MCD Report No. 2024-28

MCD

MIAMI CONSERVANCY DISTRICT

Miami Conservancy District

Pipe Inspection Manual

For Pipes Through or Adjacent to MCD Infrastructure

April 2024

Contents

1. STATEMENT OF PURPOSE

The purpose of the Pipe Inspection Manual is to provide guidance on how and when to inspect pipes that penetrate or run adjacent to the Miami Conservancy District's (MCD) flood protection infrastructure. As pipes age, deterioration adversely affects the pipe's performance and increases the risk of failure to the surrounding flood protection infrastructure, which could lead to increased risk of flooding. Therefore, MCD requires all pipes that may impact MCD's flood protection infrastructure be inspected on a regular basis and given an assessment condition as defined in this Manual.

Additionally, this Manual provides guidance on complying with permit requirements and reporting the inspection documents and results of the inspection to MCD for review. Condition assessments then lead to the potential mitigation of any issues. Following this manual's procedures is key to the effective function and ongoing integrity of MCD's flood protection system.

2. INSPECTION LIMITS

Setting inspection limits helps maintain the structural integrity of the flood protection asset(s) and ensures operational adequacy that prevents the flood protected area from inundation. A flood protection asset could be a multitude of things (walls, gates, levees, roads, pipes, etc), but all have the same task of flood protection. The following limits are minimum and general limits and MCD will assist with setting the inspection limits. Generally, specific inspection limits may be noted in the permit and generally shall include entering the pipe on the closest landside manhole, unless the manhole is on the toe of the levee slope, and extend to the outfall. There may be a need to increase these limits on a case by case basis based on site-specific knowledge and configurations of the pipe.

2.1. Structural Integrity

The area in which the structural integrity of the flood protection asset, including the maintenance/emergency access road along that asset, could be impacted by defects in the pipe is called the “influence zone”. Figure 1 is an example scenario that displays the influence zone and minimum and recommended inspection limits.

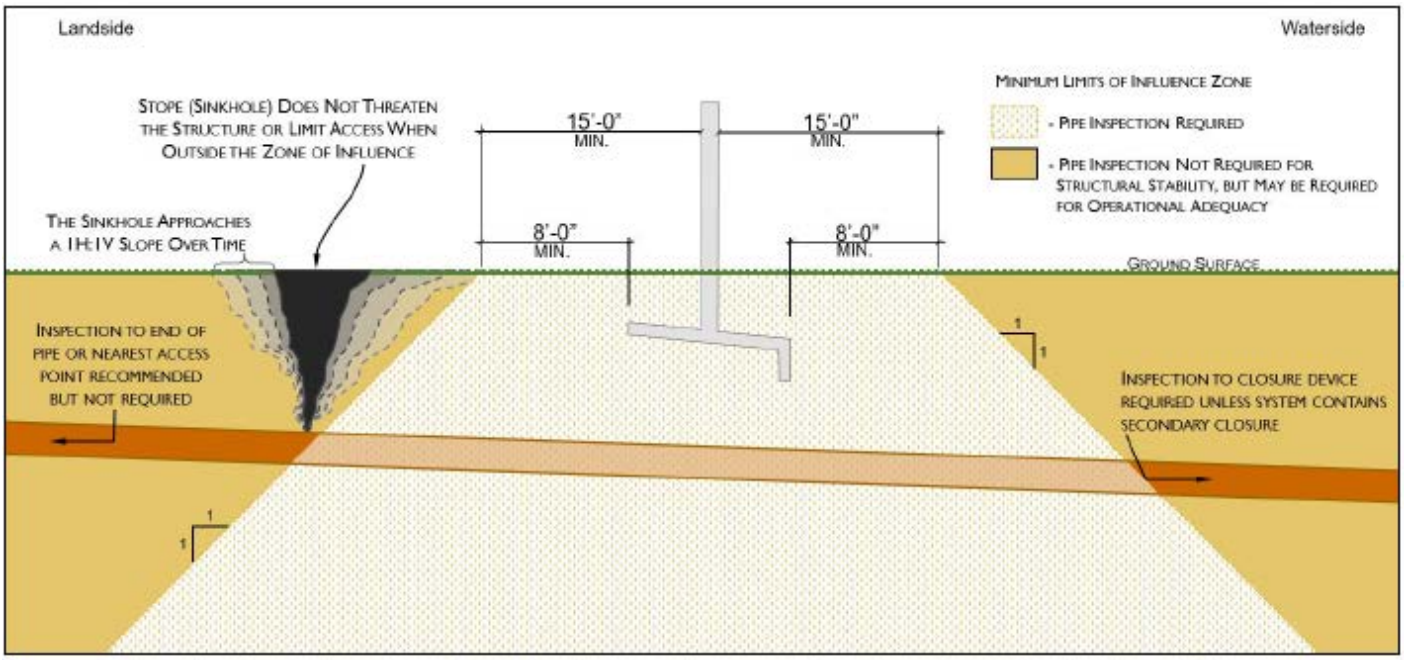

Figure 1: Influence Zone Example
USACE EM 110-2-2902 Figure 6-2

2.2. Operational Adequacy

MCD's main mission is to protect residents and properties from flooding. Operational adequacy is the flood protection system's ability to perform its job and keep the landside from inundation. The following figure (Figure 2) illustrates how inspection limits for operational adequacy are different than for structural integrity.

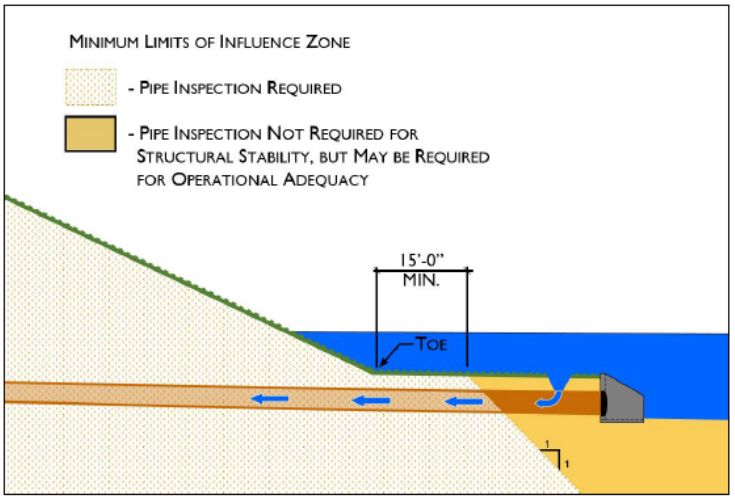

Figure 2: Operational Adequacy Example
USACE EM 110-2-2902 Figure 6-3

2.3. Pipes Through Flood Protection Infrastructure

Gravity pipes going through or under flood protection infrastructure are required to be inspected from inlet to outlet. Gravity pipes that do not daylight at the landside levee toe are inspected to 15 feet at a minimum, with a projected 1H:1V slope below the ground surface, like the example in Figure 3.

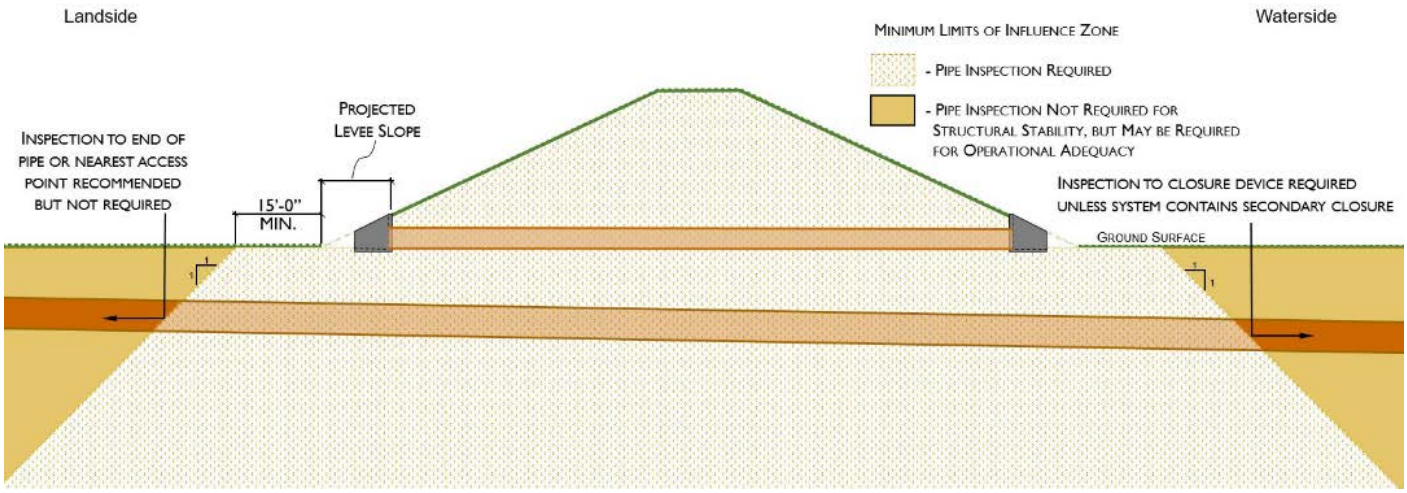

Figure 3: Cross sectional pipes through a levee example
USACE EM 110-2-2902 Figure 6-4

2.4. Pipes Running Adjacent to Flood Protection Infrastructure

Pipes running adjacent to flood protection infrastructure that are within 15 feet horizontally of the levee toe or floodwall, within eight feet of the floodwall foundation or toe drain, or below a 1H:1V slope from that point, require inspection. See Figure 4 for an example of a pipe running adjacent to a levee.

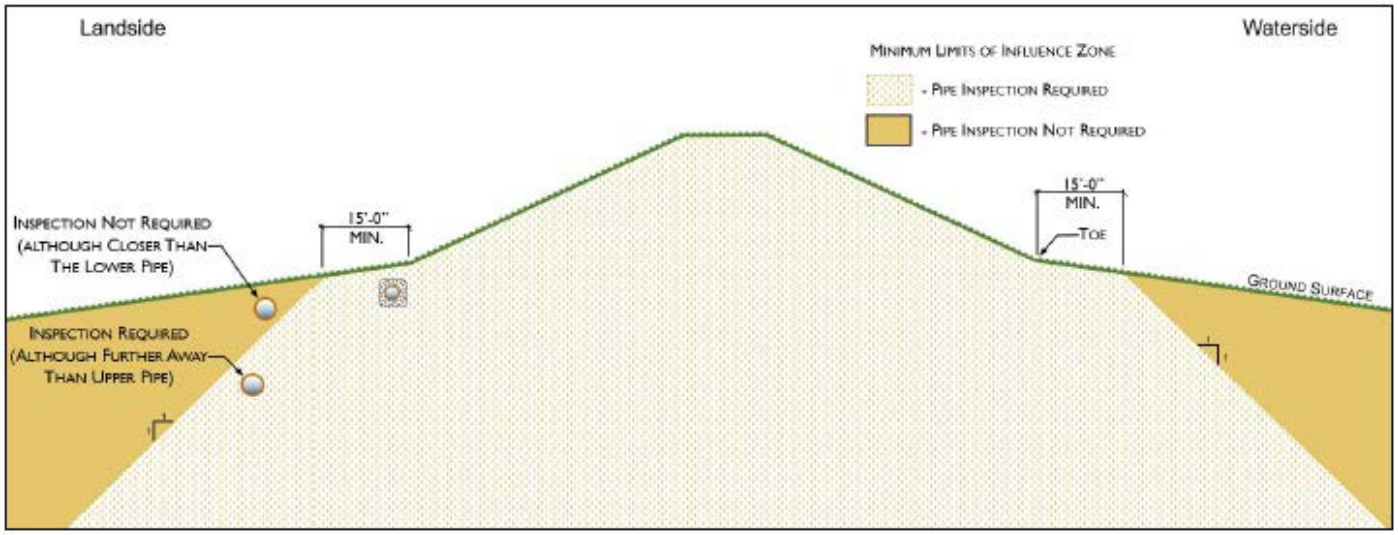

Figure 4: Pipes running adjacent to a levee example
USACE EM 110-2-2902 Figure 6-7

2.5. Pump Station Discharge Pipes

Discharge pipes from pump or lift stations are inspected from the inside of the pump station all the way to the outlet structure, regardless of the presence or absence of floodgates.

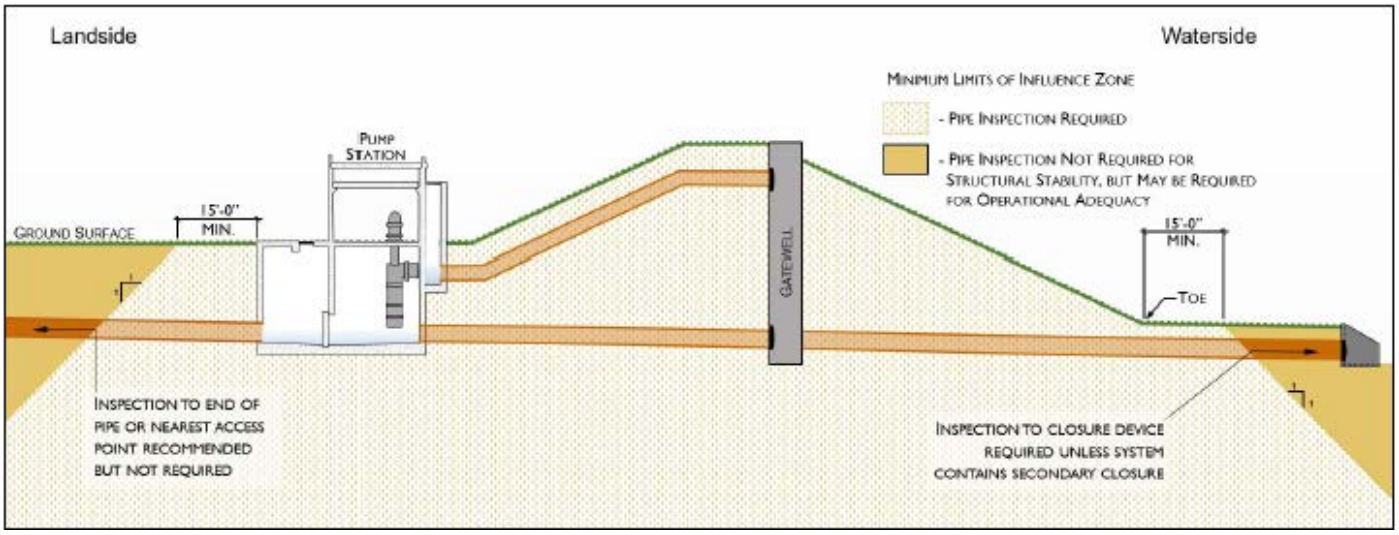

Figure 5: Discharge lines from a pump station example
USACE EM 110-2-2902 Figure 6-9

3. INSPECTION METHODS

After the determination of the inspection limits, the method of inspection must be chosen. Figure 6 is a flowchart that can assist in choosing the method of inspection. The following subsections will discuss each method in detail.

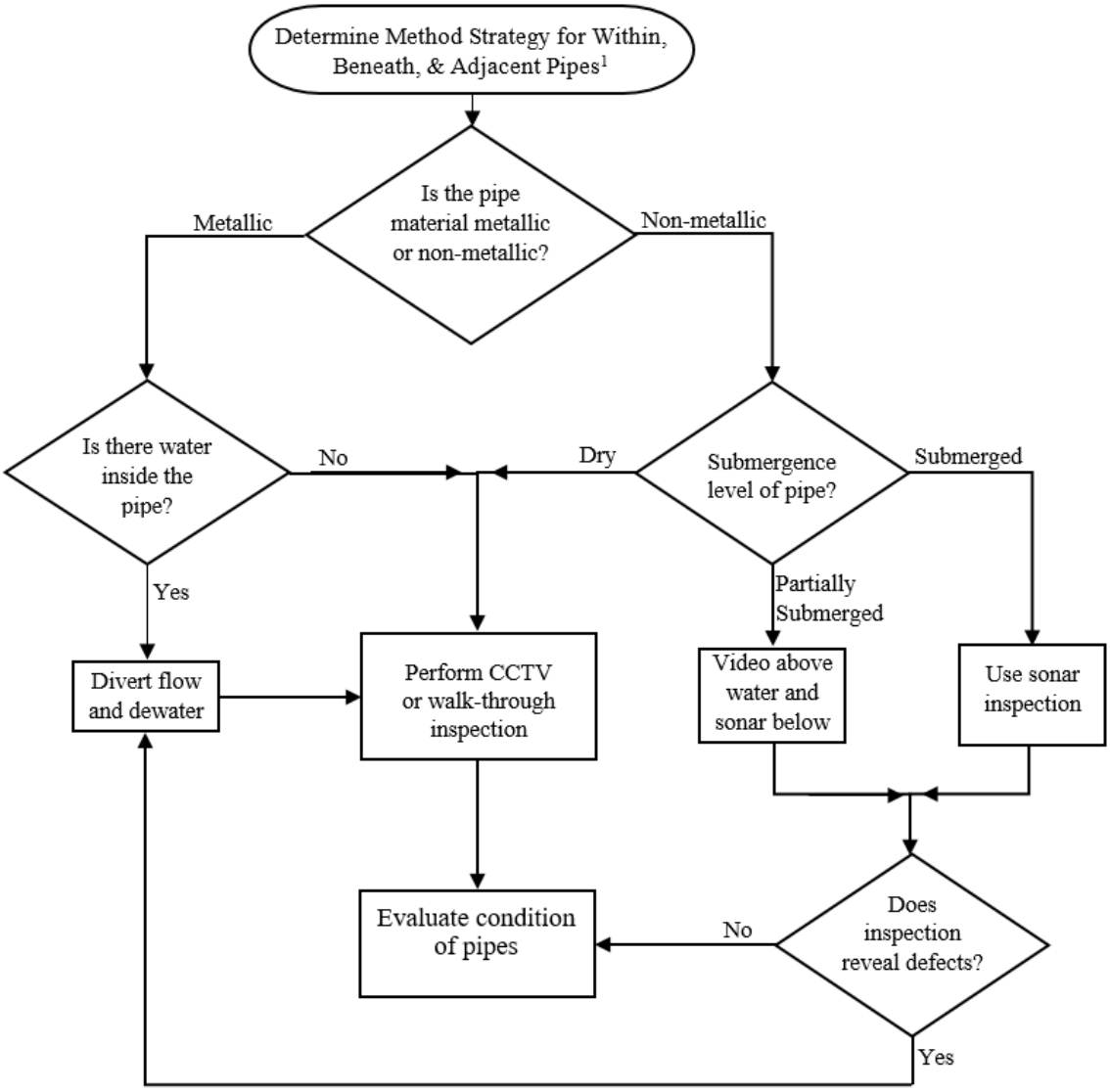

Figure 6: Method of inspection flowchart
USACE EM 110-2-2902 Figure 6-12

3.1. Walk–Through Method

The walk-through method is the preferred method of inspection when possible. This hands-on method allows the inspector the ability to touch and test areas of concern as well as make very accurate measurements. Flows up to six inches deep in the pipe invert can be tolerated when the water is clear enough that the condition of the bottom of the pipe can be seen.

Pipes 48 inches and greater in diameter are easier for entry but other factors, like air quality, may force or provide a preference for remote camera method.

Requirements of the walk-through method include:

- Inspectors should be knowledgeable about pipe design and installation, how pipe defects can lead to Potential Failure Modes (PFMs), and pipe joint and structure connection details. Inspectors should be familiar with site-specific details about the type of pipe, limitations of pipe joint movement, and plan and vertical alignment. The inspector should review construction and inspection history prior to the inspection.
- The inspector is required to demonstrate their qualifications by providing training and experience records. It is recommended that they demonstrate experience with levee or dam pipes. Individuals operating the remote inspection equipment must be trained and certified by the National Association of Sewer Service Companies' (NASSCO) Pipeline Assessment Certification Program (PACP), or an organization with equivalent standards. A minimum of one year of experience with pipe inspections using the NASSCO's PACP is required. All inspections using remote equipment are required to meet the minimum visibility and operation requirements of NASSCO's PACP.
- Any pipe with debris, sediment, or other obstruction that limits the inspection of the pipe must be cleaned prior to inspection.
- Proper equipment and materials needed include:
    - MCD inspection form, shown as Figure 8 the Appendix and available at MCDwater.org/permits.
    - Light source. Intensity adjustable lights are preferred and result in the best quality photos and videos.
    - A camera to document findings.
    - Measuring devices for showing pipe defects and to show location from entry point.
    - GPS to determine the coordinates of the inlet and outlet locations to six decimal places. Coordinates should be in decimal format.
    - Air monitoring device.

3.2. Remote Methods

When the walk-through method is not feasible, remote inspections should be considered. There are three common types of remote methods: Closed-circuit television (CCTV), Sonar, and CCTV and Sonar Hybrid. Other remote methods may be used if approved by MCD.

Requirements of the remote inspection method include:

- The inspector is required to demonstrate their qualifications by providing training and experience records. It is recommended that they demonstrate experience with levee or dam pipes. Individuals operating the remote inspection equipment must be trained and certified by the National Association of Sewer Service Companies' (NASSCO) Pipeline Assessment Certification Program (PACP), or an organization with equivalent standards. A minimum of one year of experience with pipe inspections using the NASSCO's PACP is required. All inspections using remote equipment are required to meet the minimum visibility and operation requirements of NASSCO's PACP.
- Any pipe with debris, sediment, or other obstruction of the pipe must be cleaned prior to inspection to provide and unobstructed view.

3.2.1. CCTV

Remote inspections using CCTV are best performed when the pipes are dry or mostly dry (less than six inches of water). Metallic pipes are subject to corrosion which can only be adequately observed when completely dewatered.

Tracked, wheeled or push types of CCTV cameras are good options to navigate the pipe. Each type of camera has their unique advantages.

Requirements specific to CCTV method include:

- CCTV inspection is best accomplished through low flow depths (up to six inches) of clear water. If the water is moving too fast or is too deep to evaluate all pipe and joint surfaces, dewatering or diversion is required.
- Proper CCTV equipment and materials needed include:
    - Light source: Bright, high-intensity light source that travels with the camera. Ability to control the light intensity to control glare is an important feature that can improve the quality of the video images. Lighting during the inspection must be adequate to fully illuminate, but not overly illuminate, pipe joints and individual points of interest (at a right angle to the direction of travel) for an accurate assessment. Excessive lighting or an overly-adjusted camera iris can result in a flaring of the image and exaggeration of pipe joint displacement or other pipe conditions.

Figure 7: CCTV wheeled camera

    - Camera: Color, high definition (720p or better) resolution camera with remote focus, zoom, pan, and tilt capability.
    - Video: Video image digitally recorded using a current digital multimedia video format and be configured to have the ability to use all features of the CCTV player, including fast forward capability.
    - Measurements: Footage meter with capability to record footage reading on the video at all times. Ability to record and display distance from starting point within 0.1-foot accuracy.
    - Travel speed: Maximum travel speed through the pipe not exceeding 25 feet per minute.
    - Still Images: Ability to take still images in .jpg or .png format of all significant defects observed during the inspection.
    - 360-degree Joint Views: Ability to stop traversing and record a 360-degree view of each joint.
    - Defect Recording: Ability to stop traversing if any defects are suspected and record a detailed video inspection.

3.2.2. Sonar

Sonar is the preferred remote inspection method for non-metallic pipes that have accumulated water or when it is not practical to dewater the pipe. The quality of the digital inspection obtained by sonar is less detailed than CCTV, because sonar cannot show cracks without offsets or open cracks with soil visible. Sonar inspection excels by showing offsets and distortions in the pipe interior and sediment build up. Sonar inspections are not to be used on metallic pipes. Sonar is unable to detect surface corrosion without measurable section loss common in metallic pipes. Debris or sediment in the pipe will limit the sonar's capability to produce useful images. Pipes should be cleaned before a sonar inspection, if possible.

Requirements specific to sonar method include:

- Sonar inspections must be specifically adapted using multi-frequency sound waves to locate and map irregularities by creating continuous sonar images.
- Sonar equipment must utilize digital, multi-frequency profiling in order to model the submerged portion of the pipe. Using a rotating transducer, the sonar unit must transmit an acoustic signal toward the pipe walls in a radial fashion. The time delay between transmission and reception of reflected pulse echo is used to determine the distance from the transducer to the surface that reflected the pulse.

3.2.3. CCTV and Sonar Hybrid

One common scenario where hybrid CCTV and sonar inspection method is best used is when the non-metallic pipe is partially submerged with water and cannot be dewatered. The CCTV inspects the pipe above the water surface and sonar below the water surface.

Requirements specific to sonar method include:

- Follow the manufacturer's recommendations when positioning equipment inside the pipe. Ensure to complete a 360-degree inspection of the pipe circumference at one-inch intervals along the length of the pipe.
- During the inspection, the following information must be clearly and continuously displayed on the periphery of the screen, monitor, and CCTV recording:
    - starting location ID
    - ending location ID
    - distance from access point

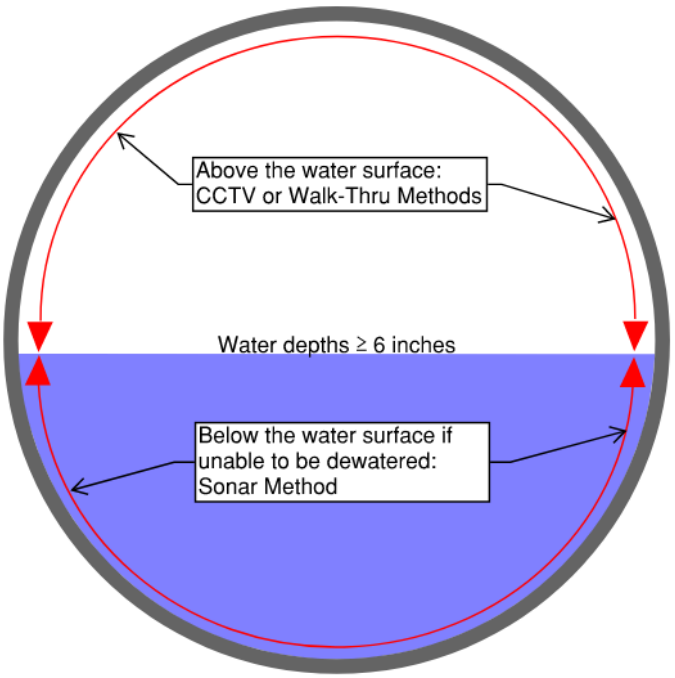

Figure 8: CCTV and Sonar Hybrid Method

4. DOCUMENTATION

4.1. Inspection Documentation

Pipe inspections must be documented either using the inspection form during a walk-through inspection, shown in the Appendix, or on a digital inspection form, similar to Figure 9 and meeting requirements of NASSCO's PACP or organization with equivalent standards, through the use of a digital program that records the pipe condition during a remote inspection (reference NASSCO PACP and MACP Inspection Forms). For both walkthrough and remote inspections, PACP, or an organization with equivalent standards ratings, must be used to rate the defects of the pipe.

List of the information that is required to be obtained as part of a pipe inspection and included on the inspection form for each pipe:

- Date of inspection
- Inspector names and qualifications
- If applicable, nearest dam or levee as-built station number
- If applicable, MCD Floodgate number
- Coordinates on inlet and outlet locations to 6 decimal accuracy, preferred in decimal format instead of DMS.
- Segment length
- Description of pipe purpose
- Type of pipe, including material, diameter, shape, segment length.
- Inspection method (walk-through, remote inspection indicating CCTV, Sonar, or Hybrid)
- Inside diameter of pipe
- Defect, PACP (or equivalent) rating
- Clock position of defect
- Distance from reference point
- If possible, defect measurements, including height, width, depth
- Picture of each defect

Inspection report

Date:	Work Order:	Weather:	Surveyed By:	Certificate Number:	Pipe Segment Ref.:
9/28/2021			Andy Jurski	U0620-2	HC2 CB3 to HC2 CB2
Year laid:	Pre-cleaning:	Direction:	Pipe Joint Length:	Total Length:	Length Surveyed:
	No Pre-Cleaning	Upstream		77.4 '	77.4 '

City:	Moraine OH	Drainage Area:		Upstream MH:	HC2 CB2
Street:	ST RT741	Media Label:		Up Rim to Invert:	0.0
Location Code:		Flow Control:		Downstream MH:	HC2 CB3
Location Details:		Sheet Number:		Down Rim to Invert:	0.0
Pipe shape:	Circular	Sewer Use:	Levee Gravity Pipe	Total gallons used:	0.0
Pipe size:	12 "	Sewer Category:	SEC	Joints passed:	0
Pipe material:	Concrete Segments (unbolted)	Purpose:		Joints failed:	0
Lining Method:		Owner:			
Additional Info:					

1:584	Distance		Code	Observation	Counter	Photo
HC2 CB3						
	0.0		ACB	Catch Basin, HC2 CB3 / HC2 CB3	00:00:06	HC2 CB3 to HC2 CB2_0001.jp
	0.0		MWL	Water Level, 5% of the vertical dimension	00:00:10	HC2 CB3 to HC2 CB2_0002.jp
	2.9	S01	FL	Fracture Longitudinal, at 10 o'clock , Start	00:00:36	HC2 CB3 to HC2 CB2_0003.jp
	6.9	F01	FL	Fracture Longitudinal, at 10 o'clock , Finish	00:00:58	HC2 CB3 to HC2 CB2_0004.jp
	22.3		H	Hole, at 5 o'clock , within 8 inch	00:03:46	HC2 CB3 to HC2 CB2_0005.jp
	58.5		FC	Fracture Circumferential, from 12 o'clock to 12 o'clock	00:07:35	HC2 CB3 to HC2 CB2_0006.jp
	77.4		ACB	Catch Basin, HC2 CB2 / HC2 CB2	00:10:03	HC2 CB3 to HC2 CB2_0007.jp
HC2 CB2						

Figure 9: Example of digital inspection form

4.2. Submittals

The following items must be submitted after completion of all required inspection activities. If the inspection is related to permit renewal, submittals are due to MCD 6 months prior to the permit renewal date, or as otherwise specified in the permit.

- Narrative report: The CCTV and/or sonar inspector must provide a brief narrative report that summarizes the following for each pipe inspected:
    - the pipe location
    - inspection limits: start and end points
    - conditions during the inspection
    - equipment used
    - general condition of the pipe
    - specific defects with location
- Clearly labeled and organized electronic inspection videos.
    - Videos shall be MPG1 or MPG4 or AVI format and deemed acceptable by MCD.
- Electronic still-captured pictures and/or sonar images of significant defects.
- Digital copy of inspection forms with information specified in Section 4.1.
- Aerial map locating deficiencies, similar to Figure 10. The location of the waterside and landside toe of the levee, or location of the floodwall centerline, must be clear and/or labeled on the aerial map. The map must also show the direction of CCTV camera travel. Sonar inspection defects are also mapped in a similar manner.
- Condition Assessment of each pipe.

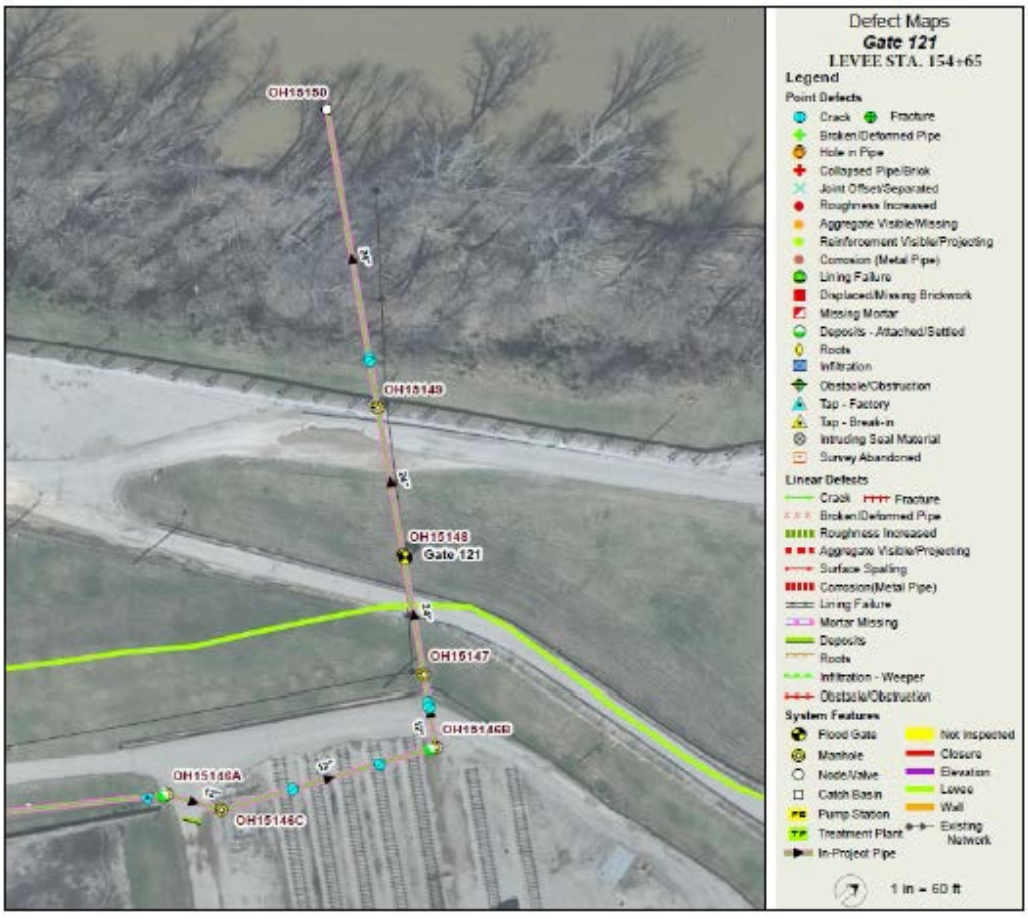

Figure 10: Example of aerial map locating deficiencies
USACE EM 110-2-2902 Figure 6-15

5. CONDITION ASSESSMENT

Once MCD has received the submittals, MCD will review each pipe's condition assessment, along with external conditions observed during an inspection, to determine the overall condition rating (1 through 5) of each pipe and determine the portion of the pipe that is likely to impact the structural integrity and operational adequacy of the flood control infrastructure (see Section 2.1 and 2.2). The MCD Chief Engineer will use their training and experience to assign the most appropriate structural or Operation & Maintenance (O&M) rating, which may differ from NASSCO's PACP recommended ratings found in Tables 1 and 2 in the Appendix.

After the condition assessment, MCD will assist in the decisions of maintenance, repair, abandonment/removal, reconstruction, etc.

Note that the acceptance standards for pipes associated with dams and levees are more stringent than those for storm or sanitary sewers not in dams or levees, due to the potential consequences and the protection against regional flooding.

6. INSPECTION FREQUENCY

The maximum interval between inspections can be found in the permit. Generally, inspections are to be conducted every 5 years. Submit the required documents to MCD 6 months prior to the permit renewal date, see the Submittals Section (4.2). The following are some considerations that may warrant more frequent inspections:

- Condition: Pipes with a larger amount of higher graded structural defects will have a higher probability of causing a failure of the flood control infrastructure component.
- Flood return frequency: A pipe that is loaded more frequently is usually more likely to fail than one that is loaded less frequently.
- Consequence: Some areas protected by a levee system would be more severely impacted by a failure based on the area flooded, depth of a flood, number of people protected, and/or number of properties protected.
- Location: Determine the pipe's proximity to critical infrastructure, evacuation routes, large populated areas, etc.
- Diameter: Pipes with larger diameters are harder to flood fight than smaller pipes and will cause faster inundation.

7. APPENDIX

SEGMENT NAME:						
Inspection Details	Inspected by:					
	Inspector Qualifications:					
	Description of Pipe Purpose:					
	MCD Levee System:					
	MCD Floodwall:					
	MCD Floodgate:		Date of Inspection:			
	Pipe Type:		Pipe O.D.:			
	Pipe Length:		Pipe I.D.:			
	Coordinates: Decimal Format 6 digit Accuracy	Inlet:				
		Outlet:				
	Inspected via:					
	Sketch (Path of Inspection, approx. locations of: defects, river, flood infrastructure, etc.)					

Deficiency Details	PACP Defect Code	Location (ft)	Time Stamp	Comments	Photo	Clock Position

Results Summary:	
Rating:	

Table 1: PACP structure defect code and grades
USACE EM 110-2-2902 Table 6-1

Defect Codes per NASSCO PACP [1] or other Organization with Equivalent Standards (reference Section 6.3 for inspection limits)		NASSCO PACP Defect Grade for Dams and Levees	Required Action
- Any crack hinge code - Any fracture, broken, or hole code - Collapse - Any flexible deformation > 10% - Any brick deformation ≥ 10% - Any rigid deformation Code - Any joint offset, separated, or angular code - Dropped invert	- Any weld failure code - Any point repair defective code - Missing brick - Any surface damage reinforcement code - Missing mortar medium and large - Surface damage missing wall - Surface damage corrosion (without further inspection or section loss ≥ 25%)[2]	4 or 5	Mitigate
- Crack longitudinal, multiple, or spiral - Any flexible deformation ≤ 10% - Any brick deformation < 10% - Displaced brick - Surface damage corrosion (with inspection and section loss < 25%)[2]	- Surface damage surface spalling - Any point repair code (non-defective) - Any surface damage aggregate code - Missing mortar small - Any lining feature code	3	Monitor
All other codes		1 or 2	Continue Inspection Frequency

[1]Defect codes are explicitly defined by the latest version of NASSCO's PACP manual. Some codes only pertain to specific pipe materials, while others indicate a location within a pipe segment.
[2]Additional inspection is recommended for observed corrosion to determine the extent of section loss using devices to measure remaining pipe wall thickness (e.g. ultrasonic thickness measuring instrument).

Table 2: PACP O&M defect code and grades
USACE EM 110-2-2902 Table 6-2

Defect Codes per NASSCO PACP [1] or other Organization with Equivalent Standards (reference Section 6.3 for inspection limits)		NASSCO PACP Defect Grade for Dams and Levees	Required Action
- Any deposits code ≥ 25% blockage - Any roots medium or ball code - Any infiltration runner or gusher code	- Any obstruction code ≥ 25% blockage - Any intruding seal code ≥ 25% - Any tap defective code	4 or 5	Maintenance & Repair
- Any roots tap code - Any obstruction code 15% - 20% blockage - Any intruding seal code 15% - 20% blockage	- Any tap intruding code - Any deposits code 15% - 20% blockage - Any infiltration dripper code	3	Monitor
All other codes		1 or 2	Continue Inspection Frequency

[1]Defect codes are explicitly defined by the latest version of NASSCO's PACP manual. Some codes only pertain to specific pipe materials, while others indicate a location within a pipe segment.

8. REFERENCES

Much of this report, including figures, tables, and information, was taken from the following:

U.S. Army Corps of Engineers. (12-31-2020). *EM 1110-2-2902 Conduits, Pipes, and Culverts Associated with Dams and Levee Systems.*