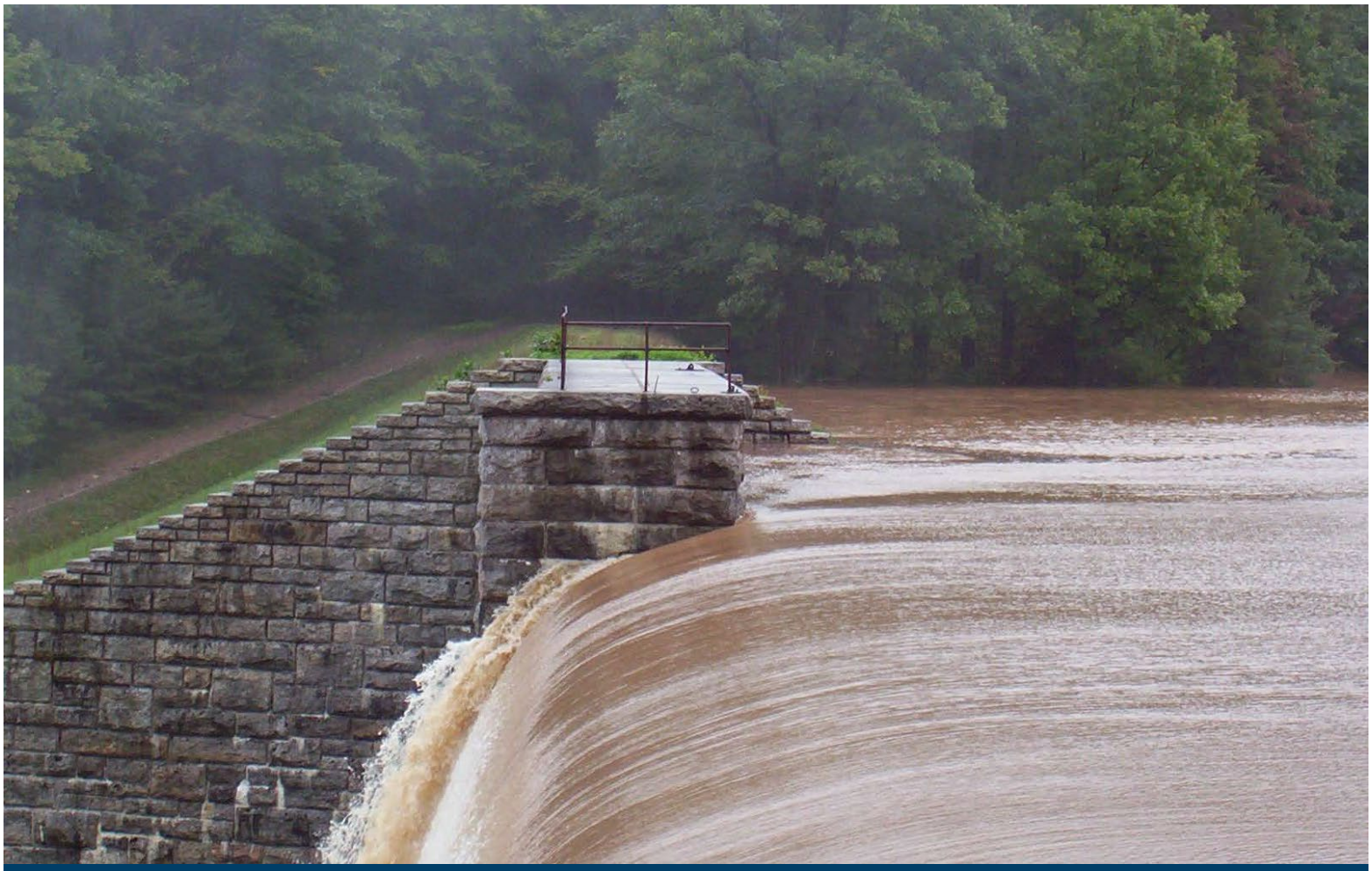

Dam Safety Warning Signs Best Practices

Promoting Public Awareness and Preventing Loss of Life

FEMA P-2188 / September 2021

FEMA

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Table of Contents

Introduction

The Federal Emergency Management Agency's (FEMA) Dam Safety Warning Signs Best Practices is a compilation of existing leading practices from industry leaders including the American International Standards Institute (ANSI) Association of State Dam Safety (ASDSO), Bureau of Reclamation (Reclamation), Canadian Dam Association (CDA), Federal Energy Regulatory Commission (FERC), Federal Highway Administration (FHA), United States Army Corps of Engineers (USACE), United States Coast Guard (USCG), United States Society on Dams (USSD) and more.

These best practices have been developed to address the need to accurately and consistently warn against the hazardous conditions resulting from dams and their operations nationally.

1. Objectives

One common control measure used to increase safety around dams is the use of safety signage to warn the public of potential hazards associated with the dam site. FEMA's Dam Safety Warning Signs Best Practices are intended to encourage the use of proven and researched safety signage practices from industry leaders to promote stronger public safety practices nationally. While readers are encouraged to contact the authority responsible for the dam, in the absence of any standards, this document can be used by any dam owner, operator, regulatory agency or member of the general public who is interested in increasing public safety around dams through the use of safety signage. Best practices outline the process for identifying the need for safety signage, designing and implementing the signs, and continually monitoring and assessing their effectiveness.

These practices provide guidance for the general use of safety signage around dams, but do not address every type of risk or hazard that may be present at all dam facilities. Therefore, these practices are intended to be adjusted to best suit each dam facility's individual circumstances and conditions. Overall, the Dam Warning Signs Best Practices aims to accomplish the following:

- Provide guidance on proven and practiced dam warning sign design, messaging, and monitoring best practices.
- Promote consistent and recognizable safety signage nationally.
- Reduce the risk of injury or death resulting from dam operations.

2. Limitations

The risks to public safety from activities occurring near and around dams are site specific. This document only addresses the best practices relating to safety signage and does not advise upon other control measures used to protect the public from dams such as, restricting access to hazardous areas using safety booms, instituting safe operating practices so that water is released

gradually and with warning or eliminating these hazards all together. A thorough risk assessment would need to be conducted to identify potential hazards to the public and to develop an appropriate risk treatment plan that covers these other forms of control measures.

3. Dam Owner's Responsibility

The dam owner/operator is directly responsible for managing and monitoring all public risk concerns caused by the dam that are present on their property. The dam owner also has the additional responsibility to understand and communicate the potential hazards impacting locations off their property resulting directly from the dam itself or its operations. Therefore, it is essential that dam owners utilize proper safety signage to warn against any potential danger resulting from dam operation.

It is also the dam owner's responsibility to coordinate with the owners of the surrounding lands to ensure that safety signage is consistent throughout all recreation areas and anywhere up or downstream from the dam that may be impacted by dam operations. This consistency in safety signage will allow visitors to become familiar with the methods and graphics used to depict different risks and hazards around the area.

Each dam owner is responsible for identifying and following any specifics laws or restrictions set out by their state and location jurisdiction.

Assessing Public Risks at Dams

Dam owners and operators are responsible for reducing risk of failures and incidents caused at or around their dams. The Emergency Operational Planning Dam Incident Planning Guide defines a dam incident as an emergency that threatens the integrity of the dam or its components and could result in an increased risk to nearby populations. An incident includes operational releases from the dam (e.g., principal spillway, emergency/auxiliary spillway) that can result in flooded roads, homes, or businesses.

According to the ASDSO's reports on public safety, in 2019 and 2020 combined, dams have resulted in 95 deaths and 37 injuries in the United States. It is essential that owners and operators take the necessary precautions to reduce the risk to public safety around dams. There are several ways dam owners and operators can reduce this risk at their dams, including developing and implementing a robust safety signage program. This section outlines the first steps in determining the necessary safety signage needed at your dam assessing the relevant public safety risks.

Additional risk assessment strategies are required for general operation and maintenance of your dam.

The key actions to take when determining what types of safety signage to incorporate at your dam are as follows:

1. Identify what types of activities are occurring at and below dams and related structures by inspecting the site, conducting interviews with site personnel, and carrying out social media searches.
2. Identify public access points and portage trails that are present at and below dams and related structures by inspecting the site, reviewing maps, and interviewing site personnel.
3. Identify the types of hazards or risks present at the dam facility under a range of scenarios ranging from low flows up to stages of flood flows, at which point the public could reasonably be assumed not to be entering the river channel or reservoir.
4. Assess the frequency and severity of these hazards or risks.

Quick Public Safety Risks Guide:
1. Identifying Dam Activities
2. Identifying Potential Risks/Hazards
3. Identifying the Frequency/Severity of the Risk
4. Risk Treatment and Mitigation

1. Identifying Dam Activities and Locations

The first step in determining what safety signage is necessary for your facility is to identify the types of public activities that take place at and around the dam. Determine locations where the public is accessing the site.

Taking note of the types of public activities common around a dam will help identify potentially risky activities or hazardous areas that may be encountered. Here are several examples of popular activities taking place at or around dam facilities:

- Boating (kayaking, canoeing, paddle boarding, tubing, motorboating, jet skiing, etc.)
- Swimming
- Fishing
- Hiking/Walking
- Camping
- Snowmobiling, ice skating, and ice fishing
- Annual/seasonal events

Techniques that can be used to determine the types and locations of activities that are occurring include:

- Site inspections, paying particular attention to any deleterious materials left behind, pathways, portage trails, boat launches, as well as signs that the public has breached existing control measures such as damaged fencing and graffiti.
- Interviewing site personnel, local jurisdictions, law enforcement and others who may have knowledge.
- Conducting social media searches.
- Reviewing maps for portage trails, boat launches, swimming areas.

Identifying the types of activities that occur at the dam and the locations where the public is accessing the site are fundamental to determining the most effective locations to place signage.

2. Identifying Potential Risks/Hazards

The next step to assessing public safety at dams is to identify the present risks and hazards that could affect public safety at a dam. A compilation of several dam related guidance documents identifies the following situations and activities as posing threats to public safety at and around dam facilities.

2.1. Hazards from water flows

The following are potential hazards resulting from unpredictable or unexpected situations involving water flows at or around a dam:

- **Hydraulic rollers**: Hydraulic rollers are lethal hazards that are commonly found at the base of low head dams, as well as the discharge points from spillways of large dams, and the discharge points of hydropower stations. Under certain flow conditions, a recirculating current can form, which pushes objects to the surface and back toward the dam before being submerged again. This can keep anything that is caught circulating for a prolonged period of time and is one of the most common and lethal hazards associated with dams.

- **Seepage/strainers:** Seepage/strainers are flows of water through the dam via cracks or joints. The force of suction created by the water flowing through the cracks/joints can pin objects, including people, trees, and plant mater to the face of the dam.

- **Flows through gated structures/Conduits:** Flows through gates on dams or breaks in the structure of a dam (conduits), may appear harmless from the surface, but can cause dangerous undercurrents and suction forces. Victims can become trapped by the hydraulic pressure which can lead to drowning or fatal injury.

- **Swift currents over spillways:** Spillways are often difficult to recognize or may not be visible from upstream of the dam. If spillways are left unmarked and without a barrier, boaters and swimmers can be drawn over the spillway, leading to very dangerous situations.

- **Sudden releases/unexpected changes in water levels:** Water levels on rivers, streams or lakes can change quickly from changes in weather, rainfall, and man-made releases of water. These sudden changes in water levels can cause the formation of deadly waves and fast-moving water which threaten the lives of those recreating downstream.

- **Risk of hypothermia:** Some regions of the United States see river and lake temperatures well below what is safe to swim in, especially during the winter months. This is also common downstream from Hydropower dams and can come as a shock to patrons swimming. Hypothermia only takes a few minutes of exposure to cold temperatures before the body experiences severe effects such as loss of motor functions which can lead to drowning.

2.2. Human Activities

The following are common human activities at or around a dam that have the potential to lead to serious or deadly injuries. These should be taken into consideration when identifying potentially dangerous scenarios or hazards.

- **Extreme sports:** Many people seek opportunities to feel an adrenaline rush or show off to their friends, and dams offer several features that people choose to take advantage of. Unfortunately, many people do not understand the dangers involved with these activities that can often lead to serious injury or death. These activities can include whitewater kayaking over dams,

skateboarding or cycling in the spillway, climbing or repelling down the face of the dam or intake structure, boogie-boarding or bodysurfing through spillways and many more scenarios.

- **Playing in spillways**: Many people assume spillways are areas to swim or slide in, however they should never be used in this manner. Swimming or playing in spillways presents several dangers including being swept away by overtopping, colliding with the structure at high speeds, and getting stuck in a hydraulic roller or the dam structure itself.

- **Jumping from structures:** Low head dams are often used as jumping or diving platforms without recreators' understanding the full extent of the dangers they face. These behaviors can result in people being swept up in hydraulic rollers, being swept downstream, or being trapped against the face of the dam, among many other risks.

- **Fishing from Dams:** Many people use dams for a variety of recreation activities including fishing. Fishing from dams can pose many risks including falling into the dam and being swept up in hydraulic rollers, swept downstream, being trapped against face of the dam as well as other.

- **Vandalism and terrorism:** Dams are often targeted for vandalism or terrorist activities due to the easy accessibility and the amount of damage they can cause to people and the surrounding areas.

- **Suicide:** Dams and dam structures have been used as a means to attempt or commit suicide. Owners and operators should take this into consideration when determining access around the dam site.

3. Identify the Frequency/Severity of Risks

Once the dam activities and hazards have been identified, the frequency and severity of these need to be assessed in order to translate them into a risk assessment using the following process.

3.1. Identify Likelihood

The first step is to identify the likelihood of an incident occurring. The Canadian Dam Association (CDA) has outlined the following criteria to ranking the likelihood of an event occurring.

Table 1: Incident Likelihood Ranking

Descriptor	Definition of Likelihood	Ranking
Very Frequent	Occurring more than 10 times in the hazardous area in any 1 of the 3 last years. -OR- 24 or more occurrences in total in the last 3 years.	5
Frequent	More than 2 occurrences in the hazardous area in any one of the last 3 years.	4
Occasional	Any occurrence in the hazardous area in the last 6 years.	3
Possible	Any occurrence in the hazardous area in the last 10 years.	2
Remote	No known occurrences in the last 10 years.	1

Note: these occurrence times should be adjusted to accurately reflect individual dam circumstances.

3.2. Identify Consequence

The next step outlined by the CDA, is to assign an incident consequence rating for the activity and corresponding hazard. The following should be used to determine the incident consequence rating.

Table 2: Incident Consequence Rating (ICR)

Anticipated Incident Consequences	Description	Ranking
Fatality	Fatal	5
Critical	Permanent, Partial or Total Disability	4
Major	Medical Treatment or Stranding (rescue required)	3
Minor	First Aid or Stranded (Self-Rescue Possible)	2
Insignificant	No Attention Required	1

3.3. Calculate Risk Rating

Once the activity/hazard's likelihood and consequence has been ranked, you can calculate the risk rating by multiplying these two numbers. Table 3 displays the possible rating resulting from the 5-point rating system suggested above.

Table 3: Risk Rating

Likelihood	Incident Consequence: Significant (1)	Incident Consequence: Minor (2)	Incident Consequence: Major (3)	Incident Consequence: Critical (4)	Incident Consequence: Fatal (5)
Very Frequent (5)	5	10	15	20	25
Frequent (4)	4	8	12	16	20
Occasional (3)	3	6	9	12	15
Possible (2)	2	4	6	8	10
Remote (1)	1	2	3	4	5

3.4. Set Risk Boundaries between Action Levels

Since it is the dam owner and operator's responsibility to manage the dam's risk, it is also their responsibility to assess and prioritize these risks. Therefore, they should set a standard for what is considered a high, medium, or low risk based on risk tolerance of the dam owner, regulatory environment and public value. The boundary for each of these three action levels should be assessed and evaluated regularly as new research and policies are released. Below are two examples of potential boundaries for each risk rating.

An example of calculating risk and setting risk boundaries can be found in the Appendix (linked HERE).

4. Risk Treatment and Mitigation:

Once potential hazards and associated risk have been identified, it is important to take measures to reduce risk to the public through risk treatment and mitigation practices. Risk treatment can take the form of:

- Eliminating the hazard: this is typically the most effective form of risk reduction when it is practical.
- Mitigating the hazard: this can take the form of altering operation or altering the infrastructure of the dam.
- Controlling exposure/access to the hazard: examples include physical fences or barriers to deter access to high hazard zones.
- Educating the public: this can be done through public outreach events, creation of pamphlets, or other educational resources.

- Prepare for emergency responses: provide 24/7 emergency contact numbers at and around the dam facility.

- Warning against risks through safety signage: Best practices will be detailed throughout the rest of the document.

4.1. Safety Signage

While efforts should always be made to eliminate or reduce the hazard, this document will focus on the incorporation of safety signage to reduce risk to the public. Additional risk assessment and risk treatment measures should be taken when conducting a full risk assessment.

Based on information gathered through the CDA, FERC, USACE, Reclamation and consultation from industry experts, this best-practices document will provide information based on the establishment of two types of hazardous "zones" along with informational safety signage.

4.1.1. DANGER ZONE

Danger zones are areas where there is a reasonable likelihood of immediate or grave danger capable of causing serious injury or death resulting from exposure to the hazard created by the dam. These areas are typically found near the dam structure both up and downstream of the dam itself.

Danger Zone Signs:

Danger signs should denote Danger Zones where the threat to the public is severe and has the potential to cause serious injury or death. Avoid using Danger signs in areas that do not denote this level of threat in an effort maintain public trust in the identified severity of all safety signs. Note that danger signs cannot, in themselves, prevent access to a given region and simply notify the public of a present danger may not be enough. Additional control measures should be installed to reduce access where warranted.

4.1.2. WARNING ZONES

Warning zones area areas with a moderate level of threat to the public and have a high likelihood of resulting in minor injury or stranding resulting from exposure to the hazard created by the dam. These zones often act as precursor before entering into a Danger Zone, but can also be present independent from Danger Zones.

Warning Zone Signs:

Warning signs should only be used to denote Warning Zone where a level of threat exists, but not a serious or potentially fatal level. Warning Zones are often used as a precursor to a Danger Zone to imply an increased level of risk as people proceed closer to the danger. As outlined later in this document, note that danger signs cannot prevent access to a given region and simply notify the public of a present danger. Additional control measures may be installed to reduce access.

4.1.3. INFORMATIONAL/EDUCATIONAL SAFETY ZONES

There exist many areas around dam related lands that do not directly pose a threat to the public. These areas can be used to convey advice for avoiding of potential hazards such as the location of dangerous waters and safe portage trails, or where information can be found on the timing of operational releases from the dam, and what action should be taken by the public if a siren is sounded, etc.

Informational/Education Safety Signs:

Informational/educational signs may be paired with danger or warning signs to provide additional context. For the purpose of this document, we will focus on signs that provide some information into potential threats/hazards that exist at a sight, but which do not cause high or moderate levels of danger which would warrant a Danger or Warning sign.

Messaging Guidance

One of the main challenges of developing effective safety signage is ensuring that the message is clearly understood by a wide range of audiences. Therefore, prior to developing and designing safety signage, we must consider what is being conveyed to the public and how it is being conveyed. The following should be considered when creating the message of your signage:

Does the Sign:

- Clearly convey the hazard the viewer is facing?
- Clearly convey the action that should be taken to avoid the risk?
- Provide the appropriate level of urgency in order to give adequate time for the appropriate response?
- Account for the education level of the viewer?
- Account for the predominant languages spoken in the surrounding community?
- Promote consistency throughout all safety signage?
- Stand out from its background and is it easily seen by all viewers?
- Provide information related to the name and owner of the facility, along with a 24/7 contact number?

Quick Message Guidance Guide

1. Challenges of Messaging

When developing safety signage, it is important to consider how people perceive and respond to risks that are presented to them in messages. Below are several challenges Mark Green Ph.D has

outlined in his article *The Psychology of Warnings,* regarding the psychology of signage along with suggestions on ways to overcome them.

1.1. Response Gap

For most people, human nature creates a "response gap" or a delay between receiving a warning and acting upon this warning. The American Association of State Highway and Transportation Officials (AASHTO) identifies this phenomenon as "perception-reaction time" and suggests allowing for 1.5 seconds of perception time for every 1 second of reaction time required to avoid a risk or hazard on roads. This perception reaction time should be taken into consideration when developing and the sign placement, text height, coloring/contrast, message complexity (i.e., length) among other items to reduce complexity and increase readability of safety signage. This will help to provide the viewer enough time to receive, understand, and respond to any risks or hazard warnings.

1.2. Perceived Risk

Most individuals do not take the appropriate actions until they believe that the danger communicated will personally affect them. However, the greater the perceived danger or risk, the greater the chance of taking action. Therefore, safety signage should include strong verbs to convey the level of risk accurately and fully.

1.3. Familiarization

The more familiar an individual is with an area, the less likely they are to act on danger/warning signs. This is since they have previously visited these areas and have not personally experienced any dangerous situations, they assume the same will always be true. However, this is particularly harmful if certain times of the year or certain times of the day produce higher levels of danger and while the patron may have been safe previously, they may not always be. To overcome this challenge, it is important to consider placing temporary signage during times of high risk or identifying specific high-risk times on the safety signage.

1.4. Dilution

While safety signage is necessary and leads to more informed viewers, having too much signage dilutes the strength of the most important signs. Therefore, it is important to prioritize the most dangerous risks when incorporating safety signage at your facility.

2. Language and Messaging Content

Concise, strong, and actionable messaging is crucial to ensuring effective communication of a hazard/risk and the appropriate action to be taken. Therefore, it is crucial to incorporate clear and recognizable signal words, include strong and impactful language, and provide an action for the viewer to take. Reclamation suggests:

- Using signal words to identify level of risk

- Using active verbs
- Using short sentences
- Using elementary level proficiency
- Avoiding gender specific language
- Identifying the hazard and state the corrective action to take

2.1. Signal Words

The Federal Energy Regulatory Commission (FERC) states that signal words (also known as trigger words) should be used as a headline to attract the viewers' attention and identify the specific level of risk. For example, for the highest risk "Danger" should be used followed by "Warning", and "Information" for lower levels of risk. The choice of signal word should accurately portray the appropriate level of risk a hazard is causing and should coincide with the suggested color combinations described in the Design Standards section of this document. The broad use of signal words across various public safety agencies has led to an increased recognition of the risk/hazard.

2.2. Active Verbs

Reclamation identifies the need to use vivid language and active verbs to fully attract the attention of safety sign viewers and increase the likelihood of acting on the danger identified. This includes phrases such as "Risk of Death" and "Rapidly Rising Water Levels." These phrases allow the viewer to easily interpret and picture the risk at hand and understand the level of danger face. Avoid loose or interpretive language such as "potentially," "may," or "possibly."

2.3. Identify Hazard and List Action

The CDA suggests that safety signs should not only identify the level of hazard the viewer is facing, but also the hazard to which the sign is referring, and the action required. For instance, the first message line could read: "Danger: Dam Ahead" or "Warning: Strong Currents." Then the second line message should then state the action required such as "Exit Left in 500 Feet" or "No Swimming or Wading." By including the hazard as well as the action, the viewer is more informed about the conditions of the location and understand exactly the action requested of them to avoid the hazard/risk.

3. Simplicity of Signage

As previously mentioned, viewer's attention spans are short, fleeting, and often lagging in time. Therefore, it is essential to keep signs as simple and clear as possible. Use the following techniques when crafting the messaging of your sign:

- Avoid any dam industry specific language (e.g., weir, low-head dam, hydraulic rollers, etc.).

- Use as few words as possible to get a message across.
- Eliminate any redundant signage.
- Eliminate signage that distracts from more important/high risk safety signage.
- Avoid acronyms.

4. Using Locally Predominant Languages

Some U.S. citizens and visitors do not speak English as their primary language, which presents a huge challenge when designing and implementing effective dam safety signage. Take time to evaluate the surrounding community as well as the dam site's visitors to identify which primary languages are widely spoken to determine the need for specialized signage. Keep in mind that communities often grow and evolve quickly in our global environment and therefore it is recommended that primary languages be evaluated every few years to determine the most effective safety signage for everyone visiting a dam site. There are two primary methods for accommodating signage for non-English speaking patrons; translated signage and pictograms: translating safety signage and including graphics/pictograms.

Check out the Resilient Analysis and Planning Tool (RAPT) to learn a bit more about your community including the % of population with a limited English Language proficiency.

4.1. Translated Safety Signage

For communities with a significant amount of non-English speaking visitors, safety signage should be displayed in English as well as the other prevalent language being spoken. Be sure to consult a native speaker of the other prevalent language to avoid misinterpretation or misrepresentation of the message. To avoid diluting the safety signage, prioritization should be placed on translating signs for the most dangerous risks. For signs warning against urgent and high-risk hazards, translated messages should be presented on separate, equally visible, and equally sized safety signs. For less urgent warning and informational messaging, consideration can be made to combine both translations of the message onto one sign. This can be done by having the translations staked on top of each other, while following the spacing and sizing guidelines identified later in this document, or by placing one translation on each side of the sign. Whenever possible and especially for urgent and high-risk hazards, separate signs should be used to reduce the audience's reaction time to the warning.

4.2. Pictograms/Graphics

Another highly effective method for conveying safety messaging to non-English speaking individuals is by using pictograms and graphics. Pictograms are especially helpful in identifying activities that are prohibited as well as identifying a hazard and the associated consequences. If an activity is

easily conveyed through simple imagery, including no swimming or no fishing, pictograms can be an effective tool to reach a broad audience and increase awareness of the risks. Additional information on specific pictogram design will be outlined in the Design Standards section of this document.

5. Community Understanding and Education

5.1. Notification of Releases

While not all dam emergencies can be predicted, timed releases are scheduled events when extra water will be released down a dam. This can be extremely dangerous for individuals recreating both up and downstream from the dam. In order to reduce this risk, the community should be notified about these releases ahead of time. These notifications can be done by social media platforms such as Facebook or Nextdoor, posting warning notices at local convenience stores and gas stations and even sending out short message service (SMS) text messages to individuals in the surrounding community. These notices, especially social media posts and SMS text messages, can also be leveraged to notify the community about unscheduled releases as they occur.

5.2. Quick Response (QR) Codes

An important aspect of public safety is educating the public about the surrounding community and the associated hazards/risks. To avoid dilution of the most important and high-risk safety signage, QR Codes can be used to provide additional information to patrons. QR Codes are a machine-readable code used for storing website links (Uniform Resource Locator [URL]) and are read by the camera of a smartphone. Essentially, one can point their smartphone camera to a QR code and automatically be linked to a website, brochure, or online resource of the QR code owner's choosing. By placing QR codes on signs at and around a dam facility, patrons can learn additional information about the area without overwhelming an area with signage or littering the area with paper signs and brochures. QR codes can also be used to link to translations of signs into a variety of languages to increase non-English speaking patrons' understanding of the risks at hand.

Note: QR codes are not appropriate for all circumstances due to the need for cellular service. Cellular service should be tested at the potential QR site prior to creating the sign.

QR Codes can:

- Be used to provide educational resources about the dam, dam facility, and the surrounding community.
- Link to translations of signs to provide more accessibility to safety signage.
- Reduce the waste and pollution caused by paper brochures and flyers.

5.3. Learning about the Surrounding Community

One way to better understand the risks at and around your dam facility is to gain a better understanding of the surrounding community. FEMA's RAPT is a free geospatial information systems (GIS) web map that allows federal, state, local, tribal, and territorial community leaders and community members to examine the interplay of census data, infrastructure locations, and hazards, including real-time weather forecasts, historic disasters, and estimated annualized frequency of hazard risk.

Design Standards

Dam safety signage should be designed to clearly and concisely convey a message to provoke action from the public. Therefore, it is good practice to harness the color patterns, formatting, and overall design standards of other well-known public safety signage guidelines to create familiarity with the message the dam safety signage is aiming to convey.

This chapter presents different signage options that are used by FERC, USACE, CDA, Reclamation and more. It is recommended that safety signage should be designed based on your individual dam needs and requirements and should follow the best practices outlined below.

Quick Design Guide:
1. Sign Layout and Paneling
2. Text Sizing
3. Text/Topography
4. Message Sizing
5. Sign Sizing
6. Formatting/Text Spacing
7. Alignment
8. Color/Contrast
9. Pictograms
10. Sign Materials
11. Assembly
12. Reflectivity/Lighting
13. Buoys and Dayboards

1. Sign Layout/Paneling

Proper layout and design of safety signage will help to produce quality signs for easy interpretation. Reclamation suggests paying attention to the following when determining sign layout:

- Making the sign the right size. Consider the location and the distance from which the sign will be read.
- Allowing the right amount of space around the text.

- Avoid diverting attention from the message. Design the sign structure and supports to easily blend with the sign and the general environment.
- Avoid distractions such as odd colors/designs or unusual words/symbols.

According to FERC guidance, safety signage typically has either one, two, or three panels. Panels are especially useful when creating large signs to provide flexibility in replacement options and providing opportunity to remove or alter sections of the sign at a time. Each public safety warning sign can contain signal words, message text, additional information about the dam facility itself (phone numbers, official names, regulatory agency etc.), and graphics/pictograms. The following are examples of potential breakouts of sections into panels. It is essential to include a signal word to identify the level at risk at hand on public safety signage. This word should be featured very clearly at the top of the sign and should follow the suggested color patterns identified below for the level of risk at hand. Pictograms can be featured alone or attached to a safety sign to further convey the message at hand.

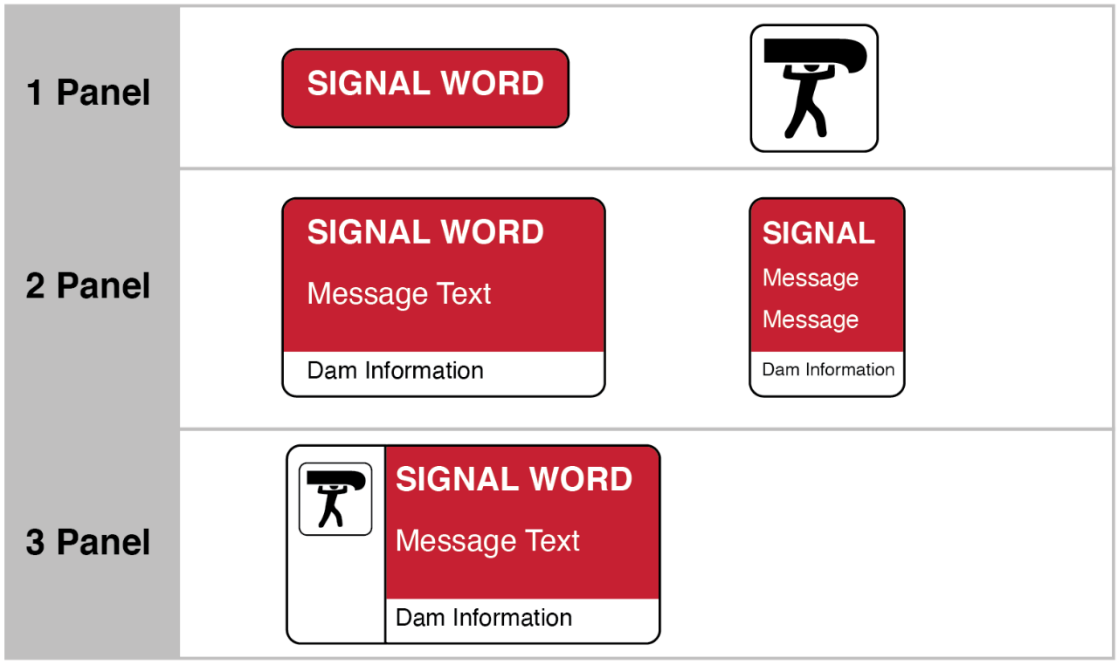


Figure 1: Sign Paneling

2. Text Sizing

Safety signage will be approached from various means of transportation, at various speeds, and by various distances. Therefore, it is important to take these factors into consideration when designing safety signage. Use the following guidance from the USACE, CDA, and Reclamation to determine the minimum text height for your safety sign. The capital letter heights identified below correlate to the size of the message component of the sign. The headline/signal word should be at least 1.5X this identified message capital letter height.

Table 4: Safety Sign Text and Sign Height

Viewing Distance (in feet):	*Operating Speed (if applicable)*	*Capital Letter Height (in inches)*	*Recreation Symbol/ Pictograph (in inches)*	*Application: Walking*	*Application: Driving*	*Application: Boating*
0-20	-	1	3		-	-
21-27	-	1	3		-	-
28-41	-	1.5	4.5		-	-
42-55	0-15 mph	2	6			-
56-83	0-15 mph	3	9			
84-111	16-25 mph	4	12			
112-167	26-35 mph	6	18	-		
166-251	36-55 mph	9	27	-		
252-335	-	12	36	-		
336-503	-	18	54	-	-	
504-671	-	24	72	-	-	
672-839	-	30	90	-	-	

3. Text/Typography

A successful and effective sign incorporates clear, legible, and well-spaced typography so that the type does not appear to run off the edge or appear too clustered. The following are researched best practices relating to text and typography from the USACE, the CDA, ANSI and FERC:

- Use Helvetic style Bold for the headline/signal words (Danger, Warning) and main message and Helvetic for all additional lettering and numbering.
- Use capital letters for all letters in the headline/signal words and capitalize the first letter of every word in the main message section.

- The headline/signal word should take up the entire width of the sign, leaving room for appropriately sized margins.
- The spacing between words should equal the capital letter height.
- Spacing between lines should equal half the capital letter height.

4. Message Sizing

Before the size of the sign can be determined, the length of the message must be calculated. This calculation is based on the width of every letter along with the proper spacing in between these letters. The following section will provide examples for calculating the message sizing using Reclamation's Sign Guidelines for Planning, Designing, Fabricating, Procuring, Installing, and Maintaining Signs for Outdoor Public Use Areas. The USACE also outlines this calculation in their Sign Standards Manual Section D: Typography. An Example of these calculations can be found in the Appendix (linked HERE).

4.1. Letter Width

Once you have determined the capital letter height based on the required viewing distance (outlined in Table 4), you can use this number to calculate your individual letter sizing. Each letter, number, and symbol take up different amounts of space on a sign and this variation must be taken into consideration when calculating your message sizing. In the Appendix Table 16, you will see Reclamation's recommended letter widths. Use these widths when determining your letter width.

Note: these widths are identified in "units" and will be later be multiplied by a "factor" number based on your determined Capital Letter Height (identified in Table 4).

4.2. Letter Spacing

Proper letter and number spacing is essential for effectively conveying a message and allowing the reader to easily understand what a safety sign is warning against. The spacing between letters or characters is called Kerning and should be taken into consideration when determining the size of your sign panel. Different spacing distances should be used between different letters, numbers, and characters. In the Appendix's Letter Spacing Section, you will see Reclamation's recommended spacing widths. Use these widths when calculating message width.

Note: these widths are identified in "units" and will be later be multiplied by a "factor" number based on your determined Capital Letter Height (identified in Table 4)

4.3. Calculating Message Sizing

Once you have identified the width of your letters along with the width of your spacing it is time to calculate the total width of your message. This calculation can be done by adding up the total units

of your letters and the total units of spacing and multiplying this number by a factor based on your determined Capital Letter Height.

Additional resources and examples on calculating message sizing are located in the appendix (Linked HERE).

5. Sign Sizing

Once you have determined the size of your message, it is time to determine the appropriate sign size. This includes vertical and horizontal margins as well as the spacing between lines. Reclamation uses the following to determine sign size:

- The signal words height should be equal to 1.5 times the capital letter height, as defined in Table 4 for the message panel.
- The main message height should be equal to the capital letter height, calculated in in Table 4.
- The horizontal margin should be equal to the capital letter height.
- The vertical margin should be equal to the capital letter height.
- The size of the entire message should account for the letters as well as the spacing in between words.
- Spacing in between lines should be half of the capital letter height.

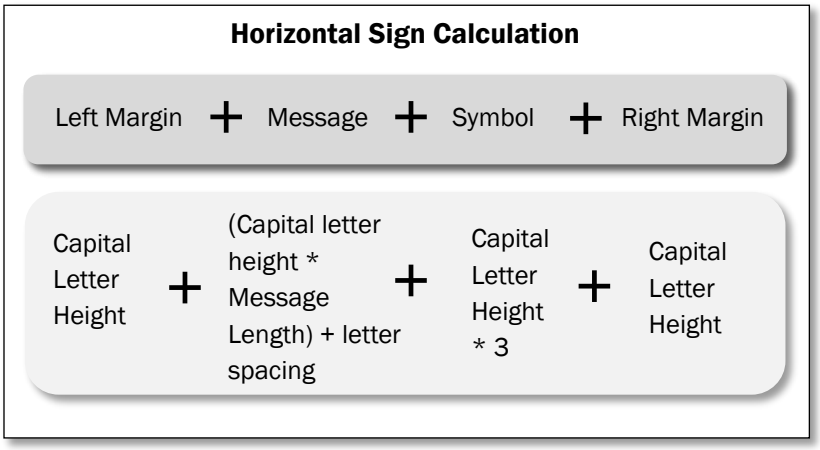


Figure 2: Horizontal Sign Calculation

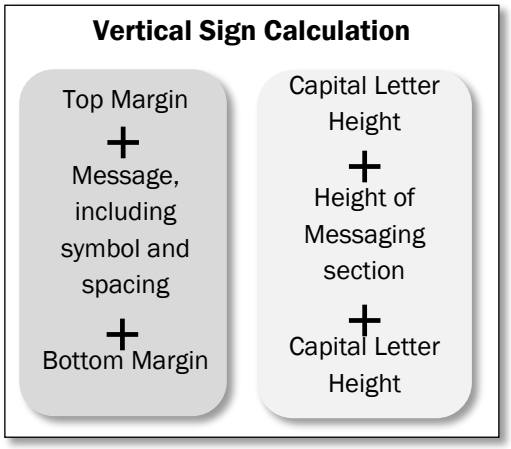


Figure 3: Vertical Sign Calculator

6. Formatting/Text Spacing

The CDA suggests that the format of a sign should consist of a headline/signal word at the top, message in the center and dam specific relevant information on the bottom. The following is an example of a best practice of the format and dimensions developed from Reclamation and CDA.

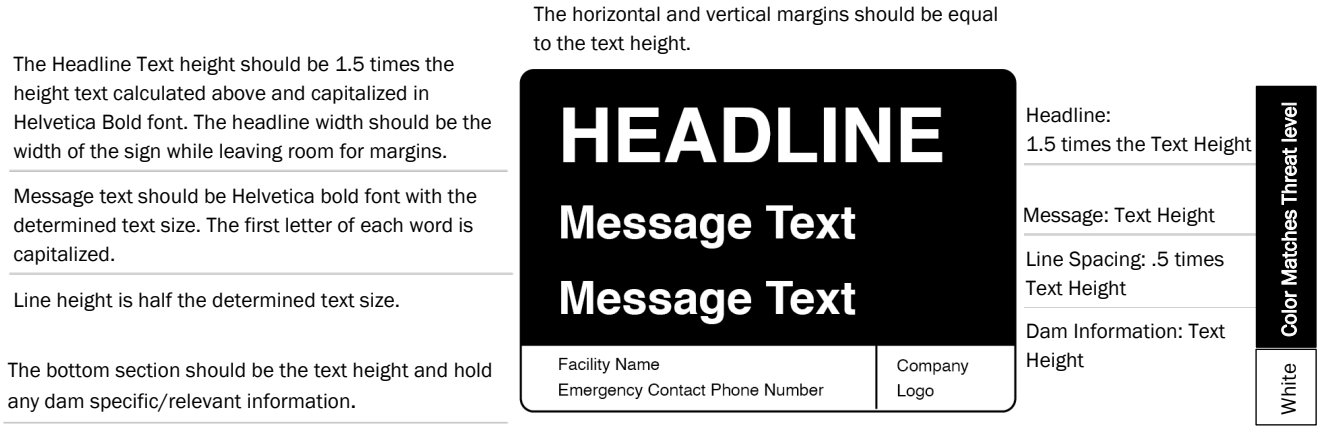


Figure 4: Sign Format/Line Height

7. Alignment

Alignment of your text can play a significant role in the viewers ability to read and digest information as quickly as possible. Sign standards from FERC, USACE, CDA and ANSI all encourage aligning sign text to the left. ANSI sign standards state that “left alignment aids in readability (compared to centered text) by creating a vertical line that the eye naturally locates when searching for the next line of text”. Therefore, in aiding to the readably of the safety message, left alignment of text should be used.

8. Coloring and Contrast

Color and contrast are critical elements of safety signage design and can drastically impact public understanding of the message. Individuals develop strong psychological reactions to colors and color combinations as a result of repetition and common cultural norms. For instance, the Department of Transportation (DOT) uses the guidelines outlined in the Manual Uniform traffic Control Device (MUTCD) to standardize road signs across the United States. Therefore, most associate red with stop, yellow with yield and green with go. By harnessing these established color associations into dam safety signage, the public can easily and effectively be warned of hazards and risks.

FERC guidance also highlights the importance of presenting contrasting colors between the text of a sign and the background on which it is placed. Therefore, signs should follow the coloring combination guidelines specified below for different levels of risk.

According to CDA, FERC and MUTCD, OSHA and many more, red has the highest level of perceived risk and should be used for danger signs. Yellow has the next highest perceived risk and should be used for warning signs. Lastly, blue doesn't have a level of threat associated with it and should be used for informational safety dam signage.

The USACE has outlined the following as the specific color standards to follow when producing safety signage for dams.

Dam Safety Signage Recommended Color Combinations:

DANGER: **Red** retroreflective sheeting **background** with **white** retroreflective **lettering**.

WARNING : Lemon **Yellow** retroflected sheeting **background** with **black** nonreflective **lettering**.

Information/Education: White reflective background with Medium Blue Lettering and details.

Note: Informational/educational signs may be different for different facilities. For example, the national park service has brown signage and many state highway administrations use green signage for information. According to the American with Disabilities Act (ADA), no matter what colors are chosen, it is recommended that characters and symbols should contrast the background by 70% by using either light characters on a dark background or dark characters on a light background. There are numerous online ADA compliance tools that can help you meet this standard.

Examples of safety signage can be found in the Appendix (Linked HERE).

9. Pictograms

As mentioned, pictograms are an effect method to reaching and warning a wide range of audiences. They can be use as either a stand along sign or as an addition to larger signs with additional messaging. Pictograms are most effective when they are black on a white background.

Reclamation has outlined the following size specification for general pictograms or symbol sizing and panel size for a variety of distances.

Table 5: Pictogram/Graphic Sizing Guide

Viewing Distance (in feet)	Symbol/Picture Height (in inches)	Panel size (in inches)
0-27	3”	3.5”x3.5”
28-41	4.5”	5”x5”
42-55	6”	6.75”x6.75”
56-83	9”	10”x10”
84-111	12”x12”	13”x13”
112-251	18”x18”	19.5”x19.5”
252-335	24”x24”	26”x26”
336-503	36”x36”	39”x39”

Examples of pictograms can be found in the Appendix (Linked HERE).

10. Sign Materials

Reclamation states that when properly used, construction material has the potential to enhance sign effectiveness. Sign materials should be selected based on:

- Cost
- Application (used for text or graphics)
- Longevity (consider flood zones, wind conditions and other environmental factors)
- Resistance to the elements/bullets (water and/or shatter resistance)
- Required maintenance

Reclamation states that signs can be manufactured from a variety of materials including wood, metal, plastic, and fiberglass. The types of materials are considered “substrates” while the “message” or lettering is either painted or printed (usually by silk screen printing) onto the substrate.

In general, the softer, more porous substrate materials should be paired with painted lettering because the paint will easily penetrate the surface of the material. Harder, less porous substrate materials should be paired with decals and pressed on vinyl lettering.

10.1. General Safety Sign Materials

The most commonly used substrates, or sign materials, from Reclamation and USACE are outlined in the following sections.

10.1.1. HIGH DENSITY OVERLAY (HDO) PLYWOOD

Marine-quality, 3/4-inch plywood with one side covered with high density overlay. This material works well with decals or pressed on vinyl lettering. This material weathers well and should be used for larger signs.

10.1.2. MEDIUM DENSITY OVERLAY PLYWOOD

Marine-quality,3/4-inch plywood with one side covered in a more porous overlay than HDO. Due to the higher porosity, this material can be paired with painted lettering.

10.1.3. MEDIUM-DENSITY FIBERBOARD (MDF)

Pressed-particle product that accepts paint (silk screening) well and weathers well. This material is widely being used for transportation signs.

10.1.4. PLASTICS

- Acrylic/plexiglass: hard material that withstands abrasion but breaks easily. Often used as a protective coating over other materials.
- Polycarbonate/Lexan: similar to acrylic, but softer with greater flexibility.
- Polyethylene/polypropylene: common materials suitable for large variety of signs. This material weathers well but is appealing to vandalism. Cost for this material are low.

10.1.5. CARSONITE

Patented material that combines fiberglass and epoxy resin to make a strong, flexible material. Very resistant to weather and impact and cost for material is low.

10.1.6. ALUMINUM

Long used, common material for routine and smaller signs. Message usually silk screened onto substrate. Easily damaged by bullets and other vandalism. Cost for material is moderate.

Aluminum-clad plastic: Similar to aluminum, with plastic core to add strength. Highly durable and light weight. Cost for material is moderate

Aluminum-clad Plywood: Similar to aluminum, with plywood backing to add support and stability to aluminum. Cost for material is moderate to high.

10.1.7. SIGNS WITH GRAPHICS MATERIALS

- **Porcelain Enamel on Steel:** Material is highly resistant to weathering and damage. Often used when working with graphics. Cost of material is high but it has a typical lifespan of over 20 years.
- **Fiberglas Embedment:** Process where a paper image is embedded in fiberglass/epoxy resin and is resistant to scratching and weathering. Cost of initial panel is high but replacement costs are significantly lower.

10.1.8. SHORT-TERM/TEMPORARY SAFETY SIGNAGE MATERIALS

- **Synthetic Textiles:** Fibrous, lightweight, and weather-resistant material used for temporary signs.
- **Tyvek:** Fibrous, lightweight, and weather-resistant material used for temporary signs.
- **Cardboard:** Paper product that degrades quickly in inclement weather. Easily painted, nailed, and stapled.

10.1.9. MATERIALS AT DAM SITE

Dam Surface and Surrounding Structures: This is especially common by using stencils to paint directly on the dam surface and surrounding structures. While this method is weather resistant and highly cost efficient, the integrity of the message should be regularly assessed and maintained to avoid deterioration of paint from the elements.

A chart comparing each sign material can be found in the Appendix (Linked HERE).

11. Assembly

Consideration should be made to ensure the foundation and assembly of your safety signage contributes to its longevity. This included planning your bolts, nails, and screw location prior to placing your messaging to ensure they do not interfere with the message of your safety sign. For detailed specifications on sign assembly, including suggestions for bolts, nails and screws, visit the

U.S. Army Corps of Engineer's Sign Standards Manual, Appendix B. Link to this manual as of 8/2021 is located HERE.

12. Reflectivity/Lighting

Any sign intended to be seen in low light conditions (dawn, dusk, overcast, and nighttime) should be created to reflect the same shape and color in both daylight and at night. Reclamation suggests using engineering grade reflective sheeting and to consider high intensity grade sheeting in situations where conditions may warrant additional reflectivity.

Lights can be used to illuminate signs, the dam itself and any potentially hazardous areas. Using external lighting systems should be considered at dams, tailrace areas, switchyards, and boat barriers for low light visibility. Lighting also has the potential to reduce vandalism of signs. According to the USACE, externally illuminated or indirectly lighting a sign should be used when adequate visibility cannot be accomplished through the use of reflective overlays. The following are best practices relating to lighting safety signage:

- The lighting source should be concealed whenever possible.
- Lamps mounted on arms should be avoided if possible because they create a glow and glare that is difficult to control.
- The preferred method for light a sign is by using concealed ground mounted fixtures.
- Floodlights must have a concealed light source to avoid illuminated unneeded areas and blinding approached drivers or boaters.
- Typically, do not use colors to illuminate signage.

Additional information can be found through the USACE, MUTCD and USCG.

13. Buoys and Dayboards

Buoys are typically used to delineate borders or mark hazardous areas on waterways. The area on a buoy that holds words or symbols are called dayboards and the symbols themselves are called daymarks. Dayboards can be used to mark dangerous regions around lock and dams.

The USCG has catalogued several standard buoy designs for different criteria such as movement within a waterway, markings for safe waters and many others. This document will focus on the use of "information and Regulatory" buoys and markings to provide general guidelines for buoys used to convey levels of risk.

13.1. Color/Materials

Information and Regulatory markings have orange geometric shapes against a white background (as shown in Figure 5).

Figure 5: USCG Standard Buoy Symbols

The USCG suggests that all symbols be created with retro reflective materials and when necessary include a lighting source so that daymarks are easily seen from far distances during any time of the day or night.

13.2. Symbol Sizing

The sizing possibilities are endless however standard buoys typically range from 1-9 feet in diameter and are up to 36 feet tall. Reference Chapter 2 of the USCG Technical Manual for detailed information. The following outlines general criteria/best practices when designing a buoy for safety around dams.

Similar to that of regular signage, the required viewing distance dictates the size and spacing of buoys and dayboards. The USCG uses the term "identification range" to designate the distance at which the numbers and letters on a buoy or dayboard can be determined.

In general, the USCG suggests calculating the daymark size by identifying the appropriate "identification range" or viewing distance and dividing by 40 to identify the legend or symbol height (in inches). Additional specifications can be found within the USCG Technical Manual. Table 6 shows guidelines for a three nautical mile visual range size standard.

Table 6: Nautical Mile Visual Range Classification

	Height (in inches)	USCG Identification Range (feet)
Symbol	72	2880
Primary Legend	10	400
Other	6	240

Location Guidance and Installation

A dam owner's plan for sign placement should be developed individually for each project sight based on the site-specific parameters. The following guidelines determine appropriate sizing, location, viewing and mounting practices for sign legibility. It is, however, impossible to anticipate all conditions a dam facility may present so this guidance should be adjusted according to the individual dam site needs.

Quick Location Guide:

Refer to the Assessing Public Risks at Dams, for insight into the types of risks/hazards to consider installing safety signage for. The CDA and FERC have identified the follow as general areas which may present a danger and should contain a warning to the public:

- **Upstream and downstream of the dam site**: Potential hazards can develop from changes in flows or water levels caused by the operation of the dam. The effect of operations on water flows and conditions can occur far downstream of the actual dam or powerplant. These locations should also be considered when evaluating downstream danger and warning zones and hazards.
- **Reservoir:** The reservoir can be defined as the dangerous areas immediately upstream of a dam created by swift currents and undertows. Within this area it can be very dangerous to swim or boat as vessels may capsize and persons may become trapped against the structure and unable to escape.
- **Structure (Dam, low head dam, canal):** Hazards associated with a structure includes slipping, falling, or having contact with dangerous equipment.
- **Spillway:** Spillways can overflow causing significant turbulence and undertow.
- **Spillway Gates:** Hazards develop when these gates open either manually or automatically to release water downstream.
- **Low Level Conduit Outlets:** These openings can create suction forces when in operation. These suction forces can put people at risk of underwater entrapment if they are close to the conduit opening.

- **Tailrace:** Shifting operations can often cause turbulence and undertow within the tailrace.

1. General Placement Considerations

Safety signage should be placed at the entrance of a hazardous area or safety zone (danger/warning) to signify the danger that is present is that specific area. Therefore, when determining sign placement, it is essential to follow the sign sizing recommendations outlined in Chapter Design Standards so that patrons can see and digest the safety message well before entering into this hazardous area or safety zone. This is necessary for providing enough time for patrons to take steps to avoid these areas. The following guidance will provide recommendations for where to place safety signage so that messaging is visible to patrons prior to them entering into the hazardous area. When determining general dam safety signage placement, consider the following from the CDA and Reclamation to increase likelihood of patrons viewing, reading, interpreting, and acting upon a safety sign:

- Providing enough distance between the sign and the danger to provide viewers ample opportunity to avoid the hazard.
- Relationship between the sign and the point of interest. The hazard the sign is warning against should be obvious at the location of the sign. The sign should signify the beginning of a hazardous area and should be viewed from a distance.
- Avoid potential sign obstructions such as trees and foliage.
- Potential obstructions during all seasons and weather conditions.
- Avoid placing a sign in a location that blocks or obscures the sight of the hazard or any other signs.
- Placing signs so that a person walking into an area from a common access point can see one or more signs.
- Warn of hazards from both up and downstream the danger zone.
- Viewing speed and viewing distance during the day and at night.
- Angle of vision of the viewer approaching the sign.
- Place signs where vandalism may be discouraged.
- Sun and glare and the presence of shadows
- Adverse effects of wind, insects, cold, heat, dust, bright sunlight, and other distracting elements to the visitor.
- Avoid sign redundancy.
- Consider flood events and survivability of the sign.

2. Placement for Land Viewed Safety Signage

Land viewed safety signage is typically for individuals engaging in activities such as hiking, swimming, playing sports or accessing boat docs or other public access points. Safety signage for these recreators should detail any potential hazard or dangerous situation that could occur within the area they are recreating. Each sight is unique and should be evaluated based on individual circumstances present at and around the dam site. General guidelines from the USACE for positioning land viewed safety signage are as follows:

- Land viewed safety signs should align with the hazard and be placed in alignments with the control measures (fending/safety booms). This may include along the riverbank, on the dam or on lock structures.
- Typically, land viewed safety signs are intended to be viewed at relatively short distances and therefore should not be overly large.
- If a large area is to be signed, use more than one sign rather than a single large sign.
- An abundance of less important signs will cause critical messages to lose their impact
- Place safety signs close to the area being warned against while providing enough time to avoid any potential threat.
- Place several smaller signs evenly spaced along a structure or riverbank wherever the potential hazard or dangerous situation is present. Avoid leaving large or uneven gaps because patrons may assume these gaps imply a lack of danger in that section.
- Signs should not be submerged during high water or placed too far from the water's edge during low water levels.
- Local conditions should dictate whether a sign is placed parallel to the edge of a structure (requiring only a single-sided panel) or perpendicular (requiring double-sided panels).
- It is important to place signs so that a person walking into an area from a common access point can see one or more signs.

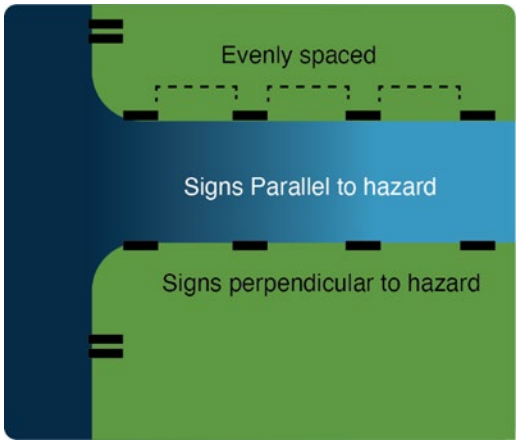


Figure 6: Land Viewed Sign Spacing

2.1. MOUNTING/INSTALLATION FOR LAND VIEWED SAFETY SIGNAGE

The method for installation will vary depending upon the size, ground conditions, and local elements/wind conditions where the sign is being located. If there is concern around the specific installing and mounting arrangement, a professional engineer should be consulted.

Mounting Height

Safety signs should be mounted at the height that is most likely to be viewed by the highest number of individuals. USACE's suggest mounting land viewed dam safety signage between 36"-48." Table 7 outlines the best practice for mounting safety signage intended to be viewed on land.

Table 7: Mounting Height for Land Viewed Signs

Lettering Size	General Pictogram Location: Undesignated	General Pictogram Location: Trail Signs	General Pictogram Location: Boat Ramp	General Pictogram Location: Swimming Area
1.5"	36"-60"	36"	36"	36"
2.0"	36"-60"	36"	48"	36"
3.0"	48"-60"	-	-	36"
4.0"	48"-60"	-	-	36"

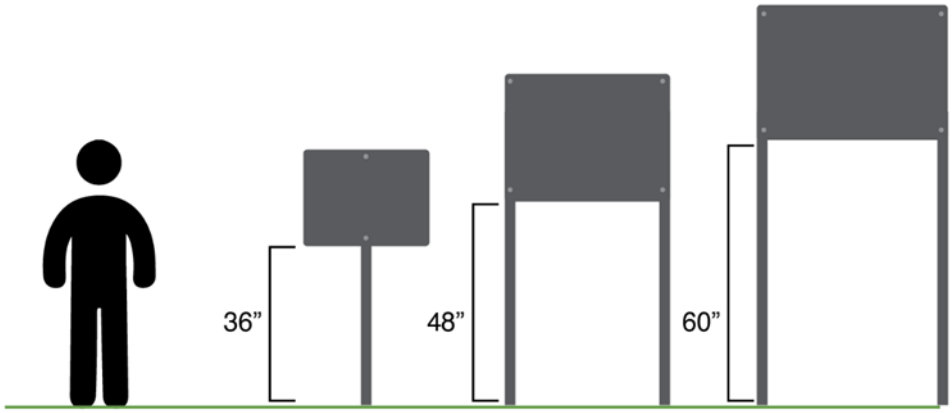


Figure 7: Mounting Height for Land Viewed Signs

Safety Signs On Roadways

When installing safety signage on roadways you must take into consideration the speed at which cars are traveling at. FERC states that for installing on roadways posting speeds for over 30mph, the bottom of the sign should be set at a minimum of 36 inches above the level of the road. For roadways set at speeds less than 30mph, the bottom of sign should be set at a minimum of 30 inches above the ground.

3. Placement for Water Viewed Safety Signage

The safety of boaters and other's recreating in the water is increased if they are able to clearly see a sign, read the message the sign is displaying, interpret the sign and respond accordingly. Therefore, the U.S. Army Corps of Engineers has identified the follow as best practices when determining the position of water viewed safety signage:

- Sign panels should identify the hazard and state the perspective safety zone present (i.e. danger, warning, information). A multi-zone sign warning system will be created to identify higher danger the closer you get to the hazard itself.
- If hazards can be mitigated using fewer signs closer to the structure, there may be no need for multi-zone sign warning system.
- Placement of signs requires review of both high and low water levels. The sign must be positioned so that it is not submerged in times of high water nor does the distance of the sign to the boater at low levels cause confusion.
- Determining water-viewed placement and sizing is much more complicated and should take into consideration the:
    - Width of the river-to determine needed warning time needed prior to avoid a hazard.
    - Water flow-in order to calculate how quickly patrons may travel down the river.
    - Natural or structural elements-these may require multiple safety signs and/or expanded length of safety zone.
    - Light conditions -to avoid sunlight obscuring line of sight to the safety sign.
    - Angle of vision-indicating the maximum angle the panel can be viewed without distortion.
- Signs should be placed at an angle of less than 45 degrees to the river to allow the smallest size panel needed in any particular situation and avoid deteriorating the legibility of the sign panel.
- Due to the unpredictable viewing conditions, it is important to plan for the "worst case scenario" to accommodate for limited viewing.

Figure 8: Sign Zones

3.1. MOUNTING FOR WATER-VIEWED SAFETY SIGNAGE

Water-viewed safety signage can be mounted on a variety of surfaces including on the rivers edge, on or above a lock wall, on cells within the water and on buoys or daymarks. While site specific situations will influence which type of surface suits best for each safety sign, it is important to consider the following when mounting water-viewed safety signage:

3.2. SURROUNDING COLORS

Safety signage should be placed such that they are visible and not obstructed from sight including avoiding placing against backgrounds that will make the sign difficult to see and read. Consider placing safety signage against neutral colors and avoiding busy and distracting backgrounds.

MOUNTING HEIGHT

Safety signs viewed from the water should be mounted at the height that is most likely to be viewed by the highest number of individuals. USACE's suggest mounting water viewed dam safety signage upwards of 48" and for larger signs should be calculated directly based on the lettering size. The following graphic outlines the best practice for mounting safety signage intended to be viewed on the water:

Table 8: Mounting Height for Water Viewed Signs

		General Purpose				
		Undesignated Signs	***No Mooring, Anchorage or Tie Down***	***Hazard Ahead***	***Dam Ahead***	***Dam Lock Signs***
Lettering Size	***3.0"***	48"-60"	48"-60"	48"-60"	48"-60"	
	4.0"	48"-60"	48"-60"	48"-60"	48"-60"	
	6.0"	54"-60"	48"-60"	48"-60"	>63"	52"-60"
	8.0"	>72"	48"-60"	>60"	>84"	>70"
	>8.0"	>9*Lettering Height	48"-60"	>7.5* Lettering Height	>10.5* Lettering Height	>8.75* Lettering Height

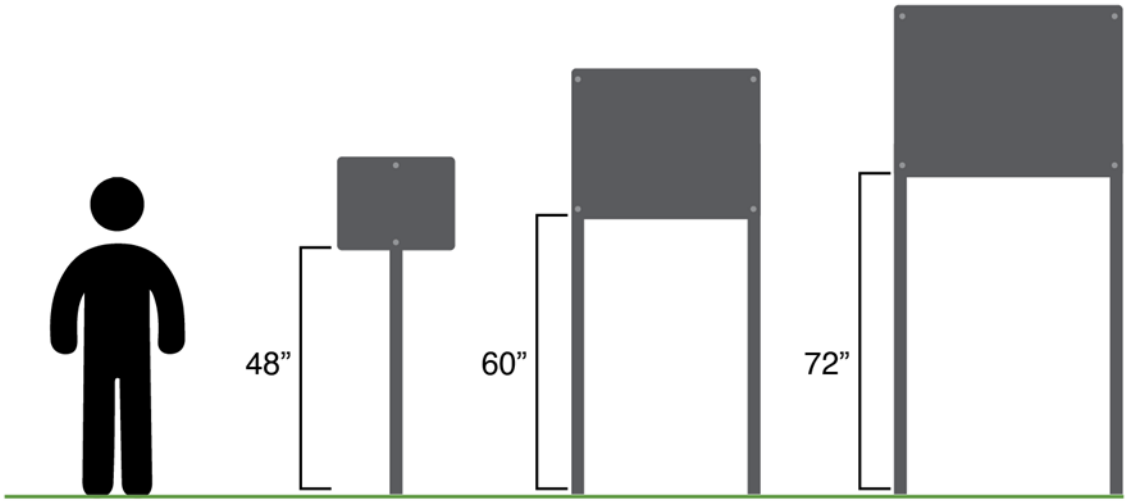


Figure 9: Mounting Height for Water Viewed Signs

4. Placement of Booms and Buoys

Similar to that of regular signage, the required viewing distance dictates the size and spacing of buoys and dayboards. The USCG uses the term “identification range” to designate the distance at which the numbers and letters on a buoy or dayboard can be determined.

In general, the USCG suggests calculating the daymark size by identifying the appropriate “identification range” or viewing distance and dividing by 40 to identify the legend or symbol height (in inches). Additional specifications can be found within the USCG Technical Manual.

The general positioning of water-based safety signage should follow similar guidelines outlined above for water viewed safety signage. Therefore, use the following to determine dayboard and buoy placement.

- Dayboards should identify the hazard and state the perspective safety zone present (i.e., danger, warning, information). A multi-zone sign warning system will be created to identify higher danger the closer you get to the hazard itself.
- If hazards can be mitigated using fewer signs closer to the structure, there may be no need for multi-zone sign warning system.
- Determining dayboard and buoy placement and distance is much more complicated and should take into consideration the:
    - Width of the river-to determine needed warning time needed prior to avoid a hazard.
    - Water flow-in order to calculate how quickly patrons may travel down the river.
    - Natural or structural elements-these may require multiple safety signs and/or expanded length of safety zone.
    - Light conditions -to avoid sunlight obscuring line of sight to the safety sign.
    - Angle of vision-indicating the maximum angle the panel can be viewed without distortion.

- Signs should be placed at a maximum angle of 45 degrees to the river to allow the smallest size panel needed in any particular situation and avoid deteriorating the legibility of the sign panel.
- Due to the unpredictable viewing conditions, it is important to plan for the “worst case scenario” to accommodate for limited viewing.

Safety Signage Maintenance Routine

A safety signage maintenance routine should not only comprise of creating a detailed and robust maintenance plan but should also involve continually updating and assessing your maintenance plan based on changing situations and discoveries. Through this continuous cycle of improvement, safety signage will drastically reduce public risks to potentially dangerous situations around dams. This section outlines the components of a safety signage maintenance plan and encourages its continual improvement.

Quick Maintenance Guide:
1. Safety Signage Maintenance Plan
2. Inventory
3. Inspection
4. Replacement
5. Assessment

1. Safety Signage Maintenance Plan

Developing a robust safety signage maintenance plan and routine will increase the consistency to which safety signage is inspected, monitored, and evaluated.

While good safety signage is essential for increasing public safety around dams, the maintenance and upkeep of these signs are just as crucial. Implementing safety signage is just one step in the overall maintenance routine and should constantly be analyzed to identify areas for improvement. Each dam is faced with a range of environmental conditions, frequency of vandalism/theft and levels of risk present, therefore, each sign maintenance plan should be tailored to an individual dam's conditions and specifications. The following guidance is general suggestions of information and steps to include in your safety signage maintenance plan.

Figure 10: Mounting Maintenance Routine

This plan can live as a standalone document or can be incorporated within a general Public Safety Plan. A Safety Signage Maintenance Plan should act as a living document to be updated and evaluated each year as sign inspections are performed. In general, your plan should include the following sections:

- Inventory of all safety signage.
- Instructions for how and when to inspect all safety signage.
- Guidelines for how to how and when to replace safety signage.
- Strategies for assessing and evaluating current safety signage and maintenance practices.
- Guidelines to review annual public safety incidents and near misses to create new signage or update existing signage and locations posted
- Guidelines to review upstream and downstream recreation and populations at risk to ensure changes are addressed with new or existing signage

2. Inventory

Your maintenance plan should include an inventory of all current safety signage along with the location in which they stand. Developing an inventory will drastically reduce the amount of time and resources needed to locate and evaluate each safety sign. This will increase likelihood of inspecting and evaluating safety signage consistently and accurately.

2.1. Inventory of Signage

The inventory of your safety signage should include a repository of photos or graphics of each type of safety signage present at a facility along with relevant information about the sign. If taking pictures, it is important to document photos of new or non-weathered signs whenever possible to properly evaluate wear and tear over time. If this is not possible, make sure to document the date in which the photo was taken and the approximate age of the sign. If the same sign is used in multiple locations at the site, one image is adequate. Additional information to include with images of each sign include:

1. General location of the sign (e.g., spillway, riverbank, canal, dam structure, etc.)
2. Color of panel
3. Color of lettering
4. Size of sign
5. Size of lettering

6. Sign Materials
7. Whether or not the sign has a retro-reflective coating
8. Whether or not the sign is illuminated by a light source
9. Who is responsible for maintaining the signage plan
10. Who manages the signage contract and is it current

2.2. Schematic/Map of Sign Location

Along with images, it is important to accurately document the locations for each of your safety signs for ease of access and to easily identify if signs have been stolen or knocked down. Depending upon resources, budget, and experience this can be accomplished through several different avenues.

2.2.1. GIS MAPPING

As GIS mapping becomes more accessible and affordable, more dam owners are opting to use GIS and Global Positioning Systems (GPS) technologies to accurately mark the latitude and longitude of each of their safety signs. This can be contracted out or can be done in house with limited equipement and prior experience.

2.2.2. ONLINE MAPPING

In order to map sign locations online, you can use a varieitiy of sources such as google maps, and other apps or online sights specifically geared towards mapping locations. Both free and paid for options are available and additonal reasearch should be done to determine the best online mapping resource for your specific needs. Through online mapping, you will essentially mark your sign locations using the functionality of your source and will be able to reference these locations whenever conducting inspections.

2.2.3. PAPER MAPPING OF SIGN LOCATION

While GIS and online mapping should be strongly considered first, paper mapping is an option when looking to create an inventory of your safety signage locations. In essence, marking can be placed on a physcial, paper map to identify where signs are located. Colors and legends can be included to identify which type of safety sign is located at each point. While this type of map can assist with accountability and organization, online and GIS related mapping products should be considered for further development.

3. Inspection

Within your safety signage maintenance plan, it is important to include detailed information on your organizations sign inspection specifications. While maintenance should be done on signs whenever they have been identified as missing or damaged, the inspection should be a pre-determined set of guidelines on the frequency safety signs will be inspected as well as the extent to which they will be inspected at those times. The CDA suggests inspecting all signage at a site at least once annually

however Reclamation suggests that 25 percent of signs should be inspected each year. Choose an inspection frequency that suits prioritizes the public's safety and suits the needs of your dam facility.

3.1. General Inspection Guidance

While the specific details of your inspection process will be tailored and adjusted depending upon each facility, the inspection process should seek to ensure that all safety signage is:

3.1.1. PRESENT

Ensure that your safety signage is still present at the pre-determined location. Signs are often stolen as "trophies," blown away by heavy winds or disturbed by wildlife. Safety signs that are no longer present should be replaced as soon as possible.

3.1.2. LEGIBLE

Signs will need to be replaced when they have experienced severe fading from weather conditions or sunlight. Legibility should also be considered when inspecting signs that have experienced any level of vandalism or damage from human interactions.

3.1.3. VISIBILE

Safety signage should not be obscured or hidden by foliage, equipment, or the structure itself. Visibility levels should be evaluated during various times of the year and during various times of the day to ensure full and complete visibility. Consider also the signs visibility during low and high-water levels.

3.2. Inspection Criteria and Documentation

Each sign should be carefully inspected to verify its condition and should be documented to maintain records of conditions overtime. This documentation will also encourage standard and consistent inspections on a regularly occurring basis. Aside from evaluating the general legibility, visibility, and presence of all safety signs the USACE suggests a variety of items to consider when completing an inspection. These criteria are listed below:

- Mounting
    - Sign is upright and straight
    - The posts are not loose, rotated or damaged
    - Wall mountings are secure
    - The material is properly sealed and stained
- Sign Panel
    - The material properly sealed and stained
    - Edges of reflective sheeting are tight to the panel if applicable
    - Reflective panel is reasonable reflective
- Sign Face

- Sign is legible and in good repair
- Letters are not missing or broken
- Color is bright and unfaded
- Panel is relatively clean and free from stains and markings
- Surface is not crazed or lifting
- Seams on the front face are sealed
- Joints on back of signs are sealed
- Edges of reflective sheeting are tight to the sign face if applicable
- Reflective sheeting is reasonably reflective

- General
  - Foliage is not blocking sign
  - Note other damage from vandalism or normal deterioration

Reclamation suggests that all field inspectors use locally generated checklists to capture information regarding the review. At a minimum, Reclamation requires a checklist documenting the sign location, date and time of inspection, inspection findings, recommendations, name of inspector, maintenance accomplished and name of person performing maintenance. Reclamation uses the rating system outlined in Table 2 when conducting signage inspections.

Table 9: Reclamation's Inspection Criteria

Ranking	Description
Excellent	Sign is new or in like new condition and requires no attention. Lettering and symbols are legible, and nothing is obscuring the sign.
Good	Sign has some weathering but lettering and symbols are legible. Sign is intact with no holes or broken portions. Some cleaning may be required to eliminate dirt and markings. Nothing is obscuring sign.
Fair	Sign has been excessively impacted by weathering and requires cleaning and painting to be restored. Lettering and symbols are legible, but barely and reflectivity is at half original. Vegetation is beginning to obscure sign legibility and the sign may have holes and minor damage.
Poor	Sign is very weathered and is no longer legible. It has been previously refurbished but has severe damage. Sign can be temporarily repaired but should be replaced shortly.
Missing/Destroyed /Obsolete	Either the sign is gone, is so severely damaged or is generally out of date. If one or more conditions exist and sign is needed it should be replaced immediately.

When determining the best process for documenting and inspecting safety signage, dam owners and operators should reference criteria such as those from the USACE and Reclamation featured

above for ideas and suggestions. Ultimately, this criterion should be tailored to meet the needs of each individual dam and may feature inspection criteria, ranking systems, and general inspections guidelines from a variety of resources.

4. Replacement

Once you have documented and inspected your facility's safety signage, it is important to establish a routine for acquiring new safety signage to replace damaged, missing, or inadequate ones.

The goal of safety signage is to ensure that the public understands and is aware of any potential risks or hazards that may impact them. Therefore, when signs are missing, one or potentially the only warning an individual may have had against a hazard has been eliminated. This drastically increases the risk placed upon the public and opens a facility up to a significant amount of liability. Therefore, it is essential to replace safety signs as soon as they are noticed as damaged, missing, or inadequate to cover the risk.

When establishing a replacement plan within your Safety Signage Maintenance Plan, it is important to consider the following:

1. Establishing a relationship with a local sign manufacturer so that if needed, signs can be easily and quickly replaced.
2. Developing a small stockpile of the most frequency replaced or vandalized signs at your dam facility.
3. Placing up temporary signs in the interim it takes to access and install a permanent safety sign.

5. Assessment

Each dam facility poses a variety of situations and circumstances that will affect the effectiveness of safety signage. Therefore, once you have established a Safety Signage Maintenance Plan, it is important to incorporate room to assess the performance and efficiencies of each safety sign as well as the maintenance plan overall. During the assessment section of your maintenance plan, you will essentially evaluate what is going well and what can be done better.

Considering the following questions compiled from FERC, Reclamation and CDA when assessing the quality of your safety signage.

1. Are any signs missing?
2. Are the existing signs in good condition?
3. Are the signs in compliance with the facilities established guidelines?
4. Are there any signs that are no longer needed or appropriate?
5. Are there obsolete signs that should be replaced with newer editions of the same signs?
6. Are all signs in proper and appropriate viewing locations?

Consider the following when questions when assessing the quality and completeness of your Safety Sign Maintenance Plan:

1. Are there too many signs present? Are they distracting from the most important hazards and risks?
2. Are the signs conveying the appropriate message? Should more pictures or graphics be incorporated?
3. Are there still instances of accidents that can be avoided by adjusting safety signage?
4. Are the safety signs suited to the current community and should there be any other languages represented?
5. Is there a vandalism or theft problem that should be solved in coordination with local law enforcement agencies/officer/authorities?

Appendix: Sign Examples and Sample Calculations

1. Calculating Risk and Setting Risk Boundaries

Using the following Incident Likelihood Ranking Table and the Incident Consequences Rating (ICR) Tables from the Assessing Public Health Risks at Dams Section of this document, the following case study and calculations were developed.

Example 1.1: Calculating Risk and Setting Risk Boundaries

Situation/Hazard: A low head dam on a moderately traveled river has led to 4 injuries, one of which caused permanent damage. Two of the incidents occurred in 1 year.

Incident Likelihood Ranking (ILR): Occasional =4

Incident Consequence Rating (ICR): Critical =4

Total Risk Rating =16

The Dam Owner/Operator has identified the follow matrix as their risk tolerance levels. Each dam owner should evaluate their own facility and determine their distinct boundaries for each safety zone. Because this hazard has an ILR of 4 and an ICR of 4, the Total Risk Rating is a 16. Based on the determined matrix, this hazard will be treated as a high threat to the public and the area around the low head dam will be identified as a Danger Zone.

Table 10: Risk Rating Boundary Setting

			Incident Consequences				
			Insignificant	***Minor***	***Major***	***Critical***	***Fatal***
			1	***2***	***3***	***4***	***5***
Likelihood	***Very Frequent***	***5***	Medium	Medium	High	High	High
	Frequent	***4***	Medium	Medium	Medium	High	High
	Occasional	***3***	Low	Medium	Medium	Medium	High
	Possible	***2***	Low	Low	Medium	Medium	Medium
	Remote	***1***	Low	Low	Low	Medium	Medium

2. Message Sizing

The following charts and guidelines can be used to calculate the size of your message. Use the following steps to calculate your message size:

1. Calculate Letter Width
2. Calculate Letter Spacing
3. Calculate total Message Size
4. Convert from Units to Inches Based on Viewing Distance.

2.1. Calculating Letter Width

Once you have identified your message, calculate your letter width by assigning each letter a width and adding these widths together. Table 11 identifies each letter, number, and character width (in units) that should be used to calculate your message size.

Table 11: Letter Width

Capital Letter	Lowercase Letter	Number/Symbol
A 36	a 26	. 7
B 32	b 25	, 8
C 29	c 21	: 7
D 35	d 26	; 8
E 31	e 22	‘ 8
F 30	f 21	“ 17
F 35	g 28	! 7
H 35	h 27	? 7
I 17	i 15	-14
J 25	j 16	(9
K 36	k 29	& 34
L 30	l 14	% 31
M 44	m 39	$ 19
N 36	n 27	1 18
O 33	o 25	2 26

Capital Letter	Lowercase Letter	Number/Symbol
P 30	p 26	3 26
Q 36	q 26	4 26
R 34	r 22	5 26
S 28	s 19	6 25
T 31	t 18	7 24
U 34	u 28	8 26
V 33	v 25	9 25
W 52	w 28	0 27
X 37	x 28	(space) 42
Y 34	y 25	-
Z 29	z 21	-

2.2. Calculating Spacing Width

Once you have calculated the width of the characters of your message, you will need to calculate the spacing between these characters. Using the Spacing Guides attached below, add up the total space between your characters.

2.3. Calculating Total Message Width

Once you have calculated the letter width and spacing width, add these together to calculate the total message width in Units. These units will be converted to inches in Section 2.4 Converting Message Width from Units to Inches.

2.3.1. CAPITAL LETTER TO CAPITAL LETTER SPACING GUIDE

Spacing Guide

Capital Letters to Capital Letters — AX — Second letters

First letters

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	2	3	2	3	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3	2	1	1	1	2	2	4
B	3	6	6	6	6	6	6	6	6	4	6	6	6	6	6	6	6	6	7	5	3	2	2	3	2	6
C	3	6	6	6	6	6	6	6	6	4	6	6	6	6	6	6	6	6	7	7	4	4	4	4	4	6
D	1	5	6	5	5	5	6	5	5	4	5	5	5	5	6	5	6	5	6	6	3	2	2	3	2	5
E	5	8	7	8	8	8	7	8	8	6	8	8	8	8	7	8	7	8	9	7	5	4	4	6	5	8
F	0	5	5	5	5	5	5	5	5	2	5	5	5	5	5	5	5	5	6	5	3	3	3	3	3	4
G	1	5	5	5	5	5	5	5	2	2	5	5	5	5	5	5	5	5	6	4	2	1	1	2	1	4
H	3	6	5	6	6	6	5	6	6	4	6	6	6	6	5	6	5	6	6	5	4	4	4	4	4	6
I	3	6	5	6	6	6	5	6	6	4	6	6	6	6	5	6	5	6	6	5	4	4	4	4	4	6
J	0	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	4
K	2	4	3	4	4	4	3	4	4	3	4	4	4	4	3	4	3	4	3	2	1	1	1	3	3	4
L	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	3	2	1	1	3	3	6
M	3	6	5	6	6	6	5	6	6	4	6	6	6	6	5	6	5	6	6	5	4	4	4	4	4	6
N	1	5	4	5	5	5	4	5	5	2	5	5	5	5	4	5	4	5	5	4	3	3	3	3	3	5
O	2	5	6	5	5	5	6	5	5	3	5	5	5	5	6	5	6	5	6	5	3	2	2	3	2	5
P	0	5	4	5	5	5	4	5	5	3	5	5	5	5	4	5	4	5	6	5	3	2	2	3	2	4
Q	2	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	3	2	0	0	3	0	5
R	2	5	4	5	5	5	4	5	5	4	5	5	5	5	4	5	4	5	6	4	2	2	2	3	1	5
S	2	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6	6	6	6	5	4	3	3	4	3	7
T	2	6	5	6	6	6	5	6	6	2	6	6	6	6	5	6	5	6	5	4	4	3	3	4	4	6
U	0	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	2	4	3	2	2	3	2	4
V	3	4	2	4	4	4	2	4	4	-1	4	4	4	4	2	4	2	4	3	4	2	2	2	2	2	4
W	3	4	2	4	4	4	2	4	4	1	4	4	4	4	2	4	2	4	3	4	2	2	2	2	2	4
X	2	4	2	4	4	4	2	4	4	2	4	4	4	4	2	4	2	4	4	2	1	1	1	2	0	4
Y	2	4	2	4	4	4	2	4	4	-1	4	4	4	4	2	4	2	4	4	3	3	2	2	2	2	4
Z	4	7	7	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	8	7	5	4	4	6	5	7

Figure 11: Capital Letter to Capital Letter Spacing Guide

2.3.2. CAPITAL LETTER TO LOWECASE LETTER SPACING GUIDE

Spacing Guide

Capital Letters to lower case letters — Ax

First letters	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	Second letters
A	3	1	1	1	1	2	2	2	2	-2	2	2	2	2	1	1	1	2	3	0	0	-1	-1	2	-1	3	
B	4				3			3	4	0		3			3			3			3				1		
C	4				3			4	4	0		4			3			3			3				2		
D	4				4			3	4	0		3			4			3			4				2		
E	5	5	5	5	5	6	5	5	5	2	4	5	5	5	5	4	5	5	6	4	5	3	3	4	2		
F	1				0			2	2	-2		2			0			2		2	2				1		
G	3				3			2	3	-1		2			3			3			3				1		
H	3	3	2	2	2	4	3	4	3	-1	3	4	3	3	2	2	2	3	4	2	2	0	0	3	0	4	
I	3	3	2	2	2	4	3	4	3	-1	3	4	3	3	2	2	2	3	4	2	2	0	0	3	0	4	
J	0				0			3	1			3			0						0				-1		
K	2				1			2	2	-2		2	2	2	1			2			0				-1		
L	4	3			3			3	3	0		3			3						3				1		
M	3		2	2	2			4	3			4			2		2	3			2				0		
N	2				1			3	2			3			1						1				0		
O	3	3	4	3	3	3	3	2	3	0	2	2	3	3	3	3	3	3	4	2	3	3	3	3	2	3	
P	2			1	0			2	2			2			0			2	2		2				1		
Q	4				3			2	3			2			3						2				0		
R	4			3	3			2	3	-1		2			3						3				0		
S	4		4		4			3	4	0	3	3	3	3	4	3	3	3		3	3	1			2		
T	3				1			3	3	-1		3			1			3	2		3	2			1	3	
U	1	3	1	1	0	2	0	2	2	-2	2	2	1	1	0	1	0	1	1	1	0	-1	-1	0	-1	1	
V	-2				-2			2	0	-1		2	-1	-1	-2			-1			-1				-3		
W	-2				-2			2	0	-1		2	-1	-1	-2			-1			-1				-3		
X	2				1			2	2			2			1						0				-1		
Y	-1	2	-2	-2	-2	0	-3	2	0	-3	2	2	-2	-2	-2	-2	-2	-2	-2	0	-2	-2	-2	-2	-3	-1	
Z	5				4			5	5	0		5			4			4			4	2	2		2		

Figure 12: Capital Letter to Lowercase Letter Spacing Guide

2.3.3. LOWERCASE LETTER TO LOWECASE LETTER SPACING GUIDE

Spacing Guide

Lower case letters to lower case letters

ax

First letters

Second letters

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
a	3	1	3	3	3	3	3	2	3	-1	2	2	3	3	3	1	3	3	4	1	1	-1	0	2	0	3
b	4	2	4	4	4	3	5	2	3	0	2	2	3	3	4	2	4	3	5	2	2	2	2	2	2	4
c	4	3	4	4	4	4	4	3	4	0	3	3	4	4	4	3	4	4	5	3	3	2	2	2	2	5
d	3	1	2	2	2	3	2	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
e	4	2	4	4	4	3	5	2	3	0	2	2	3	3	4	2	4	3	5	2	2	2	2	2	2	4
f	0	2	0	0	0	1	0	2	2	-2	2	2	1	1	0	1	0	1	1	0	1	0	0	0	0	2
g	2	0	2	2	2	3	1	0	2	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2
h	3	1	2	2	2	3	2	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
i	3	1	2	2	2	3	2	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
j	6	4	4	4	4	5	5	4	5	3	4	4	4	4	4	4	4	4	5	4	4	3	3	3	4	5
k	2	1	2	2	2	3	2	3	3	0	2	2	3	3	2	1	2	3	3	1	1	1	1	2	1	3
l	3	1	2	2	2	3	2	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
m	3	1	2	2	2	3	3	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
n	3	1	2	2	2	3	3	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
o	4	2	4	4	4	3	5	2	3	0	2	2	3	3	4	2	4	3	5	2	2	2	2	2	2	4
p	4	2	4	4	4	3	5	2	3	0	2	2	3	3	4	2	4	3	5	2	2	2	2	2	2	4
q	3	2	3	3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2	3	3
r	3	1	2	2	2	3	1	2	3	0	2	2	3	3	2	2	2	2	3	2	2	2	2	2	2	3
s	5	3	4	4	4	4	4	3	5	0	3	3	4	4	4	3	4	4	5	3	3	3	3	3	3	6
t	5	3	3	3	3	4	3	3	4	1	3	3	3	3	3	3	3	3	5	1	2	2	2	3	2	4
u	3	1	2	2	2	3	2	2	3	0	2	2	3	3	2	1	2	3	3	1	1	0	0	2	1	3
v	2	2	2	2	2	3	1	1	3	0	1	1	3	3	2	2	2	3	3	2	2	2	2	2	2	3
w	3	2	2	2	2	3	1	1	3	0	1	1	3	3	2	2	2	3	3	2	2	2	2	2	2	3
x	3	3	2	2	2	3	3	3	3	0	3	3	3	3	2	2	2	3	4	2	2	2	2	2	2	3
y	2	1	1	1	1	3	1	1	3	-1	1	1	2	2	1	2	1	2	2	2	2	2	2	2	2	2
z	5	4	4	4	4	5	4	4	5	1	4	4	5	5	4	3	4	5	6	3	3	3	3	3	3	5

Figure 13: Lowercase Letter to Lowercase Letter Spacing Guide

2.4. Converting Message Width from Units to Inches

Once you have calculated your total message width (in units), you will need to convert these units into inches depending upon your ideal letter size. This letter size is based on viewing distance and can be found in the Design Standards of this document in Table 5. Using Table 15, multiply your total message width (in units) by the letter size factor to calculate the total width of your message in inches. Example 2.1 walks through the entire process of calculating message width.

Table 12: Letter Size Factors

Letter Size	Factor
1”	0.0474
1.5”	0.0711
2”	0.0948
3”	0.1422
4”	0.1896
6”	0.2844
8”	0.3792
10”	0.474
12”	0.5688
18”	0.8532
24”	1.1376
30”	1.422
36”	1.7064

Example 2.1: Calculating Message Width

Note: All below calculations are based on Reclamation's Sign Guidelines.

Example Message (determined capital letter height=3): **Exit Left Now**

1. Step 1: Identify Letter Width:

- E=31
- x=28
- i=15
- t=31
- Space=42
- L= 30
- e=22
- f=21
- t=18
- Space=42
- N=36
- o=25
- w=38

Total =379 units

Step 2: Identifying Spacing Width:

- between E and x=4
- between x and i=2
- between i and t=1
- between L and e=3
- between e and f=3
- between f and t=0
- between N and o=1
- between o and w=2

Total=16 units

Step 3: Add the Letter Width and Spacing Width

Total Width =379+16=395 units

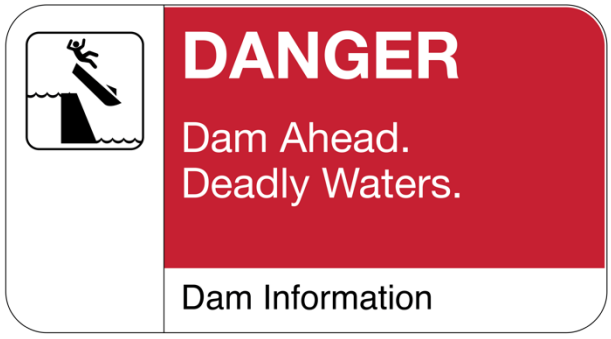
Step 4: Multiply by the letter size factor

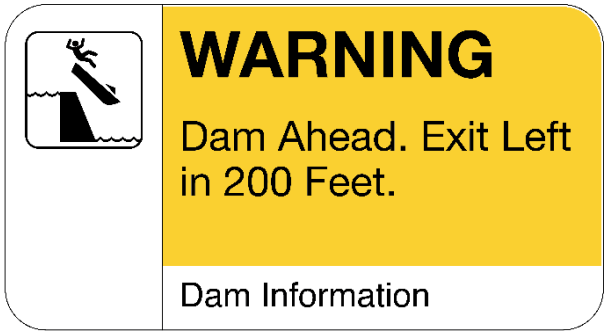
Since it is noted that the capital letter height is 3, we will multiply our calculated total width by the letter size factor of 0.1422.

Total Width of Message (in inches) = 395x0.1422=56.169 inches

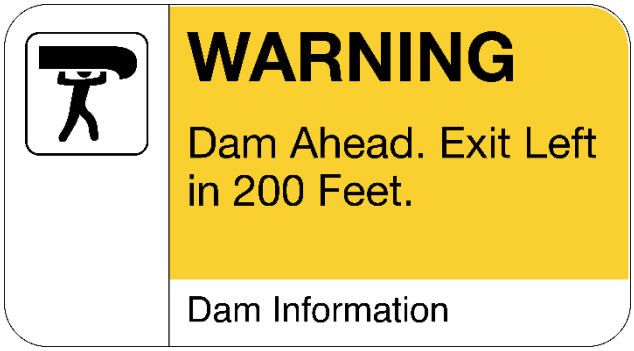
3. Safety Signage Best Practices Examples

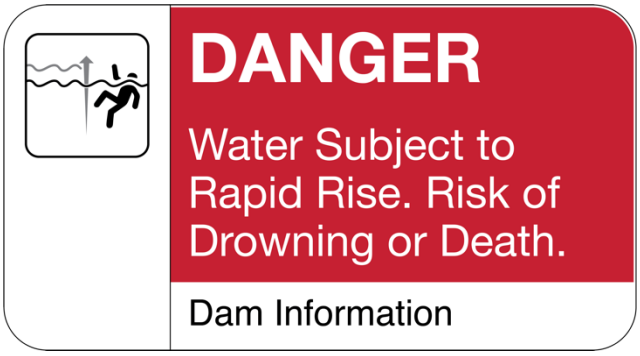
The following dam safety signage examples follow the best practices outlined in the Messaging and Design Standards sections of this document. Messages and formatting should be adjusted to accommodate your dam and dam facilities specifications.

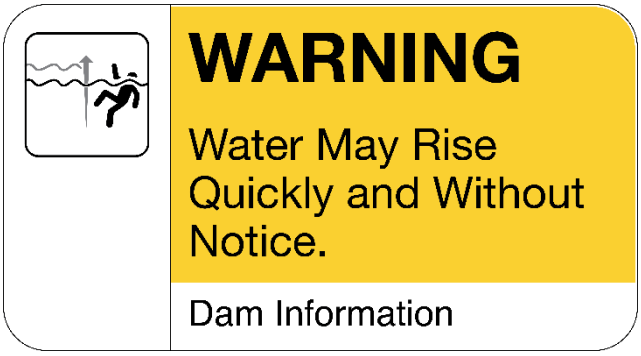

DANGER
Dam Ahead.
Deadly Waters.
Dam Information


WARNING
Dam Ahead. Exit Left in 200 Feet.
Dam Information

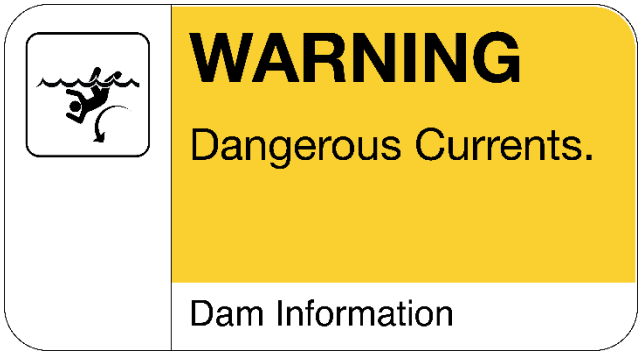

DANGER
Dam Ahead.
Exit Now.
Dam Information

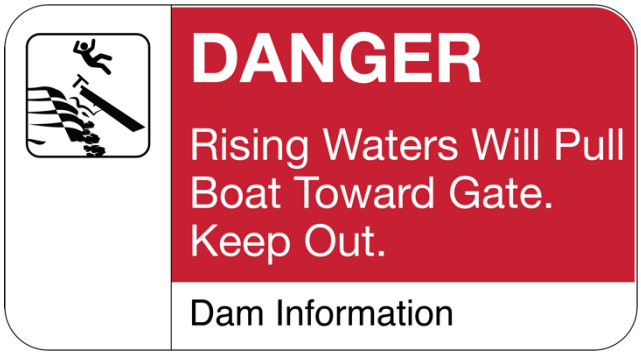

WARNING
Dam Ahead. Exit Left in 200 Feet.
Dam Information

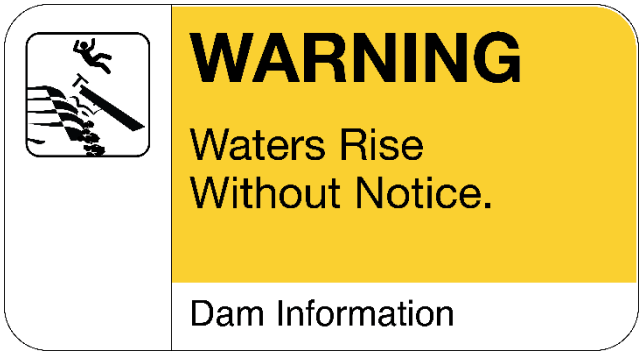

DANGER
Water Subject to Rapid Rise. Risk of Drowning or Death.
Dam Information

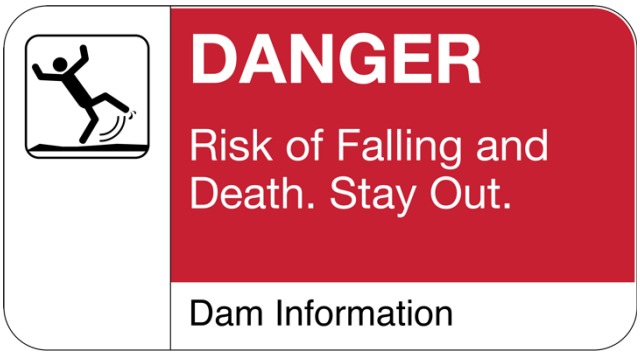

WARNING
Water May Rise Quickly and Without Notice.
Dam Information

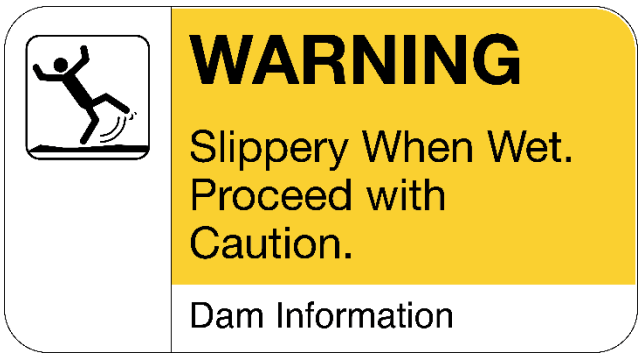

DANGER
Deadly Current. No Swimming or Wading.
Dam Information


WARNING
Dangerous Currents.
Dam Information









4. Pictogram Best Practices Examples

The following pictograms follow the best practices outlined in the Messaging and Design Standards section of this document. Messaging and formatting can be adjusted to accommodate your dam and dam facilities specifications.

Low Head Dam/ Hydraulic Roller:

Dangerous Undertow:

Slippery Surfaces:

Exit Water/Portage:

Dam Ahead (Low Head):

Dam Ahead (other):

Rapidly Rising Waters: (Can also be used below spillway)

Signifying risk going through gated structures/spillway from upstream:

5. Sign Materials

The following table can be used to compare the pros and cons of each type of potential safety sign material depending upon the sign's intended use and specifications. Additional sign materials exist outside of this list. You will see an X for all characteristics that relate that each specific sign material type.

Table 13: Sign Materials Reference Tool

Material	Cost			Application		Resistance to Elements			Longevity			Message material	
	Low Cost	Medium Cost	High Cost	General Sign Use	Used for Graphics	Weather Resistant	Scratch Resistant	Shatter Proof	Short Term Use	Moderate Term Use	Long Term Use	Painted (silkscreen)	Decals and press-on Vinyl
HDO Plywood		X		X		X				X			X
Medium Plywood		X		X		X				X		X	
Medium Fiberboard		X		X		X				X		X	
Acrylic/plexiglass		X		X		X	X						X
Polycarbonate/ Lexan		X		X		X	X	X					X

Material	Cost			Application		Resistance to Elements			Longevity			Message material	
	Low Cost	Medium Cost	High Cost	General Sign Use	Used for Graphics	Weather Resistant	Scratch Resistant	Shatter Proof	Short Term Use	Moderate Term Use	Long Term Use	Painted (silkscreen)	Decals and press-on Vinyl
Polyethylene/ polypropylene	X			X		X	X						X
Carsonite	X			X		X	X	X			X		X
Aluminum		X		X		X				X		X	
Aluminum-clad plastic		X		X		X	X	X			X	X	
Aluminum-clad plywood		X	X	X		X	X				X	X	
Porcelain Enamel			X		X	X	X				X		X
Fiberglass Embedment			X		X	X	X				X		X
Synthetic Textiles	X			X		X			X				
Tyvek	X			X		X			X				
Cardboard	X			X					X			X	
Dam Surface and structures	X			X		X	X	X		X		X	

8. Resources

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