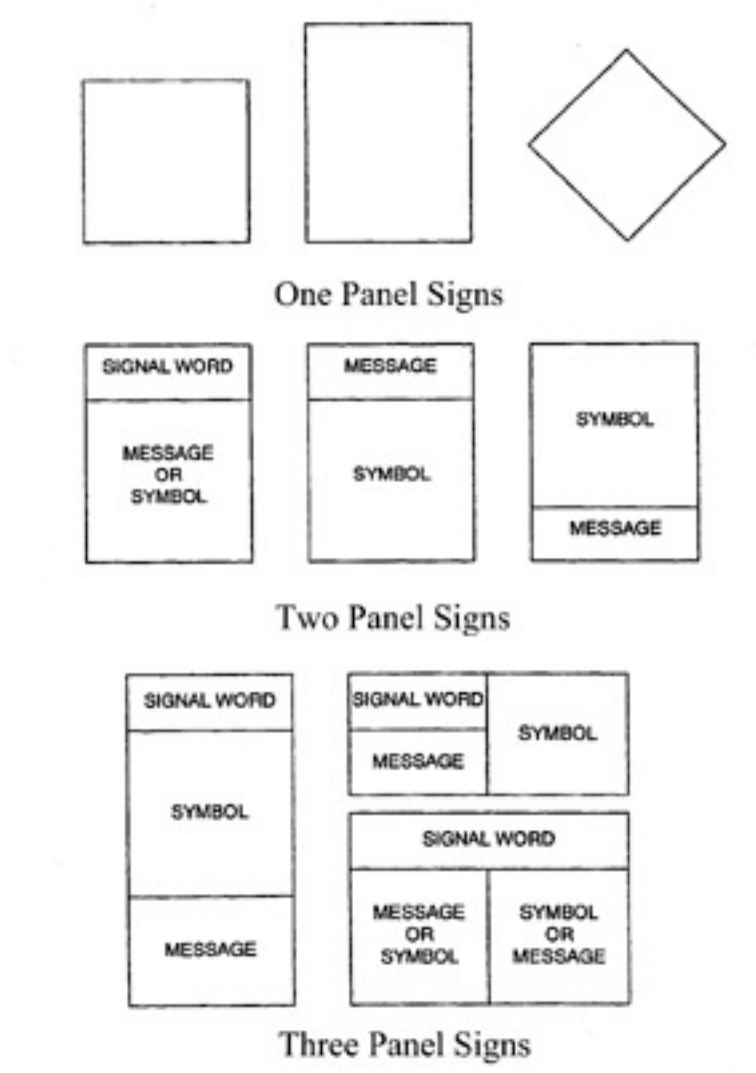
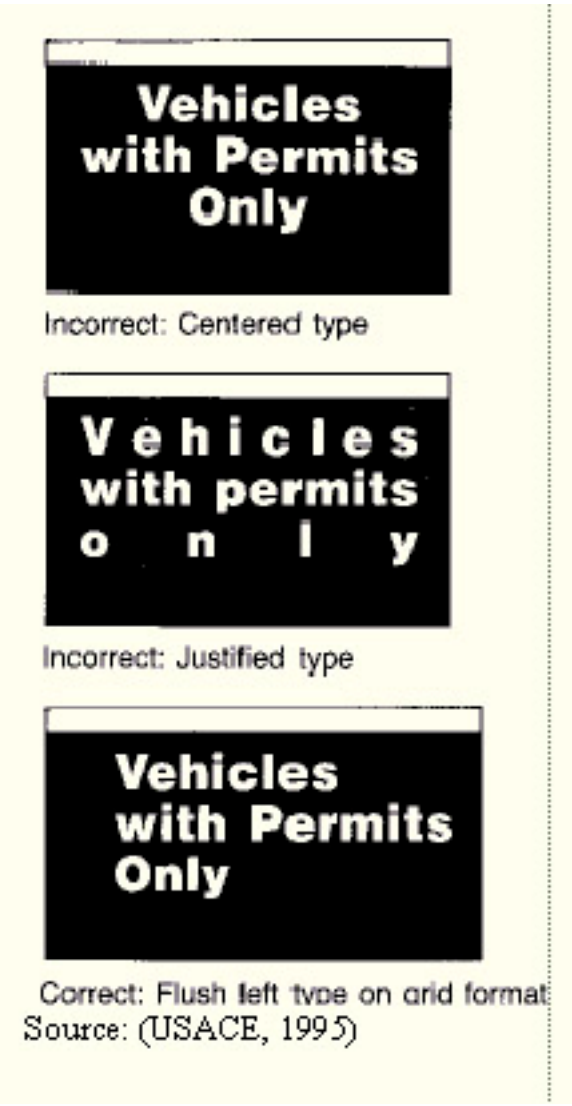


Figure 3. Examples of one, two, and three panel signs (Source: Bresnahan et al., 1993, as modified by the staff).

4. Typography

Typography describes the arrangement style or general appearance of printed text. Agencies have differing recommendations on the choice of letter style and capitalization. For example, USACE standards require that all sign legends be in Helvetica type face. They also recommend that only the initial letters of any text be capitalized; they cite evidence of increased comprehension and "glance" legibility when only the first letter is capitalized compared to the entire legend. Common ANSI standardized warning signs have all capitals used for the headline text. All capitals in the headline may increase hazard recognition in viewers. Conversely, use of italic, script, or other more stylized fonts is discouraged because they increase comprehension time and decrease readability. Although the USACE requirements stipulate a flush left text alignment, centering of sign legends is also a common practice. Full justification of text across the sign should be avoided because it decreases legibility.



Key Concepts

- Choose a more simple font for increased comprehension speed.
- Consider the effect of capitalization on comprehension and glance readability.
- Do not full justify sign text.

5. Color and Contrast Use

Color and contrast are important factors in designing appropriate signage. The contrast between the text and the background is important in determining the legibility of a sign. Often signs consist of dark lettering on light backgrounds or vice versa. Viewers discern varying levels of perceived hazard associated with different colors. Red has the highest level of perceived hazard, followed by orange, yellow, blue, green, and white (OSHA, 1997). Color can make a difference in perceived hazard even when the other aspects of the sign remain the same. One study showed that signal words such as "Deadly" connoted less hazard when printed in green than when printed in red. Another study, conducted by Dunlap, Granda, and Kustas in 1986 tested several different language groups including English, German, Scandinavian, and Spanish

for the effect of colors on hazard perception. The results showed that the perceived hazard hierarchy was the same across language groups. This is particularly important for signs in areas where English is not the viewer's first language. Standardized headlines using combinations of colors such as a black outer border, red inner area, and white text are common in many types of signs are more effective in conveying the existence of a hazard than other color/contrast combinations (OSHA, 1997).

Background color and reflectivity also can affect safety signs. Low light conditions at night, dusk, dawn, or during inclement weather may reduce visibility and make existing signs ineffective. Use of a light or reflective background material can increase visibility. At sites where night-time activities are common, licensees or exemptees should conduct night trials to assess sign effectiveness. See section III.E for a discussion of maintenance of reflectivity of signs.

FHWA has developed color codes establishing general meanings for eight colors that are used to convey traffic control information. The meanings that are associated with these colors by the general public make them appropriate for use at hydropower projects. The following general meanings can be used when designing signage:

Yellow	General warning
Red	Stop or prohibition
Blue	Road user services guidance, tourist information, and civil defense route
Green	Indicated movements permitted, direction guidance
Brown	Recreational and cultural interest guidance
Orange	Temporary traffic control
Black	Regulation
White	Regulation

The USWMS provides specific colors to be used on the buoys associated with it. These colors have recently changed and are being merged with the United States Aids to Navigation. The system uses red, green, and white colors to mark safe channels for travel. (For full details on the USWMS [see section III.C.2]; see section VI.B for web site.) The ADAAG also provide guidance for finish and contrast on signs: "The characters and background of signs shall be in eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background, either light characters on a dark background or dark characters on a light background."

Key Concepts

- Colors connote varying levels of hazard.
- The four colors most effective in communicating perceived hazard are red, orange, yellow, and blue in descending order.
- A black-red-white headline design with capitalized trigger word increases effectiveness.
- Pre-existing color standards for safety signs have preconditioned public response to specific colors.

C. Standardized Format and Message

1. Language

A significant percentage of U.S. residents do not use English as their primary language, which may present a problem for safety officers trying to design effective signage. Initially, assess the surrounding community and visitors to find out what primary languages are used and determine the need for specialized signage. If there is a need, two common methods of reaching non-English speaking groups are the use of symbols or pictograms and the use of signs with text translated into other languages.

If the message is easy to convey using symbols (e.g., No Swimming or No Boats), then it may be adequate to include symbols on the posted signs. This method has been shown to increase effectiveness in all viewer groups of any language if the symbol meaning is clear. Examples of standard pictograms can be found in the USACE Sign Standards Manual (reproduced in part in appendix A of this report and in section V.I illustrating common USACE symbols); these are primarily based on the National Park Service (NPS) symbol system. Other sources include the ANSI sign standards and FHWA. Symbols can increase the effectiveness of signs by adding recognition value, clearly defining restricted activities, and increasing retention time.

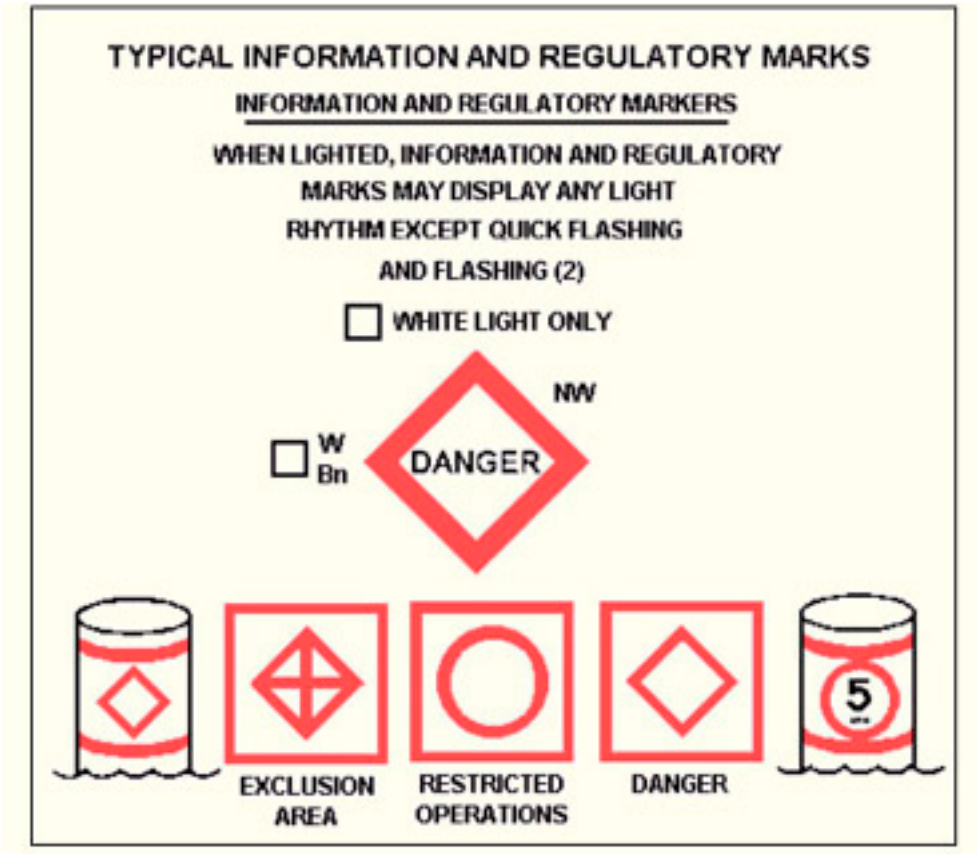
Areas with higher concentrations of non-English speakers or requiring depiction of more difficult concepts such as No Trespassing and Fast Rising Water may require additional signs

posted in a second language. Dam owners also may create specialized graphics designed and tested through the ANSI Z535 series of signage protocols. Whenever a translated sign is used, an identical sign in English should be placed beside it. The viewer can directly compare the two signs and may recognize the same warning and symbol if only the English version is posted in other areas. Note that any signs printed in non-English languages should be checked by a person fluent in that language to ensure accurate translation.

Key Concepts

- Assess the primary language of the audience and monitor over time.
- Symbols and bilingual signage increase viewer comprehension.
- Standardized symbols are better recognized by the public than unique graphics.
- Non-English signs should always be paired with English signs.

2. Symbols and Pictograms



As mentioned previously, adding symbols and pictograms can make any sign more effective. They may be used to easily display activities allowed or prohibited at a site. Appendix A and section V contain examples of pictograms used by the USACE for recreation signage. For prohibition notices, ANSI recommends placing a red circle with a

slash through it over the activity symbol. For pictograms, the ADAAG provide "Raised and Brailled Characters and Pictorial Symbol Signs (Pictograms)." Although, in general, braille is not required for safety signs, it should be considered on a case-by-case basis. The ADAAG state, "Pictograms shall be accompanied by the equivalent verbal description placed directly below the pictogram. The border dimension of the pictogram shall be 6 inches minimum in height." Another standard for safety symbols is the United States Coast Guard (USCG) USWMS.

Figure 4. Symbols of the Uniform State Waterway Marking System (Source, USCG web page http://www.uscg.mil/d11/oan/paton/state_buoys.htm accessed March 9, 2001).

For full details on the USWMS see web links in section VI.B. It uses standardized symbols and colors to guide boat user actions (figure 4). These symbols were developed in 1966 to provide an easily understood system for operators of small boats. They are the accepted standard for lake and inland waters not shown on nautical charts. The USWMS is currently being revised. It is being merged with the United States Aid to Navigation System. The phase-in period is linked to the buoy"s lifecycle to avoid unnecessary replacement cost to the agencies responsible and should be complete by the year 2003 (see web links in section VI.B). The USBR (1992a) interim working guideline "Public Safety Around Dams and Reservoirs," stipulates that, where possible, buoy markers should include text identifying specific hazards such as dams, intakes, or spillways in addition to any warning symbols.

Project-specific graphics or symbols should be used with care, planning, and testing. Use of standardized symbols or a professionally designed graphic is encouraged over "home made" versions of typical pictograms. A good example of a commonly used specialized graphic is the Minnesota Department of Natural Resources "Drowning Machine" sign which is used across the state. Similar signs are used in Wisconsin. This sign is included in section V.C. Symbols may be used without accompanying text, but with reduced effectiveness. Also, in some cases, such as in Oregon, sign text is required to be able to impose fines or other legal action on violators (see appendix C). Dam owners should check with local and state law enforcement officials or legal counsel to identify applicable laws. In addition, the dam owner should consult with local officials to gain concurrence that they would enforce a posted regulation or prohibition.

Key Concepts

- Symbols and pictograms increase comprehension and effectiveness of signs.
- A combination of symbols and text is more effective than a symbol alone.
- The use of standardized USWMS marking symbols can increase sign recognition in boaters.

- The USBR public safety guidelines support the use of text in combination with USWMS symbols.
- Non-standard symbols may be less effective in clearly identifying hazards or prohibitions unless properly designed and tested.
- Use of symbols without text may limit enforceability of prohibitions.

3. Sign Message

After enough information has been gathered, and decisions on basic sign characteristics have been made, finalize the legend text. Finalization should begin only after the dam owner has:

- sought out and collected safety information and guidance materials;
- searched records of past safety concerns at their projects (and other projects in the area);
- documented the placement and condition of the existing signage and assessed the need for new or modified signage;
- determined the viewing distance and computed the correct font and sign size;
- decided on the most effective shape of each sign;
- chosen a standard font and capitalization protocol;
- reviewed color schemes and reflectivity for effective day-time and night-time warnings;
- concluded which languages are required for each sign; and
- adopted a symbol system for land- and water-based signage.

Following these steps will enable the dam owner to set up safety signage guidelines which may then be applied to new and replacement signs in the future.

One of the challenges of designing effective signage messages is developing signs that will be understood by a wide range of audiences. The following needs should be factored into the design of the message. Do the signs:

- grab the attention of the viewer?
- clearly convey nature of and the magnitude or level of risk using signal words?
- promote visitor recognition?
- give adequate time for the proper response?
- account for the education level of the viewer?
- prioritize risks from highest to lowest?
- communicate consistently?

Getting the viewer's attention can be achieved with differing font sizes, color patterns, wording positions, and by using capital letters as discussed in the previous section. However, the words in the sign legend are a critical part of effective sign design.

Trigger or signal words are often used in the headline of a sign to grab the viewer's attention and immediately convey a specific level of risk or hazard. OSHA's standards clearly define signal words. For example, "Danger," "Warning," "Caution," and "Notice" have specific meanings and should only be used in appropriate situations:

Danger--an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is only used for the most extreme situations.

Warning--A potentially dangerous situation which, if not avoided, could result in death or injury.

Caution--A potentially dangerous situation which, if not avoided, may result in minor or moderate injury. It also may be used to alert against unsafe practices.

Notice--General informational text

The broad use of signal words for safety warnings and labels has increased viewer recognition and perceived hazard of products and sites where the markings are used. They are also easily understood by all education levels and have high "glance" legibility. USBR Public Safety guidelines (1992) state that a sign should ideally "warn of the hazard with the intensity commensurate with the outcome...explain how to avoid injury... and explain the consequences of failing to conform or obey the admonition." Generally, if the hazards are known and recognized by viewers, then the signs may not need to include consequences. If multiple warnings or prohibitions are used on a single sign, prioritize them so that the most important information is on top. Remember to use only critical text, discarding any technical or unnecessary information in favor of a succinct message. When possible, clearly identify the hazard on signs. This educates the public and may result in more voluntary compliance than a simply-stated directive.

Keeping signage consistent increases recognition and decreases the time the viewer needs to comprehend the message. The same warning legend, size, and format should be used for each occurrence of a particular potential hazard project-wide. Dam owners also may increase recognition, compliance, and safety by designing project signage that is consistent with pre-existing sign standards.Interpretive signage offers a unique opportunity to communicate specific messages to visitors that may be appropriate at hydropower projects. Development of interpretive signage is a complex process beyond the scope of this report, but it is worth

mentioning as a valuable option for owners and operators. Interpretive messages often are used to change behavior, educate, or evoke an emotion in the viewer. These signs support management objectives, tell a story, and reveal meanings of and relationships among built, manipulated, natural, cultural, and other natural resource features (USBR, 2000). Interpretation of a phenomenon that exists may offer an opportunity to educate the visitor as to the potential hazards associated with or in the vicinity of the object of interest.

Key Concepts

Gather knowledge base, assess existing conditions, and decide on basic sign characteristics for the complete safety signage program before designing specific signs.

- Use signal words appropriate to the level of risk.
- If appropriate, identify the hazard.
- Emphasize succinct legends, avoiding technical terms or jargon.
- Consider viewing time, education, and risk prioritization when choosing and arranging legend text.
- Keep sign design, and hazard-specific text, consistent for the entire project and, if possible, with pre-existing sign standards.

D. Sign Placement and Location

Safety signs should be placed based on the location of the potential hazard and the minimum distance required to avoid the hazard. Signs should attract the eye of the intended viewer. It is important to locate signs so that persons entering an area from any direction can see one or more of the signs. The location of the signs should be determined using sight lines for the location from which the individual is most likely to be viewing the sign. In some cases, a floating sign or buoy may be most appropriate. The USBR Public Safety Guidelines (1992) state that:

Posting signs should be consistent from point to point. Where the hazard is present over a large area such as a waterfront, large spillway, or conveyance structure, signs should be installed along the full length of the hazard. If a number of signs are installed at a set spacing, an illusion of safety may exist where a sign is omitted. Under these circumstances one could reasonably conclude that the prohibited activities are not only permitted, but are safe.

The height of a sign should be such that the intended audience can read it. The USACE recommends mounting at eye level: 5 to 6 feet standing; 4 to 6 feet driving a car, and higher for trucks and recreational vehicles. Other potential audiences that should be considered are snowmobilers and horse back riders. Mounting height is measured from the viewer's ground level up to the bottom edge of the sign panel. Post lengths should be adjusted for grade changes off trails and roads. Changing reservoir levels also may affect proper attachment height and method. The USACE also recommends that signs mounted next to roadways are a minimum of

6 feet from the edge of the shoulder and, if there is no shoulder, 12 feet from the edge of the traveled way. Where this is not possible, the posts should be made of a breakaway design. Ultimately the most effective viewing height may change. Reservoirs that have large water level fluctuations should have signage placed to be best viewed at full pond or at the level when most people are recreating. Spillway warning signs should be placed far enough upstream of the dam so that swimmers and boaters will be able to move against the current to shore without being swept over the spillway. These distances should be assessed under high flow conditions when the currents are strongest.

Ideally boat barriers should be installed at an angle to the current so that a swimmer holding on to the cable will be pushed toward the shore. Tailrace barriers should be placed far enough downstream so that common watercraft cannot approach too closely and be swamped when the project begins operation. This is particularly true in areas where fishing tubes are popular.

Safety signs commonly are located at public access points. Placement next to informational or interpretive displays, restrooms, garbage cans, fish cleaning stations, and boat ramps increases sign exposure. Repeated exposure to the same warning may increase effectiveness if it is not overdone. Dual exposure methods, such as placing dam warning signs at boat ramps and then again on buoys or boat barriers, increase the viewer's exposure and compliance rate. However, overexposure with redundant signs in the same viewing area or overstating the level of risk of an activity may desensitize viewers and reduce compliance. Occasionally, moving signs to different locations, or changing the sign in some noticeable way, may keep frequent users from passing a sign that becomes "part of the landscape" after repeated viewing.

The use of buoys, boat barriers, fences, and other barrier devices can be an important reinforcement for signage. These types of deterrents make it more difficult for visitors to accidentally put themselves into a potentially hazardous situation. Although a full discussion of these barriers is beyond the scope of this document, project owners and operators should be aware of their advantages and consider them on a case-by-case basis.

Some other things to consider in determining proper sign placement are sun and glare, shadows, orientation, and visitor safety. As a general rule, place signs on the right hand side of the roadway, as close to the standard location as possible. The following guidelines are excerpts from USBR (2000); please see the original document for full guidelines. In some cases, the guidelines presented offer additional information or alternatives to USACE guidelines. Where guidelines differ, site-specific assessments should determine the requirements that most effectively meet the demands of the site.

(1) Signs should be placed where they provide adequate time for viewer response, considering things such as approach speed, road conditions, etc.

(2) Select locations that minimize viewing obstructions. Some common placement locations to be avoided, if possible, include:

(a)Dips in the roadway or trail.

(b) Just beyond the crest of a hill.

(c)Where the sign may interfere with the normal operation of the facility.

(d) Too close to trees or foliage that could cover the face of the sign.

(3) Place the sign within the viewer's "cone of vision."

(4) Guidelines for installation of Warning, Regulatory, and Guide signs on roads are as follows:

(a)Height - The bottom of the sign should be a minimum of 3 feet above the level of the roadway on roads posted for speeds of 30 mph and over. For roads posted for speeds less than 30 mph, the bottom of the sign should be set a minimum of 30 inches above the ground where the sign is being placed.

(b) Lateral Clearance - The distance from the edge of the roadway to the inner edge of sign can range from 6 to 12 feet. The normal minimum is 6 feet. In cases where the roadside topography precludes the 6-foot minimum, the inner edge of the sign shall be no closer than 2 feet from the edge of the road with no shoulder and no closer than 2 feet from the outer shoulder

(c) Canting - Normally, signs should be mounted approximately 93 degrees to the direction of, and facing, those that they are intended to serve. This canting aids in the reduction of mirror reflectivity. Sign faces are normally vertical; but on up and down grades, it may be desirable to tilt the sign from vertical to improve readability.

(5) Sign coordinators and road engineers should be aware of "sign clutter," a situation in which new and different signs are added to a location over time, and the overall effect is to force the viewer to wade through a mass of uncoordinated information to obtain the information he or she needs. "Sign clutter" situations should be reevaluated to combine, redesign, and eliminate signs to reduce clutter.

Regardless of a sign's location, it should stand out from its surroundings. Signs that blend in with their surroundings are less likely to be noticed and consequently less likely to be complied with. Section V of this document contains examples of proper and improper signage placement, design, and upkeep.

Key Concepts

- Place signs at the location of the potential hazard and visible from far enough away to allow the viewer to respond to the warning.
- Post at a height that is appropriate for viewer.

- Place boat barriers far enough upstream or downstream to ensure swimmer and boat safety.
- Double exposure increases effectiveness, but too much signage desensitizes the visitor and may reduce compliance.
- Signs should stand out from their background.

1. Lighting

Lights may be used to illuminate signs, the dam itself, and potentially hazardous areas. Lighting signs should be considered at dams, tailrace areas, switchyards, and even boat barriers for night visibility, particularly if boating at night is a regular activity. Specially designed signs, including lighting, often may be necessary so that safety devices are effective under adverse weather conditions. Lighting also may reduce vandalism. A regular lighting inspection program should ensure that lights are functional.

Key Concepts

- Assess night use and lighting needs.
- Maintain system regularly.

2. Construction Materials

The materials used to construct a sign have an impact on durability and, as the sign ages, legibility. The location of a sign determines the type of material used in its construction, and the cost of the sign should be weighed against the durability. The more durable the sign, the less it will be susceptible to vandalism and damage. Some possible sign materials include: plastic, wood, high density overlay plywood, fiberglass, and sheet metal (aluminum or steel). Use of paper, cardboard, or laminated paper should be limited to temporary signs or when a replacement has been ordered. Particle board also should not be used for permanent signs. Temporary signs should be removed immediately after more permanent signs are in place. The USACE Sign Standards Manual provides detailed guidance on the construction and mounting of signs, including suggested materials, thickness, attachment hardware, finishes, and reflectivity (see appendix A).

The following list of commonly used materials is taken from USBR (2000) (note that the listing of specific brands of materials is not an endorsement of the product):

1. High Density Overlay (HDO) Plywood - Marine quality, 3/4-inch plywood with one side covered with a high density, slick material (the overlay), to which adhesives cling quite strongly. Commonly used as a substrate for pressed-on materials such as reflective vinyl. This substrate should be used extensively for larger signs. It weathers well.

2. Medium Density Overlay (MDO) Plywood - Marine quality, 3/4-inch plywood with one side covered with a smooth but more porous overlay than HDO. This takes paint much better than

HDO because the porosity of the overlay allows the paint to bond with the substrate better.

3. Medium Density Fiberboard (MDF) - A pressed-particle board product that takes paint (silk screening) very well and weathers well.

4. Plastics that may be used include:

Acrylic, which is a hard, rigid material that withstands abrasion well but breaks easily. It is often used as a clear protective covering over another sign.

Polycarbonite is similar to the acrylic panel but is softer, with a greater flex. Its softness makes it more likely to be marred by dust and blowing sand

Polyethylene and polypropylene are fairly common materials that are suitable for most routine sign applications. They are soft materials that have sufficient rigidity to stand up as small signs, but not so rigid that they are easily broken. They come in basic colors, and they take paint (silk screening) well. Generally, they weather well; however, their softness makes them easy prey to vandals wielding sharp or pointed instruments. Initial and replacement costs are low.

5. Carsonite© - Carsonite is a patented material that combines fiberglass and epoxy resins to make a strong but flexible substrate. Used most often in a thin, vertical format, it is also used for small routine signs. Its hard, impervious surface is best used as a substrate for decals, although silk screening is possible. It is very resistant to impact and weather. Initial and replacement costs are low.

6. Aluminum - A long used, common substrate for routine, smaller signs. Message usually silk screened onto substrate. Easily and significantly damaged by bullets and other forms of vandalism. It has good weather resistance. Medium initial and replacement costs.

7. Tyvek - A fibrous, paper-like material that has good short-term resistance to inclement weather and animal damage. Very flexible and light. Easily stapled to wood.

8. Cardboard - A paper product that degrades quickly in inclement weather. Takes paint (silk screening) well, depending on the slickness of the surface. Easily nailed or stapled. Used primarily for seasonal posters.

9. Porcelain enamel on steel - This material is highly resistant to scratches, impacts, and weathering. Most often used on interpretive signs, it offers a very appealing appearance, but at a high initial and replacement cost. It lends itself well to the use of graphics. While expensive, it has a lifetime of 20 years or more.

10. Fiberglass embedment - In this process, a paper image is embedded in a fiberglass/epoxy resin panel. Preparation of the first image is initially a high cost. Second, third, and subsequent copies can be quickly and cheaply made at the time of the original and set aside for later embedment at a relatively low cost to replace a damaged or stolen original. The fiberglass resists scratching, impact, and weathering very well.

11. Metal - Engraved or acid etched metals, aluminum, and stainless steel are often used for signs. Such signs have a long service life, are generally good or very good in their resistance to scratching or impact. Initial cost is generally medium to high, as is the replacement cos

12. Redwood - Routed redwood signs have been a federal land managing agency standard for a long time. These types of signs are expensive because of the high material and fabrication costs.

13. High Density Foam Boards - Three-dimensional signs made by cutting a matt and sandblasting to the desired depth. Sand blasting and matts may also be used to make three-dimensional wood signs from 2-inch thick material.

The method of mounting the sign should be adequate to withstand any elements that the sign will be subjected to, including possible inundation from flood conditions. The USACE Guidelines contain recommendations for post size and footing depth based on frost depth, number of posts, sign size, and panel height (USACE, 1995). USBR (2000) suggests mounting signs on suspended cables if a sign cannot be placed appropriately to avoid debris or heavy flows. Cables however may pose a risk to anglers or sailboats, so consider site-specific recreation use before installing a cable suspension system.

Key Concepts

- Use materials of suitable durability for site-specific conditions.
- Replace temporary signs with permanent ones as soon as possible.
- Assess possible recreation impacts before installing a cable system.

E. Regular Maintenance

Public safety reviews should be conducted frequently, and protocols should be put in place to gather and assess public comments and reports from personnel about maintenance needs. Sign maintenance is one of the most problematic areas of a safety signage program. Inadequate maintenance may reduce compliance with prohibition signage, inaccurately or ineffectively warn of potential hazards, and indicate limited enforcement. A well maintained system is safer, and it demonstrates to visitors that the dam owners are safety- and community-minded.

Vandalism is perhaps the most common reason for required sign maintenance. A program of increased site visitation; requests to police to include public sites on patrols; effective lighting; and, in severe cases, remote monitoring may all curb vandalism. Signs in vandalism-prone areas should be made of durable materials to make vandalism difficult and repairs easy. In combination with the above measures, signs that are vandalized should be replaced or repaired as quickly as possible. Enforcement action may be critical to stopping vandalism, particularly when the community knows of direct enforcement measures such as arrest and fines. Additionally, allowing increased access to popular areas that do not contain potential

hazards may help decrease vandalism directed at gaining entrance to specific reservoir/river sites.

Standard maintenance plans should have contingencies for repairing physical damage from vehicles, replacing missing letters, applying protection from weather damage, preventing overgrowth by foliage, decreasing redundancy between signs, and removing mold and mildew. The USBR (2000) sign guidelines offer suggestions for developing a maintenance schedule, as does the USACE Sign Manual (USACE, 1995). The schedule should address, but not be limited to, the following points: damage, visibility, legibility and appearance, maintenance objective, condition survey, and maintenance performance. In addition, the guidelines suggest repair techniques for a variety of sign types and damage. Fading also is a problem with many signs (e.g., red pigments tend to fade more quickly than others). Using brass or stainless steel attachments may reduce rust staining as can placement of signs above possible high water marks, as long as it would not remove the sign from the intended viewer's cone of vision. Pruning trees and bushes and mowing grass from around signs should take place on a regular basis.

In addition, if possible, when standardizing signage, use one of two methods: (1) replace all the signs at a particular access area or site, or (2) replace all of one type of sign project-wide (e.g., "No Trespassing" signs). This will increase viewer recognition of safety signs and minimize the variation in signage at the project.

Certain signs are designed specifically so as to be seen at night. The reflectivity of these signs should be tested periodically. To test visibility, create a small panel (about 8 inches by 10 inches) using sheeting which has an acceptable level of reflectivity. At night tape the test panel to the face of the sign. Step back about 30 feet, hold a flashlight about 2 inches from your face and shine it at the sign (USBR, 2000).

1. If the inspection panel is brighter than the sign, replace the sign within the year.

2. If the sign is brighter than the inspection panel, the sign still has several years of life remaining.

3. If the sign and the panel have equal brightness, the sign has 1 to 2 years of useful life remaining.

Key Concepts

- Conduct frequent inspections to ensure that signs are maintained and repaired as needed.
- Take precautions to help reduce vandalism to signs.
- Repair or replace damaged signs quickly.
- Check the reflectivity of signs that are meant to be seen at night.

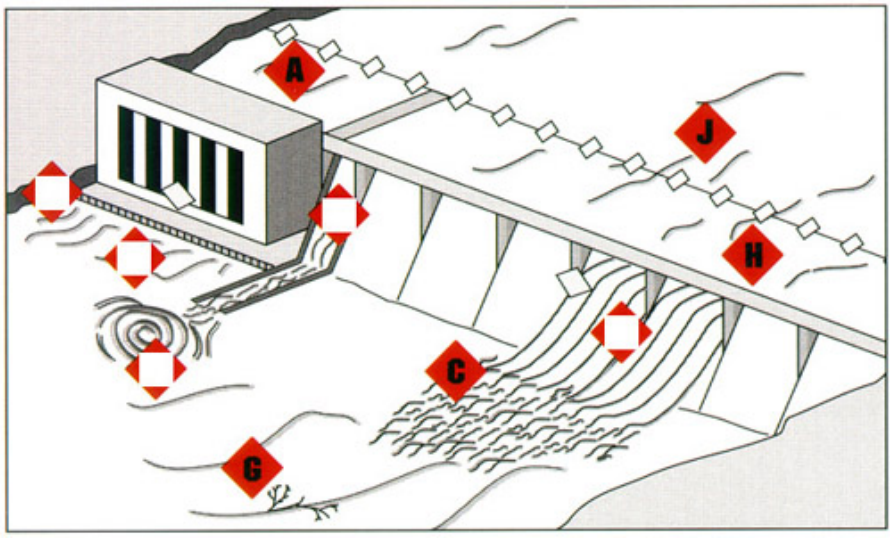
- Set up reporting protocols for employees or visitors to report signs in need of repair.

IV. EXAMPLES OF POTENTIAL HAZARDS REQUIRING SAFETY SIGNAGE

A site or condition represents a significant public safety hazard if there is reasonable potential for a visitor to suffer injury or death because of an inherent condition at that site. The potential for injury or death is related to the nature of a hazard as well as the frequency and type of visitors to a site. For example, an area that has a relatively benign hazard that is subject to frequent visitor usage may be considered a large or significant public safety hazard because of the greater possibility of an injury occurring at the site. A high hazard condition, even with low visitor usage, should be considered a significant public safety hazard.

The first step in developing a sign plan is to inventory site-specific characteristics and the dangers associated with them. Types and locations of dangers should be identified with the purpose of creating a safer environment while still providing reasonable access to the public. In the following section, we list some of the most common hazardous areas that may be found at hydropower projects, and explain the applicability of signage throughout the project area.

A. Upstream of the Facility



A Hazardous areas marked by buoy lines
C. Strong unpredictable currents above and below dam gates
G. Submerged hazards above and below dams
H. Open spillways may not be visible from above dam
J. Ice that forms near a dam is often thin and unsafe

Source: HUG Safety Pamphlet entitled "Fatal Attraction"

This is the area above the dam that is influenced by its operation, including the reservoir impounded by the project or areas of the river that are affected by a change in the operation of the project.

1. Lake Levels

Project operation may cause the level of the reservoir to fluctuate. Sometimes the fluctuation is minor, and at other times the level may rise or drop by a number of feet in the course of a day or two. As lake depths change, objects protruding from the lake bed that normally are not hazardous for users may become problems. Similarly, areas that at high reservoir levels are suitable for launching, taking out boats, or for passage may become unsuitable as the reservoir level drops. If the level of the reservoir fluctuates noticeably during the traditional recreation season for an individual project, signs can help make recreationists aware of these potentially hazardous situations. In some cases, it may be possible or even necessary to mark submerged objects with signs, buoys or floating barriers. Narrow channels can be marked to offer safe passage through shallow areas. As a reservoir level drops, it may be necessary to adjust the marked navigational channels so that navigation is still possible.

2. Recreation Sites--Boat Launches

Boat launches provide an opportunity for making users aware of potential hazards in the vicinity of the ramp itself and potential hazards that are located throughout the project area.

Boat launches are good places to post area-wide information, such as regulations, hazardous conditions and areas, clearances at bridges and power lines, and other safety information. It may be appropriate to have a map of the reservoir at the boat launch, identifying potentially hazardous areas, swimming areas, and bridges. Signs marking safe swimming areas at the boat launch site and the location of other safe swimming areas are also appropriate.

3. Recreation Sites--Portages

Well marked portages may be very important to the safety of boaters attempting to travel downstream. Portages should be indicated by appropriate signs that direct boaters to take-out points. The portages should be constructed with a safe landing, well upstream of hazardous areas such as spillways and intake structures. Canoeists and kayakers may be tempted to go over low dams and spillways where the perceived hazard is low. This should be discouraged through the use of signs and barriers and through strict enforcement by appropriate officials. HUG recommends a crossed paddles symbol on a rectangular sign with or without directional arrows to guide recreationists (HUG, 1988). See section V.F for examples of these signs.

4. Ice

During the winter, ice may build up on lakes and reservoirs encouraging public use of ice-covered surfaces. Ice fishing, ice skating, cross-country skiing, and snowmobiling are just a few of the winter activities that dam owners might expect. There may be a necessity to develop signage specific to these types of facilities. Thin ice may be hazardous to a variety of winter recreationists. There are specific project features that may cause thin ice conditions. Swift currents, devices to prevent gates from icing up, intakes, submerged gates and changing reservoir levels may create areas of thin ice. Special measures may be required to warn visitors of site conditions and to limit accessibility to areas that may be hazardous. These areas should be well marked with signs and, for high use areas, possibly fences. Where ice skating is expected, a designated area for ice skating may be the best option for confining the activity to

safe and well supervised areas where ice conditions can be monitored throughout the winter months.

Snowmobile users and cross-country skiers may be exposed to a variety of hazardous conditions. Winter hazards have a tendency to change with weather conditions and storms. For instance, avalanche danger and ice conditions vary greatly depending upon changing natural conditions. Effective route marking is one way of dealing with keeping users away from some of the hazards. If possible, limiting access to a few points will allow for information dissemination to all of the users of the area. Specific information can then be centrally located at access points.

Also, icing conditions at the dam structures may be hazardous. For instance, ice that forms on structures can fall causing injury to individuals in the vicinity. Ice formation on lines and cables can cause them to sag, which changes the nature of potential hazards in the area.

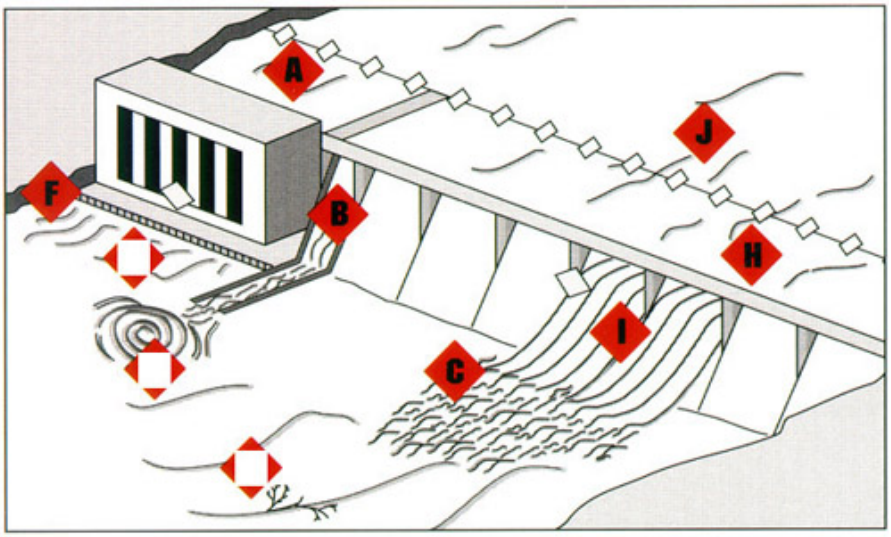
5. Bridges, Cables, and Transmission Lines

Bridges, cables, and transmission lines that cross the project may be hazardous to users, especially if they are low enough to restrict the passage of certain boats or to allow arcing of current from lines to sailboat masts. Signage that is suspended over the water via cables should be used with care, especially if there is sail traffic. The presence of sailing activity does not necessarily preclude overhead signage, but extra care will need to be taken to ensure that the safety sign itself does not pose a hazard. Fluctuating reservoir levels may affect the amount of vertical clearance, as can hot weather and ice storms that often cause power lines to sag. One option is to place staff gages at access points indicating the maximum clearance based on the water level. Signs in the vicinity of the lines or bridges should remind recreationists about height limitations. The National Electric Safety Code offers guidelines as to the minimum height above maximum pond level that is required for various voltages and sizes of reservoirs. Any hazards such as these that may extend over a large width of the project should have signs at several points along the entire area that is potentially hazardous.

6. Uniform State Waterway Marking System

The USWMS was developed in 1966 and is in use on many of the waterways throughout North America. It is a buoy system that is used to mark channels and provide information about boat restrictions on water bodies. While designed for use on lakes and other inland waters that are not portrayed on nautical charts, the USWMS was authorized for use on other waters as well. It provides an easily understood system for small boat operators. The USWMS is currently undergoing some changes. It is being merged with the United States Aids to Navigation. These changes are being implemented gradually and all users of the systems should be in compliance by 2003. Special care should be taken to inform visitors of these changes. Information about the USWMS and the modifications can be found on the Boatsafe and USCG web sites (see web links in section VI.B)

B. At the Facility



A. Hazardous areas marked by buoy lines
B. Sudden water discharge from dam gates
C.Strong unpredictable currents above and below dams
F.Slippery surfaces on dam structures and shorelines
H. Open spillways may not be visible from above dam
I. Debris passing over or through dam
J. Ice that forms near a dam is often thin and unsafe

Source: HUG Safety Pamphlet entitled "Fatal Attraction"

These areas include all areas that are directly utilized as a part of project operation. Many facilities are now remotely operated, and remote operation or automation of hydropower projects may increase the chances of accidents at the projects by eliminating the observations, judgments, and warnings of an operator. These unstaffed, remotely controlled facilities may start at any time and may require additional safety devices and signage to adequately warn and protect the public.

1. Dams

Dams may pose public safety risks, and public access to these structures may be prohibited, depending on the dam's location, type, and configuration. Signs and physical barriers should be used to keep the public out of unsafe areas on and around dams. Vertical drops, steep slopes, machinery are all potentially dangerous elements of dams. When dam access is restricted, it is important to cover all land and water access points, with signage and other appropriate safety devices.

Some dams have roads, trails, or other public access along the dam crest. When public access to a dam is desired (e.g. scenic overlook other recreational activity use) or unavoidable

(e.g. public roadways), good safety signage, along with other protective measures, must be in place to ensure safe use of authorized public access areas on a dam.

2. Spillways

Spillways can cause very hazardous situations. Ungated overflow spillways are particularly dangerous because they may be difficult to recognize from the reservoir, and boats can be easily drawn over them. The nature of spillways is such that it can be difficult to notice that there is a significant change in elevation from one side of the spillway to the other. For this reason, overflow spillways are especially dangerous during low light periods. Gated spillways can cause hazardous situations depending on their operation. For instance, when Taintor gates are raised so that the bottom of the gates are above the water surface, the spillway is essentially an overflow spillway and is very dangerous. These types of spillways are also very dangerous when the gates are raised to a point where the bottom of the gates are below but near the water surface. With the gates in this position, it is not apparent that they are raised, and the water surface is often fairly calm. However, the subsurface currents are very swift and dangerous. In some gate positions, dangerous whirlpools develop upstream of the gates. However, when gates are open only a few inches, they may pass water with little upstream hazard created. Spillway releases can create turbulent and dangerous whitewater. When spillway gates are raised or flashboards suddenly trip, the unexpected discharges can be hazardous to downstream individuals on the shore or in the water.

Deep, submerged spillways and outlet works are generally considered to be relatively safe because the hazardous currents are well below the surface. However, since these spillways cannot be seen from the surface, they are particularly dangerous to swimmers and scuba divers.

Access to spillways should be restricted. Signs and barriers should be used to keep the public out of the spillway area. To increase safety upstream of the spillway, a floating boat barrier with appropriate signage may be put in place during the entire recreation season. In many situations, floating barriers should be installed at a diagonal so that the barrier will tend to push the individual along the barrier in the direction of an escape point. Signs should be of significant size and contrast so as to be legible from a distance such that recreationists would not have to put themselves into a dangerous situation to read the warning. Access to the dam and spillway structures should be restricted through the use of signs and fences.

3. Intake Structures

Inlets to power structures, canals, tunnels, conduits, siphons, or other structures designed to pass water through openings in the project can be very dangerous. From the surface, such areas may provide little visual evidence of the dangerous undercurrents. Intake areas are usually equipped with trashracks that prevent anyone from being drawn into the turbine. However, it would be hazardous to be swimming or boating near the intake areas, because a person could be pinned against the trashracks making escape improbable. Signs for the intake areas should be visible to recreationists approaching the area from any direction. It may be appropriate to install

boat-restraining devices in addition to safety signage to keep individuals out of the hazardous area.

4. Powerhouses and Ancillary Facilities

Power switchyards are located at many facilities. The electrical shock associated with many of these facilities usually is obvious, and such facilities are generally well protected with signs and fences. High voltage lines associated with these facilities may be in areas where boaters and anglers could accidentally make contact with them. Project structures can present many safety problems where man-made structures pose a hazard due to vertical walls, drop-offs, uneven materials such as rip-rap, or slippery smooth surfaces such as spillway chutes. Signs, barriers, and other protective measures should be employed to exclude the public from unsafe project areas.

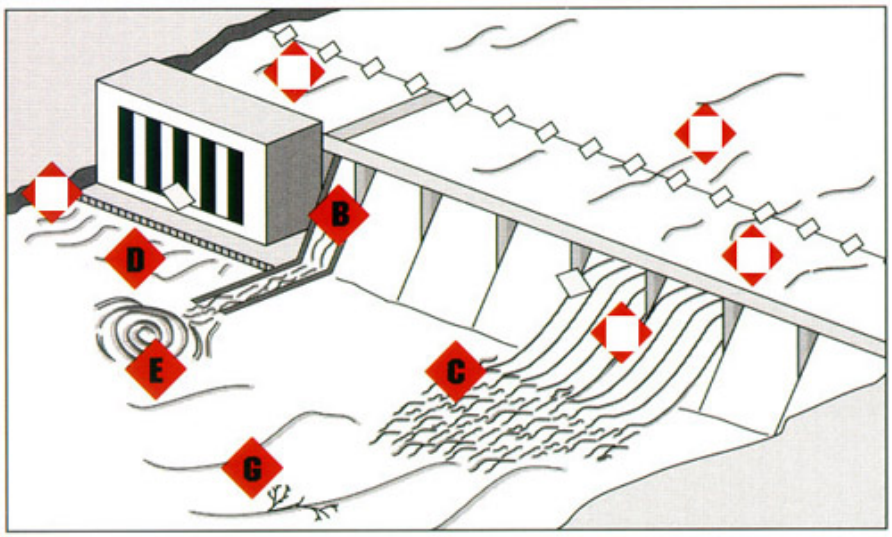
5. Canals

Some facilities have canals associated with their operation, and water may be diverted from the river through canals to produce power. These canals can be hazardous if individuals gain access to them. In addition to signage, escape ladders and grab lines may also be used as additional safety measure in canals. Ultimately, conditions may warrant the use of fencing around canals to completely exclude individuals from entering the area. Trash racks, bottom siphons or taps, and submerged intakes are all potential hazards that should be considered when assessing safety signage needs at canals.

6. Bypassed Reaches

Some riverbed areas below dams have been bypassed for many years. In the old riverbed, or bypassed reach, there may or may not be a minimum flow of water. If high volumes of water quickly spill into these areas, the potential hazard to individuals below the dam could be great. Appropriate signs for these areas are necessary to ensure that individuals are aware of the potential danger. In some cases the riverbed may be overgrown depending on the amount of time that has passed since water ran in the river on a regular basis. If spillway flows are discharged into the river bed, changing water level signs should be placed such that anyone entering the area will be aware of the potential dangers. In some cases, dam owners should consider the use of a telephone "hotline" with a recording that reports the daily release/discharge schedule. In some cases owners are required by license article to provide this "hotline." Signage at the hydropower project could be used to make users aware of this feature. Warning sirens or other active systems along with explanatory safety signage may be necessary to ensure public safety.

C. Downstream of the Project



B. Sudden water discharge from dam gates
C.Strong unpredictable currents above and below dams
D.Sudden turbulent discharges from automatic generators
E.Deceiving reverse currents below spillways
G. Submerged hazards above and below dam

Source: HUG Safety Pamphlet entitled "Fatal Attraction"

This is the area affected by the discharge associated with power generation or spillway flows. The zone of effect will differ from project to project and is largely dependant on project operations.

1. Tailraces

Both the powerhouse and tailrace areas can contain significant hazards. Tailrace areas are generally more dangerous than intake areas. Sudden increases in tailrace flows when generators go on line are often very hazardous to individuals who are near the shorelines, wading, or boating in the tailwater areas. The degree of the hazard varies depending on such factors as the volume of the flow, the rate of change of the flow, the turbulence created, and the size of the tailrace area. Tailrace areas below spillways can become turbulent and dangerous whitewater areas. When spillway gates are raised or flashboards suddenly trip, the unexpected discharges can be hazardous to individuals in the downstream tailrace area along the shoreline or in the water. It is particularly important that signs be placed such that anyone entering the tailrace areas will be made aware of the hazards. Warning sirens or other active systems may be necessary, in addition to explanatory safety signage, to help ensure public safety.

2. Water Levels

Water levels downstream of the project can change rapidly posing a danger to anyone that is in the area at the time of discharges. Adequate signage and warning devices should be placed to help alleviate any dangers. This is particularly important if patterns of flow release are erratic or changing from their past operations. A public awareness campaign should be implemented to

inform the public in the event of significant changes in discharge patterns or quantities that affect downstream water levels.

The operation of the project can have a major impact on the potential hazard associated with it. The full range of operation conditions must be considered in determining the amount and type of signage that is required.

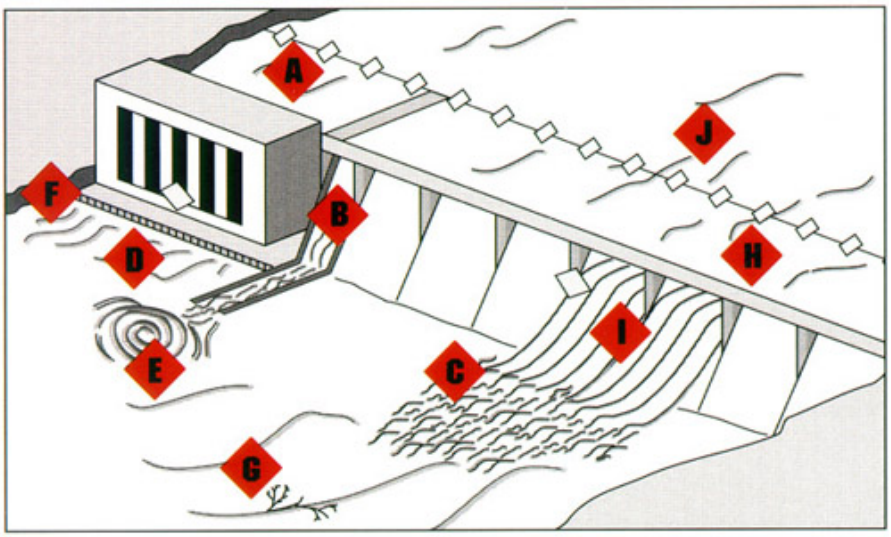
Run-of-river operations generally are less hazardous than peaking operations, because the flow through the project tends to be more constant. The flow at the project varies with inflow to the reservoir. Inflow is affected by precipitation patterns, as well as by any other facilities that are located upstream. It is possible to have a project that has no storage capacity and operates as run-of-river that actually operates on a peaking schedule because of an upstream peaking operation.

Peaking operations tend to be more hazardous than run-of-river, because calm tailwaters between generation periods can give recreationists a false sense of safety. As generation begins, the tailwaters rise. They can become swift and hazardous in a very short time. Changing water level signs as well as audible and visible (light) signals are important in warning recreationists of potential and impending danger. The use of a siren and strobe light warning system for changing water levels, in addition to safety signage, can help to reduce the risk to individuals in the area.

3. Slippery Surfaces

Changes in water levels can cause surfaces such as the shoreline or rocks downstream of the project to be very slippery. This is especially true during colder times of year when ice forms as water levels change or areas that are affected by spray from discharging gates or spillways. Signs should be used to remind individuals using these areas, especially if public access is allowed, of the care that needs to be taken to avoid injury.

D. Types of Activities, Special Events, and Temporary Conditions



A. Hazardous areas marked by buoy lines
B.Sudden water discharge from dam gates
C. Strong unpredictable currents above and below dams
D.Sudden turbulent discharges from automatic generators
E. Deceiving reverse currents below spillways
F. Slippery surfaces on dam structures and shorelines .
G. Submerged hazards above and below dam
H. Open spillways may not be visible from above dam
I. Debris passing over or through dam
J. Ice that forms near a dam is often thin and unsafe

Source: HUG Safety Pamphlet entitled "Fatal Attraction"

The types of activities that take place in the project area can vary greatly from one project to another. Some of the factors that influence activities, and therefore signage needs, are the size and depth of the reservoir, whitewater or other boating opportunities downstream of the project, the presence of sport fish species, the amount and type of public access at the project, location of parks and recreation areas, and any state and local ordinances regarding speed and type of watercraft allowed. In addition, construction or major maintenance activities may represent unique public safety concerns that require special signs, traffic control measures, or other curtailed or relocated public access.

Special events at hydropower projects require special considerations. It may be possible to partner with a sponsoring organization ensure that safety information is available to all participants through posted signs or printed materials. Special events may require new signs. There also may be a need for seasonal or temporary signs. For example, nesting periods for

threatened or endangered species, local development, or other temporary situations may require special signs.

Some events, such as fishing tournaments, may last several days and can bring large numbers of people to a hydropower project, many of them unfamiliar with the reservoir. This combination of a large numbers of people, shared activity space, and unfamiliarity with the waterway can increase the level of hazard that is present in the area. Proper planning and the use of additional temporary safety signage can reduce the potential risks.

V. ANNOTATED SIGNAGE EXAMPLES

The following section contains examples of various signs in place or planned for FERC licensed and exempted projects. Each photograph includes the signage text and brief comments. The comments are meant to point out particularly effective (or ineffective) aspects of each sign with the goal of training the viewer to identify effective signage design. Some signs also have recommendations for changes to make them more effective. Signs were included as examples of font choice, spacing, non-technical language, color scheme, trigger words or even general placement. Comments and recommendations are presented for conceptual context only, and are not legally binding.

Notes

- All company information and site names have either been removed or changed for confidentiality.

- The inclusion of company logos and contact information is encouraged on all signs, but in small text size along the bottom border of the sign panel. The contact information should be designed to avoid visually conflict with or diminish the clarity of the displayed safety message.

- These photos and examples were provided by dam inspectors, agencies, dam owners or other safety organizations. Examples were also taken from Public Safety Plans, operations and inspection reports, site visit photographs and printed and web based safety documents. In particular, many examples of safety signage were taken from the USACE Sign Standards Manual (USACE, 1995). Portions of this manual are reproduced, with permission, in Adobe Acrobat (PDF) file format in appendix A.

- The Symbols section (V.I) is provided as examples of common symbols that be used at hydroelectric projects. These examples were taken primarily from the USACE Sigh Standards Manual (USACE, 1995). The USACE adapted many of them from the NPS and the FHWA.

- Inclusion of signs that represent the style of a particular agency or organization should not be construed as a strict endorsement of that style. Signage examples are included as noteworthy examples of safety signage concepts that are currently in use.

A. Examples of Bad Signage

B. Boating Safety

C. Dam Ahead (Danger)

VI. BIBLIOGRAPHY AND WEB LINKS

A. Bibliography

This bibliography is a compilation of documents that were referenced either directly, or indirectly (resources listed in documents that were referred to). Documents with an asterisk (*) were used directly in developing this document. This is not intended to be an exhaustive list of safety signage documents but a starting resource guide. The Commission will be maintaining and adding to this safety bibliography as resources become available.

Submissions are being accepted for inclusion into this safety bibliography. Please contact FERC at SafetySignageComments@ferc.gov. Please include the reference in the same format that follows and a brief description of the document.

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B. Web Links

Name	Link
The Access Board	http://www.access-board.gov/indexes/accessindex.htm

Alaska Boating Safety	http://www.dnr.state.ak.us/parks/boating/
American Public Power Association	http://www.appanet.org/general/links/related.htm
American Public Works Association	http://www.pubworks.org/
Americans with Disabilities Act Guidelines for Buildings and Facilities	http://www.access-board.gov/adaag/html/adaag.htm
ANSI Member Roster	http://www.ansi.org/public/db_list/member.asp?category=U
Association of Energy Engineers	http://www.aeecenter.org/
Association of State Dam Safety Officials	http://www.damsafety.org/
Boat Safe	http://www.boatsafe.com/
California Department of Boating and Waterways	http://dbw.ca.gov/
Canadian Boating Safety Office	http://www.ccg-gcc.gc.ca/obs-bsn/main.htm
Clark County Marine Patrol	http://www.boatclarkcounty.org/
Colorado State Parks Boating Safety	http://parks.state.co.us/boating/
Energy Search	http://www.energysearch.com/
FERC Guidelines for Public Safety	https://www.ferc.gov/industries/hydropower/safety/psguideline.pdf

GSA List of Signage Terms	http://www.gsa.gov/pbs/firstimpressions/signage/glossary.html
GSA Signage Guidelines	http://hydra.gsa.gov/pbs/firstimpressions/signage/signage_guidelines.html
GSA Signage Presentation	http://hydra.gsa.gov/pbs/firstimpressions/signage/introduction/introduction.html
International Organization for Standardization	http://www.iso.ch/
Manual on Uniform Traffic Control Devices	http://mutcd.fhwa.dot.gov/
Michigan Dept. of Natural Resources	http://www.dnr.state.mi.us/
Minnesota Water & Boating Safety	http://www.dnr.state.mn.us/information_and_education/water_safety/
National Safe Boating Council	http://www.safeboatingcouncil.org
National Water Safety Congress	http://www.watersafetycongress.org/
National Survey on Recreation and the Outdoors (NSRE)	http://www.srs.fs.fed.us/trends/nsre.html
Nevada Dam Safety	http://ndwr.state.nv.us/engineering/damsafety.htm
Oregon State Marine Board	http://www.boatoregon.com/
OSHA Hazard Communication Publication	http://www.osha-slc.gov/SLTC/hazardcommunications/hc2inf2.html
Pennsylvania Dam Safety	http://www.dep.state.pa.us/dep/deputate/watermgt/we/DamProgram/Main.htm

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Washington Boating Safety Officers Association	http://www.boatwashington.org
West Virginia Dam Safety	http://www.dep.state.wv.us/wr/OWR_Website/index.htm

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APPENDIX A Selected Chapters from USACE Sign Standards Manual (Reports EP 310-1-6A and EP 310-1-6B, last updated 1995)

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APPENDIX B FERC Guidelines for Public Safety at Hydropower Projects

APPENDIX C Oregon Uniform Sign Guidelines for Recreational Boat Launching and Transient Tie-Up Facilities

APPENDIX D HUG Public Safety Committee Recommendations