Guidelines for Onshore Hydrocarbon Pipelines Affecting High Consequence Floodplains

API RECOMMENDED PRACTICE 1133
FIRST EDITION, FEBRUARY 2005

REAFFIRMED, FEBRUARY 2010

AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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Guidelines for Onshore Hydrocarbon Pipelines Affecting High Consequence Floodplains

1 Scope

This recommended practice (RP) sets out criteria for the design, construction, operation, maintenance and abandonment of onshore pipelines that could affect high consequence floodplains and associated commercially navigable waterways. This RP applies only to steel pipelines that transport gas, hazardous liquids, alcohols or carbon dioxide.

The design, construction, inspection and testing provisions of this RP should not apply to pipelines that were designed or installed prior to the latest revision of this publication. The operation and maintenance provisions of this RP should apply to existing facilities.

The contents in this RP should not be considered a fixed rule for application without regard to sound engineering judgment.

2 References

The following codes, standards, practices, specifications and publications are incorporated in this RP.

API

Spec 6D	*Pipeline Valves (Gate, Plug, Ball, and Check Valves)*
Std 1104	*Welding of Pipelines and Related Facilities*
RP 1109	*Marking Liquid Petroleum Pipeline Facilities*
RP 1110	*Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids or CO_2*
RP 1117	*Movement of In-service Pipelines*

AGA[1]

AGA Submarine Pipeline On-bottom Stability Analysis and Design Guidelines

ASCE[2]

89 *Pipeline Crossings Handbook American Society of Civil Engineers (ASCE)*

Pipeline Rules of Thumb Handbook, published by Gulf Publishing Company, Houston,

ASME[3]

B31.4	*Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids*
B31.8	*Gas Transmission and Distribution Piping Systems*

AWS[4]

D1.1 *Structural Welding Code*

NACE[5]

DOT RSPA—Pipeline Safety Regulations
49 *Code of Federal Regulations* Part 192
49 *Code of Federal Regulations* Part 194
49 *Code of Federal Regulations* Part 195

NASTT[6]

Guidelines for a Successful Directional Crossing Bid Package, 1996

OSHA[7]

29 *Code of Federal Regulations* Part 1926.650 through 1926.652 (Trenching and Shoring Code Only)

PRCI[8]

In*stallation of Pipelines by Horizontal Directional Drilling* (PRCI no. PR-227-9424)

Water-crossing Design and Installation Manual, developed for AGA (PRCI no. PR-237-9428)

Offshore and Onshore Design Application (PRCI no. PR- 170-9522)—*Design Application L51767, Integrity Assessment of Exposed/Unburied Pipe in River*; *Design Application L51768, Pipeline Free Span Design*

3 Definitions

For the purposes of this publication, the following definitions apply:

3.1 abandonment: Permanently removing a pipeline from service.

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[1]American Gas Association, 400 N. Capitol St., NW, Suite 450, Washington, D.C. 20001.www.aga.org
[2]American Society of Civil Engineers, 1801 Alexander Bell Dr., Reston, Virginia 20191. www.asce.org
[3]ASME International, 3 Park Avenue, New York, New York 10016-5990. www.asme.org
[4]American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126. www.aws.org
[5]NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, P.O. Box 218340, Houston, Texas 77218-8340. www.nace.org
[6]North American Society for Trenchless Technology, 1655 N Ft. Myer Drive, Suite 700, Arlington, Virginia 22209. www.nastt.org
[7]U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Ave. NW, Washington, DC 20210. www.osha.gov. *Note: OSHA Regulations are posted on, and can be downloaded from, the OSHA web site.*
[8]Pipeline Research Council International, Inc., 1401 Wilson Boulevard, Suite 1101, Arlington, Virginia, 22209. www.prci.org

3.2 buoyancy: The tendency of an object to rise when submerged within a fluid.

3.3 carbon dioxide (CO_2): A fluid consisting of more than 90% carbon dioxide molecules compressed to a supercritical state.

3.4 clamshell: An excavator which consists of a dredging bucket with two hinged, jaw-like pieces.

3.5 cofferdam: A temporary structure built around a site to permit construction in (relatively) dry conditions.

3.6 cribbing: A temporary structure to support a pipeline and/or its components.

3.7 cuttings: A mixture of drilling mud and soil that is generated during drilling operations.

3.8 erosion: The wearing away of soil or other material by the action of water or other agents.

3.9 floodplain: The area adjacent to a watercourse that may be submerged by floodwaters.

3.10 gabions: Steel wire mesh baskets filled with stone used to prevent erosion**.**

3.11 gas: Natural gas, flammable gas, or gas which is toxic or corrosive.

3.12 geology: A science that deals with the surface and subsurface features of the earth (i.e., topography, bodies of water, watercourses, subsoil formations and character).

3.13 hazardous liquid: Petroleum, petroleum products, or anhydrous ammonia.

3.14 high consequence floodplain: A floodplain adjacent to a waterway used in commercial navigation.

3.15 holiday: A discontinuity in the coating.

3.16 hydrocarbon pipeline: Pipelines used for the transportation of natural and other gases, hazardous liquids, carbon dioxide and alcohols.

3.17 hydrology: The science dealing with the properties, distribution and circulation of water on the surface of the land, in the soil and in the atmosphere.

3.18 jeep: A method of inspecting pipe surface coatings for holidays, also known as holiday detection.

3.19 matting: Installing wood planks, or other material in an effort to stabilize a work area or route of ingress/egress.

3.20 meanders: A channel pattern characterized by a series of pronounced alternating bends formed by stream processes.

3.21 microtunneling: A remotely controlled, guided, pipe jacking process that provides continuous support to the excavation face.

3.22 onshore: The area landward of the established coastline in direct contact with the open sea, and landward of the line marking the seaward limit of inland coastal waters.

3.23 riprap: A permanent, erosion-resistant ground cover of large, loose singular stone installed wherever soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that soil may erode under design flow conditions.

3.24 scour: To abrade or wear away, as in the wearing away of a stream bed or surface by the erosive action of flowing water.

3.25 silt fence: Specifically designed synthetic fabrics or other materials fastened on supporting posts, which are designed to efficiently control and trap sediment runoff.

3.26 subsidence: Act of sinking, settling or downward movement

3.27 thalweg: The line following the deepest part of the streambed.

3.28 trenched crossing: Method of installing pipe by which access is gained to the required elevation by excavating an open cut. After placing the pipeline, the excavation is then backfilled and the surface restored.

3.29 watercourse: A natural or man-made channel through which water flows or accumulates (i.e., streambeds, creeks, rivers, lakes, ponds, floodplains, etc.).

4 Design

4.1 ROUTE SELECTION

4.1.1 General

When high consequence floodplains cannot be avoided in the planning stage of a new pipeline route, analysis of the crossing should consider available information from United States Geological Survey (USGS) quadrangle topographic maps, aerial photographs, watercourse hydrology data from the U.S. Army Corps of Engineers, geotechnical data from USGS, aerial reconnaissance or other qualified sources. Major considerations in the selection of a route for a pipeline across a floodplain are suitable conditions for initial installation and the stability of the crossing over the life of the pipeline.

Typical methods for crossing a floodplain and watercourse include: directional drilling; conventional trenching and lowering or pulling the pipeline into the trench and aerial crossing using a dedicated support structure or a host support structure. *See Section 2 for references on pipeline crossing of waterways.*

In selecting a route across a high consequence floodplain, it is very important to address possible hazards to the integrity of the pipeline crossing: erosion of the channel bed, failure of the banks, migration of the thalweg, damage from vessels navigating the water course, dredging and debris carried by currents—particularly during flood conditions. These risks can be managed if the hydrology of the watercourse is adequately analyzed and the pipeline crossing is located both laterally and vertically so as to minimize future exposure to these hazards.

4.1.2 Buried Crossings

In locating the route vertically, the potential for future degradation or scour of the channel should be considered by reviewing the hydrology of the channel, conducting a geotechnical investigation, as well as reviewing site records and existing topographic maps. The pipeline should be placed at a depth below the expected level of scour. Minimum burial depth of trenched crossings shall comply with U.S. Army Corps of Engineers, Department of Transportation (DOT), Office of Pipeline Safety, and other applicable regulatory requirements.

The lateral location of the pipeline should be determined after a careful review of channel hydrology. The lateral stability of the channel should be determined. Characteristics of channel instability include the following:

- Bank erosion,
- Migration of the channel within the floodplain, and
- Migration of meanders downstream.

The rate of bank erosion and migration can be projected by reviewing the hydrology and forecasting the changes in the channel for the design life of the pipeline. The lateral location of the pipeline and effective length of the crossing are then determined based on these projections. Adequate depth should be maintained to eliminate impacts from the future migration of the channel. For example, if the migration rate is 2 ft per year and the design life is 50 years, the depth below the level of scour should be maintained for at least 100 ft from the bank in the direction of channel migration. Special consideration should be given to previously existing channels that may scour as a result of secondary overbank flows during flood conditions.

Significant savings can be realized if several pipelines are bundled together in one crossing. Directionally-drilled crossings may be bundled if the diameter of the bundled pipelines does not exceed the largest diameter bore that can be installed. One or more spare pipelines within the bundle may be considered to allow for future expansion. For pipelines that are bundled together, provisions should be made for adequate corrosion control to prevent interference of cathodic systems or to prevent one or more lines from acting as a sacrificial anode.

See the following publication for further guidelines: *Installation of Pipelines by Horizontal Directional Drilling, an Engineering Design Guide* (PRCI no PR-227-9424).

4.1.3 Aerial Crossings

Aerial crossings of floodplains and watercourses can be made by using existing host bridges or dedicated bridges, and self-supporting spans that are specially designed for the pipeline crossing. The following should be considered in design of aerial crossings:

- Pipe selection (internal pressure as well as span length and ballistic protection),
- Atmospheric corrosion control (coatings and or insulation),
- Stresses due to thermal conditions,
- Isolation of cathodic protection,
- External loads such as wind, snow, etc.,
- Clearance for water traffic.

Physical security should be provided to prevent unauthorized access and/or damage to the crossing.

Host bridges can be the most economical method of aerial crossing of watercourses, although they are not often conveniently located along the proposed route of a pipeline. The primary design considerations for locating on a host bridge are:

- The adequacy of the host bridge to support the additional weight of the pipeline and its appurtenant support system,
- The design of the pipeline support system itself, and
- The location of the pipeline on the host bridge so as to protect it from outside force damage.

Installation on a host bridge requires compliance with the host bridge owner's standards and design practices. The host bridge should be structurally analyzed to ensure the bridge is not overstressed as a result of the weight of the pipeline and its contents.

- A dedicated bridge may be designed specifically for a pipeline crossing. Several different bridge designs are suitable for a pipeline crossing of a water course, including suspension, prefabricated steel, reinforced concrete, and self-spanning pipe.

Aerial crossings should be designed by a qualified engineer experienced in bridge design.

4.2 CONSTRUCTION METHODS

Construction methods will be influenced by many factors. The crossing's length and depth, the floodplain's hydrology, the waterway's flood stage, the geology determined by soil borings, available workspace, the presence of environmentally sensitive areas, the presence of fish or other wildlife, local population densities, economics, and compliance with regulatory requirements are but a few of the considerations.

There are several construction methods for consideration.

- Horizontal-directional drilling (HDD) has developed into a viable, low-impact construction method especially suited for longer, deeper crossings that might have potential environmental concerns. More detailed information is available in "Guidelines for a Successful Directional Crossing Bid Package," *1996 Directory of the North American Trenchless Technology Contractors*.
- Trenching (either dry or wet) is a cost-effective technique especially suited for shorter crossings with relatively insignificant environmental impact.
- Microtunneling can be considered in short crossings.
- Aerial crossings.

4.3 MATERIAL SPECIFICATIONS FOR TRENCHED AND DRILLED CROSSINGS

Materials specified for a pipeline crossing should comply with previously established practices and standards for pipeline construction. Allowances should be made for any additional stresses that may be induced during the installation of the pipeline, particularly in the case of a directionally-drilled crossing. More information on pipeline design can be found in ASME B31.4 and ASME B31.8. Analysis of stresses induced during the installation of a pipeline crossing should be performed by a qualified professional engineer.

Pipe specifications should include limitations on maximum, as well as minimum, yield strength. The selected grade of pipe should provide sufficient ductility to minimize the likelihood of damage during installation. Additional wall thickness or pipe yield strength should be considered as a corrosion allowance in areas where mitigation or repair would be difficult or impossible (i.e., a drilled crossing).

Buoyancy calculations must be made for trenched crossings to ensure that the pipeline will not float after installation. The pipeline crossing should be designed with an adequate safety factor to provide negative buoyancy during all anticipated conditions. The pipeline will float if the weight of the pipe and coating is less than the fluid displaced by the pipeline. The greater density of salt water must be accounted for when crossing salt-water courses. Buoyancy can be controlled by the use of continuous concrete coating, concrete weights or screw anchors. Typical buoyancy calculations may be found in *Pipeline Rules of Thumb Handbook* or *AGA Submarine Pipeline On-Bottom Stability Analysis and Design Guidelines*.

In addition to providing protection against corrosion, pipe and weld joint-coating systems for trenched and directionally-drilled crossings should be sufficiently durable to prevent damage during installation. If gravel or rock is expected to be encountered, the coating system should include a highly abrasion-resistant, smooth-surfaced outer layer with a high hardness factor. The outer coating should be well bonded to the first layer coating. For example, the first layer of coating could be a fusion-bonded epoxy (FBE) of 22 mils – 24 mils and the outer coating could be an epoxy-based polymer concrete of 40 mils – 60 mils.

4.4 VALVES

4.4.1 General

Block or check valves should be considered on pipelines crossing floodplains adjacent to large watercourses to limit the volume of a potential release. The check valve acts as a one-way flow device and automatically prevents the backward flow from the downstream pipeline section into lower elevations within the floodplain. The block valve can be operated either locally, automatically or remotely to isolate the pipeline in the floodplain from upstream and downstream pipeline sections.

A variety of valve types can be used and their effectiveness depends on proper design, location, and prompt action by the pipeline operator or control system to minimize a pipeline release.

4.4.2 Determination of Valve Type and Location

The type, location and necessity of block and/or check valves should be based on an engineering/risk analysis of the floodplain and should take into account the following variables:

a. Uses of the watercourse (barge traffic, potable water supply, farm irrigation, etc.).
b. Environmental concerns.
c. Topographic conditions (potential spill volume).
d. Materials being transported.
e. Access.
f. Availability of power and communication (if valves are or will be automatically or remotely operated in the future).
g. Security.
h. Regulatory requirements.

The pipeline's elevation profile is one important factor to be considered when choosing valve locations.

It is important that valves be installed at locations accessible during flood conditions. If valves must be installed within a floodplain, barricades, valve guards, or other means of protecting the valve from floating debris during flood conditions should be considered.

The type of valve actuation method selected by the designer should be coordinated with the requirements imposed for closure, materials being transported, compatibility with technology currently used, availability of energy sources, availability of remote communications, and maintenance requirements. A variety of valve actuation methods may be employed depending on the application and can include the following:

- Manual.
- Hydraulic.
- Electrical.

- Electro-hydraulic.
- Pneumatic.
- Mechanical (swing or drop check).
- Pilot operated.

There are three primary control modes for valves:

a. Operated by local manual or local powered controls.
b. Remote controls.
c. Automatic controls.

In a local manual control mode, the possibility of future remote operation of these valves should be considered when choosing the locations and types of block valves.

The control mode selected for operation of power-actuated valves should be coordinated with the overall hydraulic characteristics of the pipeline system. Important considerations include the topographic conditions along the pipeline and the proper sequencing of station shutdowns. In general, automatic, power-operated valves are not recommended on liquid pipelines without an appropriate surge analysis because pressure surges can occur in cases of sudden and/or uncommanded closure. If the pipeline operator feels that an automatic valve is warranted, the pipeline operator should conduct a hydraulic analysis of the use of such valves. If automatic or remotely actuated valves are installed, the operator should provide protection against uncommanded closures and/or protection against excessive surge pressure.

4.4.3 Valve Design Considerations

Valve type, trim, and pressure rating should be compatible with service conditions of the pipeline and surrounding environment. All valves should be manufactured in accordance with API 6D Specifications.

In designing valve sites, consideration should be given to the installation of facilities that would allow the floodplain crossing to be purged during emergency situations.

5 Construction

5.1 ENVIRONMENTAL CONSIDERATIONS

5.1.1 Permitting

Construction across many waterways requires government agency permits. For example, the U.S. Army Corps of Engineers, Environmental Protection Agency, and/or the U.S. Fish and Wildlife Agency may require permits as well as other federal, state, and local agencies. Sufficient time should be allowed for obtaining permits and any required environmental studies. Local community involvement is encouraged to allow input about local concerns.

5.1.2 Environmental Impact

Minimizing environmental impact is a prime consideration during the construction phase. Floodplain crossings have the potential to significantly impact local ecological systems. Consideration should be given to choosing construction techniques which will result in acceptable short-term impacts on the local environment. For example, open trenching across marshy, slow moving waterways may be acceptable, but it may be necessary to directionally drill or microtunnel under swift moving, environmentally-sensitive waterways. A process should be developed for handling slurry and cuttings from the drilling process to prevent contamination of the watercourse and surrounding areas. The following should be considered: composition of the slurry, temporary containment, recycling and disposal.

Care should be taken not to endanger fish, cause environmental damage, increase stream turbidity or cause erosion during construction.

5.1.3 Socioeconomic Impacts

Crossings of floodplains and waterways can take several weeks, or longer, to complete. Consideration should be given to the impact on the local population and users of the waterway or host bridge. If it is decided to construct 24 hours a day, steps should be taken to mitigate the impact on local residents and users.

5.2 SAFETY

5.2.1 Contingency Planning

Floodplain crossings provide some unique situations not commonly encountered during normal pipeline construction. In addition to the safety considerations associated with the actual construction, forethought must be given to the waterway, adjacent work areas, and weather conditions. Contingency plans for rains, rising water, or flash floods should be considered, when appropriate.

5.2.2 Pumping Equipment

When the water flow is diverted by the use of cofferdams, flumes, or other techniques, these facilities must be designed to handle the highest expected water flows plus an acceptable contingency. If pumps or other mechanical equipment are used to move water around or out of the construction area, these pumps must be adequately sized to handle the range of flows expected. In addition, spare pumping equipment should be kept at the site in anticipation of mechanical failure of the primary equipment.

5.2.3 Shoring

The close proximity of water to open ditches will affect stability of the ditch walls. Consideration should be given to additional shoring where needed. Trenching and shoring must be conducted in accordance with OSHA 29 *CFR* 1926.

Wetland construction techniques may be required. Refer to the *Water-Crossing Design and Installation Manual* developed for AGA (PRCI no. PR -237-9428).

5.2.4 Coordinating Activities

It may be necessary to coordinate activities with the U.S. Coast Guard, U.S. Corps of Engineers or a local port authority.

5.2.5 Location of Other Utilities

Existing utilities and pipelines should be located and clearly identified. Special attention must be given to other crossings of the same waterway. Local one-call systems can provide valuable information on other facilities in the area of the crossing. Local one-call systems shall be contracted prior to construction to assist in locating other utilities or pipelines.

5.3 SELECTING A CONTRACTOR

Selecting a proper contractor is a key component that can affect the successful completion of a new waterway crossing. Choosing a contractor experienced in the proposed construction technique is essential.

If it is necessary to use more than one construction contractor, there are advantages to hiring one firm as the primary contractor and having them sub-contract with the other companies. Individual contracts to several specialty firms requires more time and planning on the part of the owner company to coordinate activities. The terms of the contracts should include provisions to minimize conflicts among contractors.

Prior to the start of construction, it is essential that the contractor(s) be informed of any permits or other requirements that may affect their activities. These requirements, along with any safety or construction guidelines, hydrological and geotechnical data, job description, and material specifications, should be included in the bid specifications and should be discussed in the pre-bid job showing and in the preconstruction meeting held with the successful bidder.

5.4 ACCESSIBILITY

Access to both sides of the waterway is necessary and may involve providing plank roads or matting to either, or both, sides of the waterway.

Easy travel between work sites is advantageous and may require the use of boats, pontoons, or temporary bridges if other acceptable alternatives are not available.

5.5 PIPE HANDLING

Regardless of the construction technique, special care should be given to pipe handling to avoid damage to the pipe and coating. One of the last steps before pulling or lowering the pipe into place should be to inspect the coating for holidays.

Pipe handling equipment such as rollers, cradles, slings, etc., should be checked to insure they are properly sized, and in good working condition, with no exposed protrusions that might result in pipe or coating damage.

5.6 SPACE CONSIDERATIONS

5.6.1 Staging

The watercourse crossing technique will dictate the amount of staging space required on each side of the watercourse.

5.6.1.1 Horizontal Directional Drilling will require workspace on the drilling rig side (drill side) that is adequate to assemble the different components of the drilling unit. Due to the flexibility in configuring the equipment, an area with different dimensions can be used provided sufficient square footage is available. The drilling contractor should be consulted to determine exact minimum requirements.

The pipe fabrication side (pipe side) should contain sufficient room to weld up the crossing pipe in one continuous section. If sufficient working room is not available for one continuous pipe section, multiple sections can be welded up; however, during pulling of the pipe into the hole, it will be necessary to stop the pull and weld the sections together, perform radiographic inspection, and coat the welds. Each time the pull is stopped, there is a risk that the section in the borehole will become lodged when trying to resume the pull. The use of a traveling or a movable welding station may be considered if it is necessary to use multiple sections.

Adequate room must be provided to handle the drilling mud and spent tailings as addressed in 5.1.2.

5.6.1.2 Open-trench construction normally requires sufficient working room to stage draglines, clamshells, or other trenching equipment, plus sufficient area to store stockpiled backfill. For excavation performed from a barge, less workspace is needed onshore.

5.6.1.3 For dry ditch construction, adequate space is needed to divert the water flow. Additionally, sufficient room to store standby pumps and other equipment is needed.

5.6.1.4 Microtunneling requires sufficient room on each side of the waterway for the bore pits and storage of the backfill material.

5.6.1.5 Aerial crossings require a different strategy in determining space requirements. A barge may be required to drive piling or drill piers. Crane locations may have to be established and traffic on host bridges may be disrupted.

5.6.2 Staging Areas

All types of construction require room to stockpile sufficient amounts of pipe, expendable construction supplies, and support equipment. Easy access to these critical components must be provided to avoid delays.

5.7 WELDING

Pipe welding shall be performed in accordance with applicable regulatory codes, industry standards, and the operating company's procedures.

5.8 INSPECTION AND TESTING

In most cases, it is difficult or impossible to repair crossings after they are installed. Strict construction inspection requirements for pipe body weld and coating defects should be established.

All girth welds within the flood plain should be non-destructively tested.

If the crossing pipe is fabricated as a unit prior to installation, a pre-installation pressure test is recommended. This test will supplement the final pressure test performed after the pipe is moved or pulled into place. Some operators maintain the final test pressure for 1 hour and perform a visual inspection during the pre-test.

After the pipeline is installed, pipe wall deformation should be checked with sizing plates or geometry tool. Pipe with unacceptable deformation shall be replaced. Consideration may also be given to running a post-installation geopig (inertial guidance with caliper) looking for dents, buckles, ovalities and high curvature to establish the baseline condition for the crossing.

The final pressure test should be performed in accordance with API RP 1110 and/or applicable regulations.

5.9 AS-BUILT DRAWINGS

After the installation of the new crossing, the contractor should provide as-built drawings and survey data tied into permanent benchmarks. The as-built drawings should show exact lateral and vertical placement of the pipeline, as well as the profile of the streambed channel. The drawings must be sufficiently accurate for future work at this location. Global Position Stationing (GPS) should be considered

5.10 SITE RESTORATION

Access roads to the construction site should be restored to preconstruction conditions and may require the repair of existing roads or seeding and revegetation of temporary roads or workspaces.

Temporary structures, such as cofferdams, flumes, bridges, bore pits, and excess backfill, should be removed and the site restored to preconstruction conditions.

Special attention should be given to trenched crossings. Careful evaluation of bank stability must be performed. It may be necessary to stabilize banks to prevent erosion of the newly installed crossing by using the following techniques:

- Revegetation,
- The use of stabilized backfill material,
- Mats,
- Riprap,
- Gabions,
- Geotextile fabrics,
- Other techniques to ensure stability.

5.11 CONSTRUCTION COMPLETION

Notifications of construction completion must be submitted to the appropriate regulatory agencies, as stated in the permits. The pipeline crossing location should be clearly marked in accordance with regulatory requirements. API RP 1109 may be applicable.

Appropriate information should also be submitted to one-call systems.

Appropriate construction records must be completed and submitted to the owner company for retention in accordance with applicable regulatory requirements.

6 OPERATION

6.1 SYSTEM GUIDELINES

6.1.1 General

Each operating company should develop operating procedures based on the provisions of this RP, the company's experience with and knowledge of its facilities, regulatory requirements, and the conditions under which its facilities are operated. Alternatives to the methods and procedures in this RP may be justified based on local conditions, such as the characteristics of the fluid transported, the water depth and velocity, the line cover, and the floodplain conditions.

6.1.2 Plans and Procedures

Each company operating a pipeline that crosses a floodplain should develop and maintain the following plans and procedures:

a. A plan to identify and review changes in conditions affecting the safety of the pipeline. The review should not be limited to the specific crossing location, since changes upstream, downstream and in other areas of the floodplain may impact the pipeline crossing.

b. An emergency plan—for implementation in the event of abnormal conditions, accidents or other emergencies—that includes features in 6.3.

Unless warranted by unique site specific conditions or risks, a separate plan need not be developed for each line section that crosses a floodplain.

6.2 PIPELINE OPERATIONS

6.2.1 General

Pipeline operators should be alert to weather patterns and conditions that are precursors to flooding or soil movement and have personnel available for surveillance, preventative maintenance activities and emergency response actions.

6.2.2 Surveillance

Pipeline operators should maintain a pipeline surveillance program that includes observations for leaks, erosion, subsidence, scour, encroachments, and other potentially threatening conditions within the floodplain. Conditions should be reviewed in accordance with applicable regulations and the plan established under 6.1.2, item a.

Personnel responsible for patrolling the pipeline right-of-way should be trained to identify areas that are potentially susceptible to washout, scour, erosion, subsidence, or other conditions that could be detrimental to the safe operation of the pipeline.

During abnormal conditions, surveillance should be increased to ensure that adequate lead time is provided to assess conditions and implement procedures identified in the emergency plan.

6.2.3 Periodic Evaluations

Periodic engineering/risk evaluations of pipelines crossing high consequence floodplains should be performed. The purpose of these evaluations is to assure continued crossing integrity. Several factors should be considered to determine evaluation intervals. These include, but are not limited to:

- Type of crossing.
- Depth of cover.
- Rate of scour or bank erosion.
- Characteristics of floodplain, i.e., hydrology, soil type, flow rates, etc.
- Development or activity that may affect floodplain and/or pipeline crossing.
- Major floodplain events.
- Product transported.
- Population density in vicinity of pipeline crossing.
- Environmental sensitivity.
- Regulatory requirements.

The factors listed above should be considered in determining evaluation intervals, but in no case should the maximum interval be greater than 10 years or applicable regulatory interval.

6.3 EMERGENCY PLAN

6.3.1 Plan Provisions

The emergency plan should identify the criteria that will be used to determine the threat to the pipeline, and the escalating response actions that will be taken as the threat to the pipeline increases. Depending on the specific conditions at the crossing, response actions could escalate through the following:

- Increased surveillance,
- Reduced operating pressure,
- Shutdown,
- Isolation of the section, and
- Purging of the pipeline contents.

Prior to purging the pipeline of its contents, the pipeline located in the floodplain should be checked for its on-bottom stability. *AGA Submarine Pipeline On-bottom Stability Analysis and Design Guidelines*, AGA Project No. PR-237-9428, and AGA Project No. PR-170-9522, may be utilized to determine the on-bottom stability.

The plan should address access requirements for critical facilities needed to safely operate or shutdown the pipeline, and identify alternate access routes or sites to be used in the event that flooding restricts access to, or submerges, those facilities, and include provisions to address power or communication failure.

If facilities that are normally aboveground are expected to be submerged during abnormal conditions, provisions should be included to de energize electrical components, mark their locations with buoys, if appropriate, and protect them from floating debris.

Emergency plans should be reviewed at least once during a calendar year and modifications should be made as required by changing conditions.

6.3.2 Communications

Procedures in the plan should cover communication with appropriate government agencies and the notification of parties including other pipeline operators who should be involved in the emergency action.

6.4 RESTORATION

Following a significant flood event, operators should evaluate the conditions along the pipeline and take remedial action as required.

The condition of the pipeline should be assessed to determine if the facilities require a detailed examination for possible damage from the incident. If damage (i.e., dents, gouges, buckles, cracks, high curvature, etc.) is found, the facility should be operated at a reduced pressure or shutdown commensurate with the damage until detailed examinations or repairs are completed.

Operators should ensure that line markers are in place, or are replaced in a timely manner in accordance with API RP 1109. Operators should notify contractors and others involved in post-flood restoration activities of the pipeline's presence and the risks posed by reduced cover, or silt and debris removal.

Pipeline company personnel should monitor all repair clean-up activity near the pipeline. Local one-call systems shall be contacted if cleanup work is performed near the vicinity of the pipeline. Operator should also notify local community of condition and repair plans.

7 Maintenance

7.1 MITIGATION OF EXPOSURES

If exposed pipe is found in a floodplain, the pipeline operator should evaluate the exposure and determine the risk. Consideration must be given to the risk to the watercourse and other structures in the watercourse if a repair is made. Repairs in the watercourse can cause further scouring, bank washouts and other unintended changes. Therefore, it is important to analyze both the risk of exposure as well as the detrimental consequences of repair.

All exposures do not necessarily warrant corrective actions. For example, if a trenched crossing has become exposed, but is not in the water flow and is not considered a risk to the pipeline or the environment, it is acceptable to treat the crossing as a span as long as it is then maintained as exposed piping.

The same risk criteria should also help the operator determine the timing of mitigation, should mitigation be warranted. Some crossings will require immediate response, while others might be better handled when favorable weather conditions enable the best repair (dry season).

Repair methods may include but are not limited to the following:

a. Lowering by trenching or jetting (see API RP 1117).
b. Sandbagging around the exposure.
c. Placing concrete mats over the pipeline.
d. Placing riprap over the pipeline.
e. Installing cribbing or supports.
f. Installing structures to allow deposition of silt over the pipeline.
g. Replacement of the crossing.

The exposed pipeline should be inspected for damages. Damage to the pipe, such as gouges, grooves, dents, or scratches, should be evaluated using the ASME B31.4 or B31.8 criteria. Maintenance welding performed on the pipe should comply with applicable regulations, industry standards, and company procedures.

7.2 ABANDONMENT

7.2.1 Abandonment

A pipeline should be abandoned when the operator determines that there is no longer viable use for the pipeline or the condition of the pipeline has degraded to a point where the operator determines that the risk of operation is not acceptable. The operator of pipelines crossing which could affect a commercially-navigable waterway should consider the issues in 7.2.2 when preparing the line for abandonment. Markers should be maintained on both sides of the waterway to identify the operator and the location of the crossing.

7.2.2 Abandonment Plan

The agency or private owner who has jurisdiction over the watercourse and floodplain being traversed by the pipeline should be contacted and involved in the abandonment plan. Depending on the nature and condition of the floodplain crossing, several methods for abandonment should be considered:

a. Cut the pipeline on either side of the floodplain crossing, displace the contents of the pipeline with inert gas, and seal the pipeline. This method is effective if it is possible to leave the pipe in the floodplain and the pipe will not become buoyant.
b. Cut the pipeline on either side of the floodplain crossing, displace the contents of the pipeline, and fill with slurry (masonry grout) or water.
c. If the pipeline poses a risk to the public or watercourse traffic, isolate and displace the pipeline and take the pipe out of the floodplain. Careful consideration must be given to this method due to the effects such work can have on the watercourse banks and the floodplain.

Records of abandonment and any necessary jurisdicitional agency notifications should be processed and retained.

If the pipeline will be left in place (i.e., item a or b above), it may be necessary to continue monitoring the abandoned crossing which may be affected by floods or other watercourse emergencies.

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