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Video and Sonar Assessment of the Coronado Transbay Sewer Force Main Under San Diego Bay

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ABSTRACT: The City of Coronado's (City) Original Transbay Sewer Force Main (original force main) was in continuous service and was never fully inspected from its construction in 1974 until mid-2007. The original force main was the City's only option for conveying wastewater across San Diego Bay to treatment facilities in San Diego. When a new parallel force main was completed in May 2007, the City wanted to inspect the original force main and determine options for its reuse or abandonment. Because of its high value, and potential for redundancy of wastewater conveyance, the original force main had the potential to be a valuable asset if an inspection could confirm its condition. The original force main is approximately 3,200 linear feet of 24-inch ductile iron pipe buried below the bottom of San Diego Bay with both termination points in busy tourist areas. Any inspection would require great care to avoid risk to public health, the environment and locally important tourist facilities. This paper provides a summary of the risk management plan prepared to identify and resolve potential issues that might occur, the robotic technology used to complete the inspection, a summary of the 2008 inspection results, and the 2010 follow up inspection.

INTRODUCTION

The City of Coronado's (City) Original Transbay Sewer Force Main (original force main) was in continuous service from its construction in 1974 until mid-2007. The original force main served as the City's only option for conveying raw wastewater across San Diego Bay to the City of San Diego until the City constructed a new parallel force main in May 2007. Committed to protecting the environment, reducing the potential for water quality impacts, and preserving ratepayer investments, the City wanted to shut down the original force main, inspect it and determine rehabilitation options for ongoing use. The relatively young age and value of the original force main made it a perfect asset for reuse: it could increase both the reliability and redundancy of the City's sewer force main system.

The original force main is a 24-inch diameter ductile iron pipe buried approximately 5 feet below the bottom of San Diego Bay. The 3,400 linear foot alignment begins at the Transbay Pump Station located within the Coronado Ferry Landing Restaurant and Shopping District and terminates at an outfall manhole on the south side of Seaport Village, a shopping and dining center, in the City of San Diego. The approximate location of the original force main alignment across San Diego Bay is shown in Figure 1.

Figure 1: Aerial Photo Showing Approximate Alignment of Original Force Main (Photo Courtesy of Google Earth)

The available as-built drawings do not indicate how the pipeline and trench were constructed. Specifications for the ductile iron pipeline were not available. In addition to its highly visible end points and lack of detailed construction information, other factors that made inspection difficult included:

- vertical slopes of greater than 30%;
- maximum depth of 50 feet below mean sea level;
- concern that dewatering would expose the interior of the pipe to oxygen which may accelerate the corrosion process.

Traditional closed circuit television (CCTV) inspection was a not viable because of the length of pipe and the extreme slopes near the Transbay Pump Station and the outfall manhole. By using visual and sonar inspection together, Winzler & Kelly's team was able to provide a condition assessment of the original force main. These inspection methods required an inspection vehicle capable of inspecting pipelines with access points greater than 1,800 linear feet, providing visual inspection without dewatering, and providing information if there were any significant structural damages to the interior of the pipe. Because of technical challenges of this assignment, as well as the high profile location of the facilities, the City and consultant team pre-planned every aspect of inspection in order to minimize risk and provide for rapid response to any foreseeable situation. Winzler & Kelly teamed with Pure Technologies and was supported by Affordable Pipeline Services (APS) to provide visual and sonar inspection services for the City. Pure Technologies' inspection crawler (crawler) was designed for inspection of pipelines without dewatering by means of a camera capable of providing visual data under full pipe conditions and inspecting distances close to 5,000 linear feet. Pure Technologies' crawler also has sonar capabilities which can provide continuous profiling of the interior of the pipe. This provides accurate quantifiable data representing the characteristics of the pipeline. This data can be plotted in a variety of formats indicating pipe size, deformations, defects and debris.

DEVELOPMENT OF THE RISK MANAGEMENT PLAN

The City and the inspection team determined that the inspection would start at the Transbay Pump Station because the outfall manhole on the City of San Diego side of the original force main was in poor condition, adjacent to a souvenir shop, and would require some coordination with the Port of San Diego, the underlying property owner. This inspection point was used in 2004 inspection attempt that provided sonar data only for approximately two-thirds of pipeline. The previous inspection attempt utilized a blind flange in the valve vault at the Transbay Pump Station to enter the original force main. During their previous attempt, the City found sewage sludge behind the blind flange and based on this past experience, the inspection team included pre-inspection activities such as removal of the blind flange and cleaning of possible sewage sludge.

Because of the difficult conditions, the inspection team developed a risk management plan to identify potential problems or issues that might occur, based on the City's previous inspection experience and a review of the plan and profile as-builts of the original force main. The risk management plan described procedures for resolving the issues, providing for worker and public safety and protecting water quality. This risk management plan was a critical element of the project and anticipated a full range of technical issues including staff and public safety as well as managing potential technical issues such as having the crawler stuck in the force main.

Risk Management Team

The Risk Management Plan defined roles and responsibilities for the project team, as a first order of business. It was important to include lead field personnel on the development of the risk management plan because they would be executing the inspection and were familiar with the operation of the inspection and cleaning equipment. The following table summarizes key members, their roles and responsibilities:

Table 1: Roles and Responsibilities of Risk Management Team

Name	Organization	Role	Responsibilities
Eric Minicilli	City of Coronado	Project Manager	Project Manager and Point Of Contact for City
Ed Walton	City of Coronado	City Engineer	
Kim Godby	City of Coronado	O&M	Manage City O&M Staff
Marc Solomon	Winzler & Kelly	Consultant/Engineer	Lead Risk Manager
Elmer Alex	Winzler & Kelly	Consultant/Engineer	Alternate Risk Manager
Corey Charfauros	Affordable Pipeline Services (APS)	Entry Point cleaning Lead	Manage cleaning & inspection support efforts
James Milward	Pure Technologies	Inspection Lead	Pilot/Equipment Operator

After the team members were identified, a risk management method was developed using a step-by-step process of (1) risk identification, (2) risk analysis, (3) risk response, and (4) risk tracking and reporting. The first three steps happened in sequence, and the final step, risk tracking and reporting, occurred throughout the inspection process.

Risk Identification

The Risk Management Plan developed presented the obvious risks of the inspection, however the Plan also recognized that risk identification was a continuous activity. The job of identifying risk did not end once the risk management plan was written. Because new unexpected risks could develope during the inspection of the force main, every member organization had representation during the inspection of the force main to identify any unexpected risks that were not previously identified.

Risk Analysis

The risk analysis included two main tasks: 1) assessing each risk for its potential harm to the project or public health and safety, and 2) prioritizing risks for attention and actions. Each risk that was identified was assessed and given a category and priority based on its potential to harm the project. The following table was used by the project:

Table 2: Risk Categories with Definition and Priority

Category	Definition	Priority
Red	Potential to cause 100% failure of project	High
Yellow	Potential to lengthen inspection	Medium
Green	Very low risk to the success of the project	Low

Risk Response

Risk response included two main tasks: 1) planning on how to respond to risks and 2) executing and monitoring action plans for responding to risks. The types of risk response that were developed for the project included:

1. Avoid: This risk response would require changing the project plan to avoid the risk completely.
2. Accept: This risk response would require the risk management team to document and communicate the risk, but did not require any action.
3. Mitigate: This risk response required the risk management team to take action to reduce the probability and impact of a risk to reasonable threshold. There were two types of risk mitigation activities:
- **a. Prevention:** activities the team could do before the risk occurs to reduce its probability and impact. Planned prevention activities answered the question "What can we do now?"
- **b. Contingency:** activities the team could do once the risk occurs to reduce its impact. Contingency activities answered the question "What can we do if the risk happens?"

Risk Management Process

The risk management team developed the analysis prior to beginning any cleaning and inspection activities. Each potential risk was assigned a number in order of expected occurrence, a risk category color, and a risk response category. Specific team members were assigned responsibility for managing the risk event and appropriate response activities were described for each risk event. The following is a summary of the analysis performed for the risk management process.

Risk #1: Confined space hazards
Category: Yellow **Response:** Mitigate **Team Member:** APS
Activity: Use certified confined space personnel through the inspection and pre-inspection process. Follow confined space procedures including air monitoring, having a tripod with wench, air blowers and escape respirators on site, having standby rescue personnel on site.

Risk #2: Trouble removing flange from entry point at Transbay Pump Station
Category: Red **Response:** Mitigate **Team Member:** City, APS
Activity: APS to enter vault one week prior to inspect flange and determine what tools are necessary to remove. APS to perform all cleaning and flange removal the day before inspection.

Risk #3: Visual and odor impact from inspection activities
Category: Yellow **Response:** Mitigate **Team Member:** All Parties
Activity: Work to be performed at night. City to notify stakeholders. Winzler & Kelly to prepare any document support for the City.

Risk #4: Lowering camera into vault and dropping the camera
Category: Yellow **Response:** Mitigate **Team Member:** APS, Pure Technologies, Winzler & Kelly
Activity: Pure Technologies to communicate camera weight and dimensions to APS. Winzler & Kelly to follow up with team member to ensure information is communicated.

Risk #5: Sludge at insertion point
Category: Red **Response:** Mitigate **Team Member:** APS
Activity: APS to clean any sludge at the access point. All sludge will be vacuumed not pushed down.

Risk #6: Sharp vertical bends in pipeline endanger the cable behind the inspection vehicle
Category: Yellow **Response:** Mitigate **Team Member:** Pure Technologies
Activity: During inspection, Pure Technologies will monitor angles and visually observe the pipe welds. If sharp bends were found, more slack would be provided to cable.

Risk #7: Poor visibility and cloudy water in pipeline
Category: Yellow **Response:** Mitigate **Team Member:** City

Activity: City will force clear water into pipeline and allow pipe to “sit still” for minimum of 2 weeks, in order to reduce sediments in the pipe and suspended solids in the existing fluid.

Risk #8: Inspection bends and steep slopes prevent inspection
Category: Yellow **Response:** Mitigate **Team Member:** Winzler & Kelly, Pure Technologies
Activity: Winzler & Kelly and Pure Technologies will measure length of pipeline from as-builts to anticipate bends, slopes, and actual inspection length.

Risk #9: Partial blockage in bottom of pipe
Category: Yellow **Response:** Mitigate **Team Member:** Pure Technologies
Activity: Size of unyielding material will be assessed. Any blockage greater than 6-inches will prevent inspection.

Risk #10: Blockage greater than 6-inch blocking inspection camera
Category: Red **Response:** Mitigate **Team Member:** All
Activity: City to decide if inspection team is authorized to televise from Seaport Village side of project.

Risk #11: 1/3 to ½ of target inspection distance achieved; but slope, sludge and drag cause power consumption to exceed safe operating levels
Category: Red **Response:** Mitigate **Team Member:** All
Activity: APS and Pure Technologies deploy inspection system from Seaport Village with City’s approval or Winzler & Kelly to perform engineering analysis in lieu of internal observation.

Risk #12: Complete blockage after deployment of inspection from Seaport Village
Category: Red **Response:** Mitigate **Team Member:** APS, Pure Technologies
Activity: Retrieve Equipment.

Risk #13: Equipment Retrieval
Category: Red **Response:** Mitigate **Team Member:** APS, Pure Technologies
Activity: Heavy equipment on standby for retrieval.

Winzler & Kelly was responsible for monitoring and communicating risk with all other team members and maintained a risk log which tracked the occurrence of each identified risk event and any unexpected risk events. The risk log also recorded the response of the inspection team for each risk event.

Pre-Inspection Activities

After the development of the Risk Management Plan, the City began flushing the pipeline with clear water to mitigate with Risk Event #7. The pipe was allowed pipe to “sit still” for minimum of 2 weeks, in order to reduce sediments in the pipe and suspended solids in the existing fluid. After 2 weeks, APS planned to remove the blind flange in the valve vault and clean any possible sewage sludge cake that would hamper insertion of the crawler the night before the inspection was scheduled to mitigate Risk Event #5. While this activity was performed, the team followed confined space procedures (Risk Event #1) and high levels of hydrogen sulfide (H_2S) were measured by the air monitor which required immediate removal of all personnel from the valve vault. Several attempts were made to mitigate the high levels of H_2S but were APS was not able to lower the H_2S to levels that would allow complete removal of the blind flange. The high levels of H_2S were unexpected. The blind flange was re-tightened and the inspection team decided to deploy the inspection crawler at the outfall manhole at the Seaport Village in the City of San Diego. However, because the risk management plan involved appropriate decision makers, the project team was able to remobilize to the City of San Diego side of the pipeline without any additional remobilization cost to the City. The City notified the appropriate agencies about the anticipated work at Seaport Village.

Inspection Activities and Results

On the night of May 12, 2008, Pure Technologies with the support of APS performed the inspection of the original force main starting at the outfall manhole at Seaport Village in the City of San Diego moving toward the Transbay Pump Station in the City of Coronado. The Pure Technologies crawler inspected the entire length of the pipeline. Despite the mitigation activities performed for Risk Event #7, the turbidity of the water in the pipeline hampered the video inspection during the first 130 linear feet of the inspection. However, the turbidity was greatly reduced after 130 linear feet and visual inspection did produce data which is summarized in Table 2. The distance provided is the distance measured from the outfall manhole. The development and execution of the Risk Management Plan along with constant risk monitoring provided the inspection team the tools and preparation that led to a successful inspection.

Table 3: Summary of Video Inspection Data

Distance from MH Entry (ft)	Description
5.0	Start of Run. Camera underwater with close to no visibility
16.9 to 130	Heavy debris makes visibility zero.
245	Camera comes out of water. Air pocket found.
257	Joint inspected with no visible damage.
262.1	Camera submerges. End of air pocket.
1223	Camera comes out of water. Air pocket found.
1250	Turbidity lowers with increased visibility.
1280	Camera submerges. End of air pocket.
1476 to 1490	Heavy debris build up.
1606	Inclinometer reads 0° slope. Approximate “bottom” of pipeline
1865	Inclinometer reads 6° upward slope. Pipe begins ascent up to Coronado.
3606	End of Inspection.

The beginning of the inspection from 5 ft to 130 ft revealed that there was a build up of heavy organic material and sludge in the force main. During this first 130 feet, the crawler had difficulty moving forward at normal inspection speed. The clarity of the water in the pipeline improved as the crawler moved toward the Coronado side of the pipeline. The previous flushing of the force main with potable water appeared to help increase visibility from the half way point of the original force main to the Transbay Pump Station.

Instantaneous slope values from the inclinometer were used to plot the approximate profile of the pipeline. The plot of the profile is shown in Figure 2. Winzler & Kelly plotted the data starting from the outfall manhole in the City of San Diego to Coronado and vice versa. Because the slope values were instantaneous values and not continuous, the profiles shown in Figure 2 should not be deemed exact representations of the actual profile. In both cases, the profile generated from the inclinometer data shows the inspection ending at an elevation offset by 30 feet. This is likely due to the constantly changing slope and high level of debris during the first 130 ft of inspection that can affect the crawler’s ability to obtain accurate inclinometer readings. The plotted profiles should be represented as a guide of the general profile that the pipeline has. The plotted profiles generally follow the as-built drawings, however there were several intermediate high points or humps in the pipe.

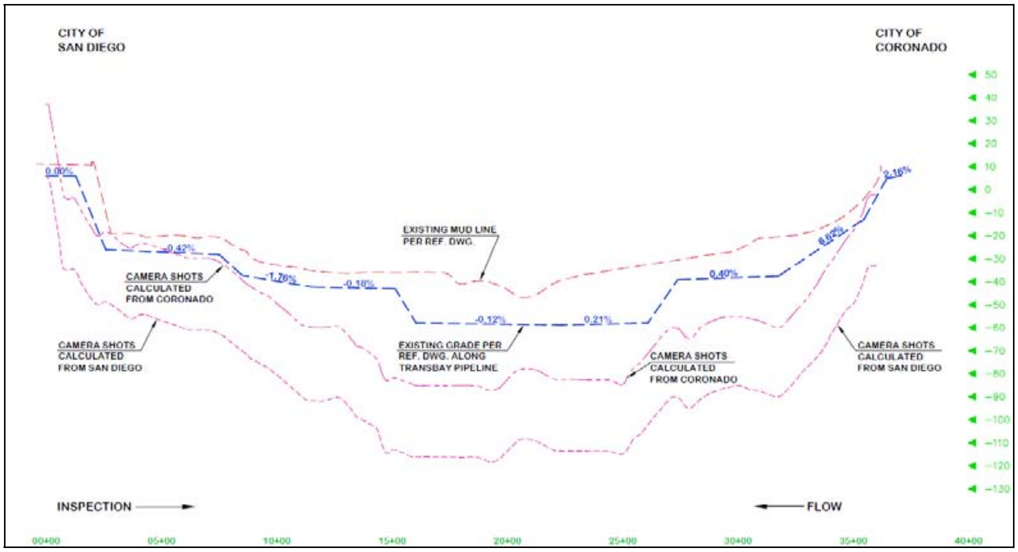

Figure 2: Profile of Original Force Main using As-Built Data and Camera Data

Two air pockets were discovered by the video camera from 245 ft to 262 ft and from 1223 ft to 1280 ft. The air pockets allowed for visual inspection of the pipe. These air pockets correspond to upward sags shown on the profiles located in Figure 2.

After reviewing the location of the heavy debris from 5 ft to 130 ft in the pipeline, it was determined that the heavy debris is downstream of the first intermediate high point and in the steepest section of the pipeline. The debris was likely caused by the flushing activities which pushed accumulated sediments and solids to near the discharge point of the pipe. However, these materials and solids were too heavy to be pushed through the pipe because of the low velocity used for flushing.

The sonar inspection revealed that the original force main has an approximate interior diameter of 22.8-inches. During the inspection from 5 ft to 130 ft where the visual inspection revealed the heavy debris in the water, the sonar was unable to penetrate the debris and sludge in the water which provided unreliable data. Figure 3 is a screen shot of the sonar image at approximately 45 LF, showing debris produced reflections.

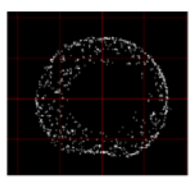
Figure 3: Sonar Screen Shot at 45 LF Showing Debris

Beyond the 130 feet, the heavy debris cleared which allowed for good sonar data. Many factors can affect and degrade the sonar image. The sonar inspection report revealed 10 air pockets within the pipeline. Figure 4 is a screen shot of the sonar image at approximately 130 LF. The top portion of the pipe is “missing” because sonar requires water to produce meaningful data and this “missing” portion reveals an air pocket which supports the team’s visual observations.

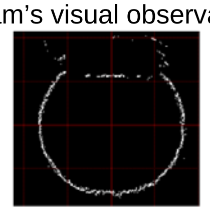
Figure 4: Sonar Screen Shot at 130 LF Showing An Air Pocket

Sonar was capable of identifying additional air pockets that the CCTV camera was unable to detect.

Winzler & Kelly also checked the locations of the air pockets found by Pure Technolgies' sonar inspection on the profile of the pipeline. All the air pockets either correspond to an intermediate high point or are located in a relatively flat area of pipe.

The heavy organic material and sludge accumulation from 5 ft to 130 ft from the outfall manhole prevented the sonar from collecting clear sonar images. The condition assessment of the pipeline in this section was inconclusive. The heavy debris and sludge accumulation is most likely caused by a sag in the pipeline upstream of this section. However 130 ft past the outfall manhole, the continuous sonar produced data does not indicate any structural defects in the pipeline. This is further confirmed by the air pockets; air would escape if there were cracks or openings in the pipe.

Pipeline Rehabilitation/Re-use Analysis
As described earlier, the City's goal for this project was to understand options for reusing the original force main and enhancing the overall reliability of its system. Winzler & Kelly performed the rehabilitation/re-use analysis using the inspection data together with previous construction experience, and input from manufacturers' representatives, contractors, and industry publications. Four alternatives were considered including:

- Abandoning the original force main
- Operating the original force main "as-is" in an alternating fashion with the new force main
- Rehabilitating the original force main and operating in an alternating fashion with the new force main
- Using the original force main "as-is" as an emergency standby

For the rehabilitation alternative, Winzler & Kelly evaluated sliplining, cured-in-place pipe (CIPP), pipe bursting, fold and form liners, and spiral wound liners as alternatives.

An evaluation matrix was used to assist in the process. The matrix includes a series of performance criteria in which each alternative is judged against the performance criteria based on a 1 through 10 scoring system, with 1 being the worst performance and 10 being the best performance. The matrix can guide the decision-making process by focusing the process on the most favorable alternative. A weighting factor was also applied to the individual criterion based on the importance of a particular criterion.

The evaluation criteria and weighting factors developed through meetings with City staff and are described below:

"Impact to Surroundings" : Represents the disturbances to the environment surrounding the original force main that may occur during rehabilitation. Effects of trenching and "lay down" area needed are examples of considerations taken into account for this criteria. A high score in this criteria means that the alternative has very little or no construction impact and a low score means that there is significant impact during construction. This criterion was given a weighting factor of 18% because the City felt that any construction activities at the Transbay site and Seaport Village would have significant impacts to the adjacent businesses and residents.

"Structural Integrity": Represents the performance of both rehabilitation and "non rehab" alternatives structurally or the potential for a structural failure. A high score means that the alternative will provide the pipe with additional structural strength which translates to minimum risk for pipeline failure and release of raw sewage. A low score means that the alternative will not add any additional structural integrity to the pipe which translates to higher potential for leakage or breaks. This criterion was given a weighting factor of 7%.

"Operational Reliability": Represents the alternative's reliability. A high score means the alternative will provide reliable means of conveying wastewater. A low score means that the alternative will not increase the reliability. The criterion was given a weighting factor of 15%.

"Operational Flexibility": Represents each alternative's ability to accommodate situations beyond the original purpose. An example would be the ability of the force main to adequately operate during "low flow" conditions. A high score means that the alternative will provide more operational flexibility than other alternatives. A low score means that the alternative does not add any additional operational flexibility. This criterion was given a weighting factor of 5%.

"Constructability": Represents the difficulty of constructing and implementing the alternative. A higher score means that the alternative is relatively easy to construct compared to other alternatives. This criterion takes into account the amount of pre-cleaning required, the ability to attract multiple bidders, and the ability to implement other construction alternatives. A lower score means that the alternative will have significant construction constraints that could jeopardize the success of the project. This criterion was given a weighting factor of 12%.

"Hydraulic Improvements": Represents the improved hydraulic performance of the force main and pump station after implementing a particular alternative. A high score means the alternative will improve pump performance, pipe hydraulics, or odor abatement. A low score indicates the alternative does not provide improved hydraulic or odor reducing performance. This criterion was given a weighting factor of 3%.

"Risk": Represents the potential risk of the original force main leaking or failing and thus causing adverse impacts to the City and the environment. A high score means the alternative will minimize risk relative to other alternatives. A low score means the alternative does not provide any risk minimization. This criterion was given a weighting factor of 15%.

"Capital Cost": Represents the capital cost of implementing each alternative. A high score means the alternative is the less costly relative to other alternatives. A low score means the alternative is more costly relatives to the other alternatives. This criterion was given a weighting factor of 8%.

"Operation & Maintenance Cost": Represents the cost associated with maintaining and operating each of the alternatives. A high score means that the alternative will most likely cost less in maintenance and operations than the other alternatives. A low score means that the alternative will most likely cost more than the other alternatives. This criterion was given a weighting factor of 9%.

"**Lifecycle Cost":** Represents the present worth cost of an alternative and is based on the capital costs and operation & maintenance cost. A high score means that lifecycle costs are lower compared to other alternatives. A low score means that the lifecycle costs are higher compared to other alternatives. This criterion was given a weighting factor of 8%.

During the evaluation, CIPP, Fold and Form, and Spiral Wound rehabilitation methods were removed from consideration because of the limited applicability to the original force main. The results of the analysis are summarized in Table 5-1.

Table 4: Evaluation Matrix for Rehabilitation and No Rehabilitation Alternatives

		REHABILIATION ALTERNATIVES					"NO REHAB" ALTERNATIVES		
Criteria	Weighting Factor	Alternative 1 - Sliplining	Alternative 2 - Pipe Bursting	Alternative 3 - CIPP	Alternative 4 - Fold and Form	Alternative 5 - Spiral Wound	Alternative 6 - Abandonment	Alternative 7 - Parallel Main "As-Is"	Alternative 8 - Emergency Standby
Impact to Surroundings	18%	2	2	N/A to Transbay Sewer FM	N/A to Transbay Sewer FM	N/A to Transbay Sewer FM	7	9	9
Structural Integrity	7%	10	10				10	6	4
Operational Reliability	15%	10	10				0	5	5
Operational Flexibility	5%	10	7				0	7	5
Constructability	12%	7	4				9	10	10
Hydraulic Improvements	3%	10	5				0	5	5
Risk	15%	9	9				5	5	3
Capital Cost	8%	7	3				9	10	10
Operation & Maintenance Cost	9%	6	4				10	6	8
Lifecycle Cost	8%	6	4				10	8	8
Total Score		**71.3**	**58.1**	N/A	N/A	N/A	**62.1**	**72.2**	**68.6**
Total weight	100%								

The results of the evaluation matrix indicate that two options are the apparent best: Alternative 1 - Sliplining and Alternative 7-Parallel Main "As-Is". Those two alternatives are followed closely by Alternative 8 – "Emergency Standby". Based on this evaluation tool, the City decided to keep the original force main for the purpose of emergencies and would monitor and inspect the force main based on their risk tolerance with the condition of the original force main considering inactivity.

2010 Inspection

In 2010, the City decided to inspect the original force main to assess the pipeline after 2 years of inactivity. During that two year period, Pure Technologies had furthered developed their crawler to have a range of 8,000 LF, increased the speed of its sonar head, and improved the accuracy of its inclinometer. With the updated equipment and software, the 2010 inspection produced results that differed from the 2008 inspection. The internal diameter was recorded by the crawler to be 24-inches in diameter. The "increase" in the diameter was attributed to the increased frequency of the sonar head. In 2008, the sonar head was only able to complete by 360-degree revolution every 10 seconds. In 2010, the sonar head could complete a 360-degree scan in less than 1 second.

In addition, the length of the pipeline was found to be approximately 3,500 LF. With the improved inclinometer, the profile of the pipeline could be better mapped as shown in Figure 3. The profile was created using the same techniques from 2008. Instantaneous slope values from the inclinometer were used to plot the approximate profile of the pipeline. The profile calculated more closely matches the profile from the as-built drawings.

The continuous sonar produced quality data that does not indicate any detectable structural defects in the pipeline. This is further evidenced by the air pockets; air would escape if there were cracks or openings in the pipe. The crawler was able to detect 10 intermediate high points in the pipeline where air pockets have formed as compared to the 11 air pockets found in the 2008 inspection. The air pockets provided a clear visual inspection of the force main interior. In those areas no visible signs of corrosion were detected.

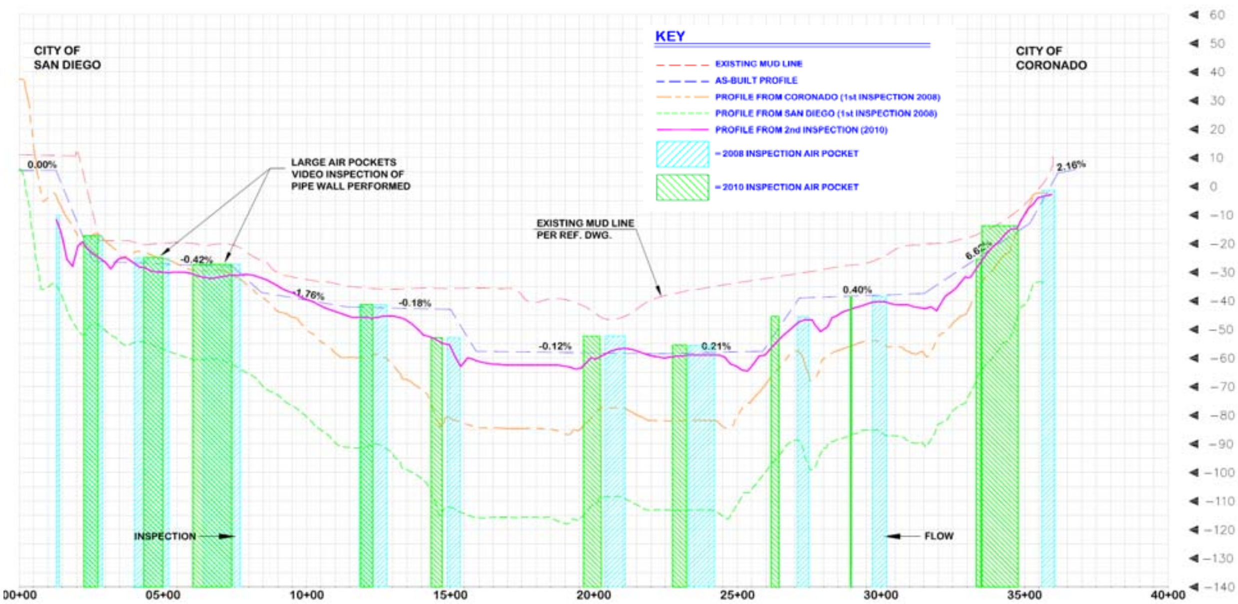

Figure 5: Profile of Original Force Main using As-Built Data and Camera Data from 2010 Inspection

The exact linear distances of the air pockets from the manhole differs from 2008 but is attributed to the new winch and more accurate software. Based on these results, the inspection team concluded that original force main appeared to be similar condition over the two year period and was reasonable to extend the inspection period to a three year period.