Krause Force Main Assessment and Replacement Alignment Study

City of Tampa
Wastewater Department

FINAL DRAFT – March 2013

GREELEY AND HANSEN

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Executive Summary

In general, it appears the condition of the 1951 pipe material is good. It is a heavy duty pipeline with no significant signs of advanced degradation. This does not mean it cannot fail in the near term; only that with a cursory assessment, we found no alarming conditions or symptoms. The pipe was surveyed with ground penetrating radar on Harbour Island and probed in a few locations. The exterior was sound. The pipe under Sparkman Channel was detected using sub bottom sonar and revealed it has cover and was not exposed to flowing saltwater. Photography of a dozen tapping coupons removed from the pipe wall and the statements from the retired resident engineer for the tapping operations indicate the pipe material at the time (1984 through 1987) was in surprisingly good condition.

The development that has occurred over and beside the pipe is extensive and would significantly interfere with emergency repairs should a break occur. The overall location of the pipeline running from Downtown Tampa, around the Convention Center, across the bridge over Garrison Channel, beneath Harbour Island Tennis Courts and through upscale residential neighborhoods, across the critical commercial shipping traffic thoroughfare (Sparkman Channel) and across Tampa Ship, LLC property, on Hooker's Point to the Howard F. Curren Advanced Wastewater Treatment Plant, means that a failure anywhere on this line would be in the public eye and potentially detrimental to environmental and sanitary conditions.

Several contingency plans were considered and the only quality alternatives were to construct a redundant force main or, as recommended, construct a replacement force main. Once built, the first 3300 linear feet of the current force main would be retained. Most of this pipe has already been replaced during the 1980's. Once the newly constructed force main is placed in service, the pipe removed from service could be assessed for condition and rehabilitated for future emergency use if necessary by simply turning a couple of valves. This would mean that a future emergency failure downstream of the first 3,300 linear feet could be quickly isolated and addressed without suffering an overflow likely worse than that experienced during a break on the 12th Street Force Main next to the river in November of 2004.

Construction of a replacement or parallel force main will be a challenging project with significant required easement acquisition, likely opposition from stakeholders, lengthy preliminary to final design phase timeframes, and significant cost. The project does not have particularly difficult permitting challenges and the need for the project is irrefutable.

Recommendation: Due to the age of the older portions of this force main (62 years), the critical role it provides as the central urban backbone of the collection/transmission system, the difficulty in containing, bypassing or repairing an emergency break in this unique pipe, and the long estimated schedule to replace it (7 years), we recommend the City move forward now with preliminary engineering to perform a detailed route study including public outreach, geotechnical investigations, environmental evaluation, regulatory permitting discussions and property records research to form a basis for route selection and easement acquisition; and then immediately move forward with easement acquisition. Final design and permit acquisition can follow easement acquisition or start shortly before its conclusion.

It is our opinion that expecting satisfactory service from this pipe beyond 75 years of age is optimistic. A firmwide inquiry did not reveal any known concrete pipe force mains 75 years or older that are still in service. There are several such water transmission mains.

Section 1 Assessment

1.1 Background

Construction of the Krause Force Main, originally called the Seddon Island Force Main, was completed in 1951. The force main conveys wastewater from the Krause Street Pumping Station in Downtown Tampa to the Howard F. Curren Advanced Wastewater Treatment Plant on Hookers Point. The original force main included subaqueous crossings of Garrison Channel and Sparkman Channel. Three segments of the original force main have been relocated and replaced with new pipe. In addition, a small portion of the discharge end of the force main was re-routed from the screen and grit building to Junction Chamber No. 1 in 1976. The remainder of the original pipe is now over 60 years old and, to our knowledge, has been in continuous service since 1951. The route of the original force main is shown on Figure 1.

1.1.1 Original Construction

The original force main is comprised of mostly of 54-inch diameter reinforced concrete pressure pipe, non cylinder type. The original 54-inch force main pipe conforms to the following design criteria:

Test Pressure	40 psi
Steel Design	
Total cage area – sq. in./ft.	1.843
Number of cages	2
Area per cage, outside sq. in./ft.	0.710
Area per cage, inside sq. in./ft.	1.133
Diameter of rods, ASTM A15-39, outside and inside	½ inch
Spacing of rods, outside	3.32 inches
Spacing of rods, inside	2.08 inches
Longitudinals – equally spaced each cage	6
Wall Thickness	5 ½ inches

This is heavy duty pipe with total cage area of 1.843 square inches per linear foot. In contrast, modern 54-inch Class V RCP (ASTM C 76) has a total cage area of 0.93 square inches per linear foot. This pipe is very similar to ASTM C 361 Reinforced Concrete Low Head Pressure Pipe, Class D-125 designed for 125 feet of internal pressure head and 20 feet of external earth load. The pipe used for construction of the subaqueous crossings is 48-inch diameter and expected to be of similar composition, except that the pipe wall to diameter ratio may be slightly higher (thicker walled) as it was customary to thicken the pipe wall slightly to achieve a non-buoyant pipe. Both original pipes are expected to have steel joint rings with rubber gaskets. Access manholes are shown on each side of Sparkman Channel. The subaqueous pipe beneath Garrison Channel has been replaced and removed or abandoned. Several portions of the original force main were concrete encased beneath some of the numerous railroad tracks present at the time.

FIGURE 1
ROUTE OF THE ORIGINAL FORCE MAIN

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AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012

1.1.2 Relocations

Two significant relocations were constructed in 1984. First; the relocation for Tampa Shipyards, Inc was performed to accommodate the extension of two dry dock facilities for ship maintenance. The entire relocation was about 765 feet in length.

The second relocation, just months later, was for Harbour Island. The relocation for Harbour Island included replacing the Garrison Channel crossing with an aerial 48-inch steel pipe attached to the then newly constructed Harbour Island Bridge. This relocation (1,993 feet in length) extended from approximately 200 feet north of the channel to approximately 1,000 feet south of the channel. The southern terminus of this relocation is located underneath a parking lot adjacent to the northwestern most tennis court at the Harbour Island Tennis Club.

Another significant relocation was constructed in 1987 to accommodate construction of the Tampa Convention Center. This relocation included 80 feet of 36-inch pipe and 1,467 feet of 54-inch pipe. This relocation extended from the outside wall of the Krause Pumping Station to a point about 140 feet short of the beginning of the Harbour Island relocation. Of this 140 feet of old pipe, approximately 105 linear feet is concrete encased and currently located in the intersection of Old Water Street and Franklin Street between the Waterside Marriot Hotel and the Tampa Convention Center. The railroad tracks have been removed.

All three relocations are shown on Figure 2. Pipe used in the construction of all three relocations is Prestressed Concrete Cylinder Pipe (PCCP) conforming AWWA C 301 Standard. This pipe is not expected to contain class IV defective prestressing wire commonly used in the late 1970’s and early 1980’s.

FIGURE 2
RELOCATIONS AND CURRENT FORCE MAIN CONFIGURATION

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MARCH 2013

1.2 Current Conditions and Development

1.2.1 Current Configuration of Force Main

City of Tampa Wastewater Department
Krause Street Force Main Assessment and Replacement Alignment Study

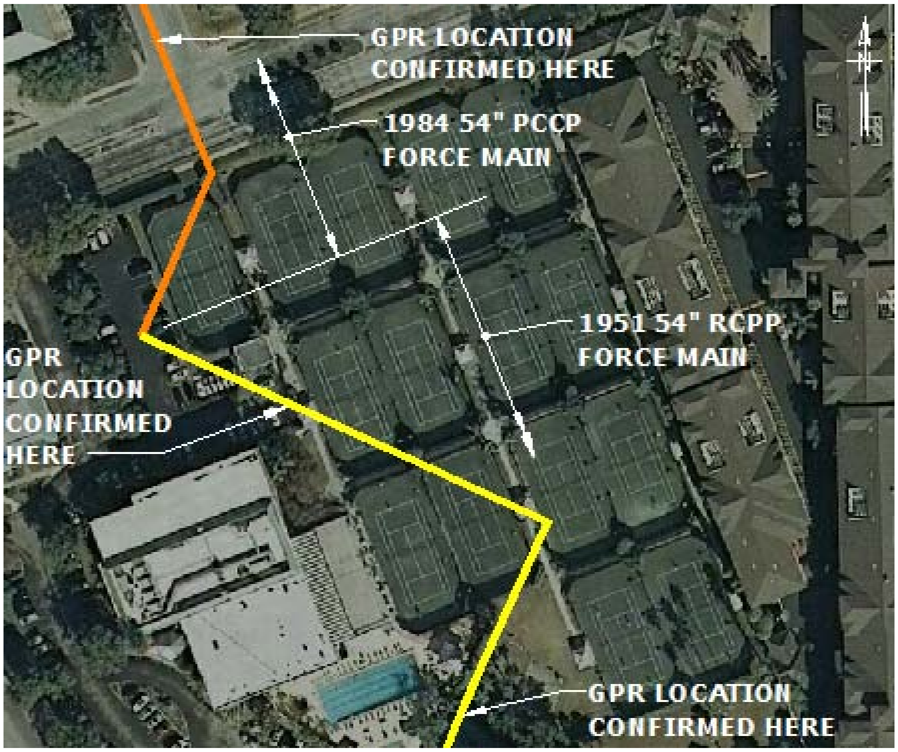
Existing Krause Force Main Breakdown by Segment

No.	Segment	Pipe Size	Type & Year	Length (LF)	Comments
A.	Convention Center Relocation	36"	PCCP, 1987	80	Meter vault bypass line is 62' long - not included in this 80' length
		54"	PCCP, 1987	1,387	**1,467**
B.	Old 54" Force Main between Convention Center Relocation and Harbour Island relocation	54"	RCPP, 1951	140	This pipe is mostly concrete encased
C.	Harbour Island Relocation				
a.	From Ashley St. to north end of Garrison Channel	48"	PCCP, 1984	196	
b.	Garrison Channel Aerial Crossing	48"	Steel Pipe, 1984	422	
c.	South end of Garrison Channel to 54" connection point	54"	PCCP, 1984	1,375	**1,993**
D.	Old 54" Force Main on Harbour Island	54"	RCPP, 1951	3,969	
E.	Sparkman Channel Crossing	48"	RCPP, 1951	671	
F.	Old 54" Force Main on Tampa Shipyards east end of Sparkman Channel to Tampa Shipyards relocation connection point	54"	RCPP, 1951	1,085	
G.	Tampa Shipyards Relocation	54"	PCCP, 1984	765	
H.	Old 54" Force Main on Tampa Shipyards from connection point to JC-1	54"	RCPP, 1951	1,044	
	Total Pipe Length			**11,134**	

PCCP = Prestressed Concrete Cylinder Pipe
RCPP = Reinforced Concrete Pressure Pipe

1.2.2 Development

On Harbour Island residential and light commercial development has been dense. While the City retains an easement for the force main, some of the development, namely the Tennis Club, has disregarded the City's easement and constructed courts and fences on top of the pipeline as shown on Photo 1.



Photograph 1 – Pipe under Tennis Courts

South of the courts, upscale, multifamily residential development crowds the relatively narrow 20-foot wide easement. The easement is made into a lushly landscaped trail with backyard patios lining both sides of the easement as shown in Photos 2 and 3.

Photograph 2 – Landscaped, Narrow Force Main Easement

Photograph 3 – Force Main is Parallel and 7.5 offset from Short Block Wall

There are even two low bridges constructed over the force main severely blocking access. All of the once numerous railroad tracks on Seddon Island have been removed for redevelopment of Harbour Island; but the concrete encasements remain.

On Hookers Point heavy industrial development has coexisted with the pipeline since its construction. The roads are mostly owned by the Tampa Port Authority. Most of the easements here are paved and the force main appears to pass under a building in the Tampa Shipyards. The force main crosses two sets of railroad tracks on Hookers Point although one set of tracks appears to be inactive. See Photo 4.

Photograph 4 – Force Main on Hooker's Point

1.2.3 Maintenance Accessibility

Maintenance access to the pipeline is limited as it passes under tennis courts, fencing, residential landscaping and the canopy type building in Tampa Ship Yards. Of particular concern is the portion of old pipe between the tennis courts and the east side of Sparkman Channel. Emergency access to repair a break on this part of Harbour Island would involve significant disruption to residents and clearing of surface improvements including landscaped walkways, lamps, trees, or tennis courts with fencing, just to gain equipment access to the break site. If the break happens to occur at either of the southernmost two road crossings, the pipe is underneath bridges constructed at or just above surrounding grade. If a break was located where the pipe is deep, adjacent homeowner dwellings and retaining walls could be compromised further complicating repair. The depth of pipe encountered on Harbour Island is discussed in greater detail in the subsection headed “Survey and Probing”. In general the pipe commonly had 5 to 8 feet of cover when it was detected by ground penetrating radar. One location was shallow at just under 3 feet of cover.

If a break were to occur beneath Sparkman Channel, subaqueous repair efforts would have to coordinate with shipping traffic including tourism industry cruise ships. Further exacerbating the concern of a break in this section, is the fact that a pump around or bypass arrangement would be extremely difficult to arrange. Tapping and line stopping the pipe would take several weeks and possibly months to manufacture custom tapping saddles and arrange for equipment transportation. Crossing the ship channel and railroad tracks with a temporary pipeline would be challenging. Some contingency scenarios are addressed hereinafter in this report in the section headed “Contingency Operations”.

1.2.4 Tampa Port Authority Planned Projects

The Tampa Port Authority 2008 Master Plan indicates that significant dredging projects are planned in the near term; however, discussions with the Tampa Port Authority Engineering Department staff (Mr. Bruce Laurion) indicate that they recognize this utility and many others which cross Sparkman Channel in the vicinity, including TECO power lines. He mentioned that the Sparkman Channel maintained navigational depth north of the R.E.K facility is 34 feet and south of the facility is 41 feet, and that no deepening or widening of the channel is planned north of the R.E.K. facility. The R.E.K. facility is located near Berth 230, north of the tip of Hooker’s Point as shown in Photo 5. The Tampa Port Authority regulations requirements regarding new pipeline crossings are addressed hereinafter in this report in the section headed “Alternatives”.

Photo 5 - Location of R.E.K. Facility,
No Dredged is Planned for Sparkman Channel North of this Facility

Source: Tampa Port Authority Master Plan (July 17, 2008)

1.3 Assessment

There are numerous methods of assessing the condition of concrete pressure pipes, but many are unique to prestressed concrete cylinder pipe (PCCP) as they target broken prestressing wires. These methods will not be addressed herein. The old portion of the Krause Force Main is not PCCP; it is reinforced concrete pressure pipe (RCPP). The reinforcing is not pretensioned. The failure mode of this type of pipe is typically quite different than for PCCP that tends to have violent ruptures when compromised reinforcement causes the cylinder to yield to internal pressure. While a transient surge pressure wave (water hammer) could indeed overload reinforcement in RCPP, it would likely crack concrete while most reinforcing would remain unbroken. The more likely failure mode for RCPP would result from a loss of pipe wall occurring from corrosion or erosion progressing from either the interior or exterior surface. Unless adverse environments are present, this progression would be very slow. Flowing salt water is one such adverse environment as the recurring supply of chlorides can carbonate the concrete compromising the alkalinity of the concrete and deteriorating its ability to protect reinforcing steel from oxidation. Other adverse environments include corrosive soils or interior sewage gases that contain sulfides which are converted to sulfuric acid causing common crown corrosion.

The most appropriate non destructive assessment techniques for the in service force main are visual observation and detection of pipe wall thickness with an ultrasonic thickness testing device in order to estimate wall thickness loss. To properly use this technique, the pipe surface must be accessible and the ultrasonic device must be calibrated at a location where the wall thickness is known. One of the coupons from where the pipe was tapped for previous relocations would be ideal for calibration. However, excavation to access a significant sampling of the exterior surface to perform this testing would be beyond the scope of this report. Sub aqueous pipe can also be tested for wall thickness, but removal of existing cover is complicated by environmental/regulatory concerns and logistical effort and cost. Other methods for assessing pipe wall can be retrieved from equipment placed within the pipe, however, in this size range, said equipment would require the force main be removed from service or would pose an unacceptable threat of getting stuck and are not recommended. This report and investigation does include using ground penetrating radar to assess earth cover over the pipe where buried on land and sub-bottom sonar to assess cover over the pipe beneath Sparkman Channel. The results from these techniques are addressed hereinafter.

1.3.1 Observation

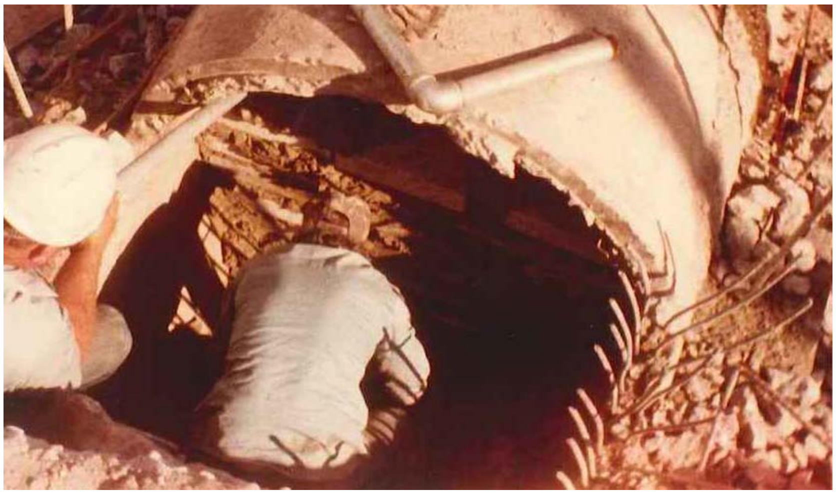
The best assessment of the overall condition of the now 62 year old pipeline has come from the three relocation projects where the pipe was tapped, usually four times for each relocation. At the end of each relocated segment, the pipe was tapped for flow diversion and tapped for insertion of a line stopper. The flow diversion taps are made into the side of the pipe and the line stop taps are made in the top of the pipe. The top of the pipe is where crown corrosion from collecting gases would be evident. All of the coupons retrieved from making the 30-inch to 48-inch diameter taps during the period 1984 to 1986 looked satisfactory. Several of the coupons and edges of cut pipe wall are shown in the following Photos 6 through 11.

Photograph 6 – 48-inch Coupon, May 14, 1987, Convention Center Pipeline Relocations

Photograph 7 – Cut Pipe Wall, June 26, 1987, Convention Center Pipeline Relocations

Photograph 8 – 48-inch Coupon, May 8, 1984, Tampa Shipyards Relocation

Photograph 9 – 36-inch Coupon, June 22, 1987, Convention Center Pipeline Relocations



Photograph 10 – Cut Pipe (note double row of steel reinforcing), March 24, 1984, Harbour Island Relocation

Photograph 11 – 36-inch Coupon, March 21, 1984, Tampa Shipyards

I discussed the condition of the coupons with our retired resident construction engineer who provided resident construction services for all three relocations and took the photos. He recalled observing the condition of the coupons as surprisingly good. The pipe at that time was approximately 35 years old. One of the tapping operations was performed just upstream of where the old force main dipped beneath Garrison Channel where collection of gases might be expected, but the coupon showed no sign of crown corrosion. This can also indicate that the City staff has been adequately using manual air release valves to vent accumulating gases.

1.3.2 Survey and Probing

Starting at a point on the west bank of Sparkman Channel, ground penetrating radar (GPR) was used to locate the main and estimate earth cover present. Efforts progressed northwesterly from the starting point. The area within 100 feet of the shoreline was difficult for detection due to depth and water table interference. About 150 feet from the shore, the force main lines up in a portion of the easement bounded on both sides with retaining walls. Here the cover was detected at 6 feet and the pipe was located 7.5 feet from the east boundary of the 20-foot wide easement. Moving the GPR 100 feet northwest, the pipe was detected again with 6 feet of cover in the same alignment. From this point northward to a point about 1,800 feet northwest, the pipe was not detected with confidence. One suspect detection showed over 8 feet of cover. Observing the surrounding area indicated the likelihood that development had added significant fill in this area and that the pipe may simply be too deep to detect.

Just on the north side of the second road crossing progressing along the route from the southeast, the pipe was easily detected in a drainage swale with just less than 3 feet of cover. This point is adjacent to where the pipe crosses beneath a bridged roadway. Probing confirmed the curved profile of the top of the pipe. Impacting the pipe with the probe returned a sharp reply indicating the exterior of the pipe was sound. An air release valve is located approximately 100 feet northwest of this location. Moving the GPR to the air release valve returned a detection of 4.5 feet of cover.

Photograph 11 – Air Release Valve with Fake Rock Enclosure, note Low Bridge Beyond

Moving the GPR to a sidewalk crossing about 200 feet northwest of the air release valve returned a high confidence detection of 6 feet of cover. Again the pipe was located about 7.5 feet from the east boundary of the 20-foot wide easement. Moving about 80 feet northwest, the GPR returned a cover of about 5 feet.

Working northwest from this point the pipe seemed to get deeper and detection was not evident until a point 200 feet south of the tennis courts where the pipe had 7 feet of cover. No attempts were made to detect the pipe beneath the busy tennis courts. Just west of the tennis courts, the old pipe was detected with 6.5 feet of cover beneath a parking space. This point should be within about 80 feet of the south end of the Harbour Island relocation. Thus pipe north of here would be newer PCCP which is not the focus of this report.

In summary, the pipe generally had 6 feet of cover or more, except at specific locations where the grade was less built up from development. This somewhat deep characteristic has two significant implications. First; emergency repair access would be difficult and adjacent structures could be impacted. Second; while the 20-foot wide easement is relatively narrow for this size pipeline, the depth of the existing pipe does accommodate the addition of another shallower pipeline placed in the same corridor as shown in the cross section on Figure 3.

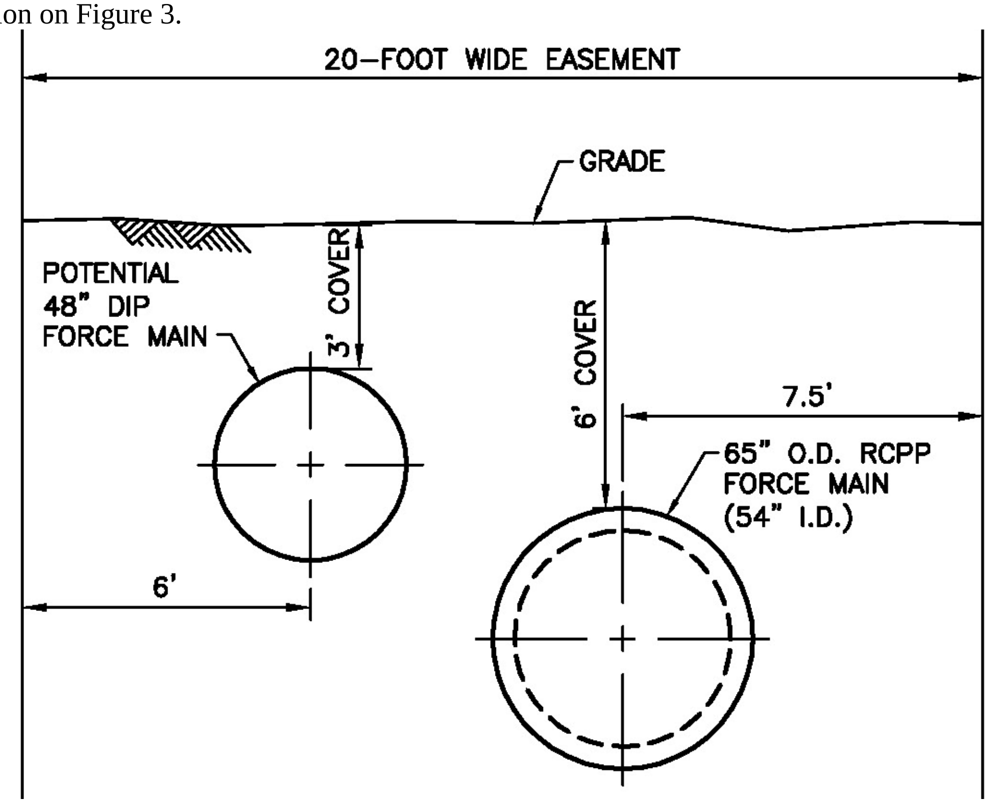


Figure 3 – Section Looking North, Scale: 1/4" = 1'-0"

This does not imply that sufficient temporary construction easement is available for this crowded permanent easement arrangement. Of course, maintenance access to the old pipeline would be further impaired, but the newer pipeline could possibly be a replacement, thus negating the need to access the older pipeline. Alternatively, the newer pipeline could provide temporary bypass to allow detailed assessment or rehabilitation of the older pipeline perhaps by slip lining or swagelining.

1.3.3 Sub-Bottom Sonar Investigation

The appendix contains a separate report prepared by Sonographics, Inc. of Fort Lauderdale, Florida. The report provides equipment details on sub bottom sonar transponders and receivers, the tow fish, post processing software, sidescan sonar and like technologies. Sub bottom sonar performed in the water is similar to ground penetrating radar performed on land in that it is powerful enough to penetrate soils and even rock. In general, the pipe was detected by sub bottom sonar frequently enough to indicate the pipe does indeed have cover throughout the Sparkman Channel crossing. To further confirm the pipe is not exposed, sidescan sonar provided high resolution graphics of the bathymetry or surface of the bottom of the channel. See Figure 4. This is an important discovery, since flowing salt water can cause accelerated carbonation of concrete and the loss of its alkalinity which protects steel reinforcement from corrosion.

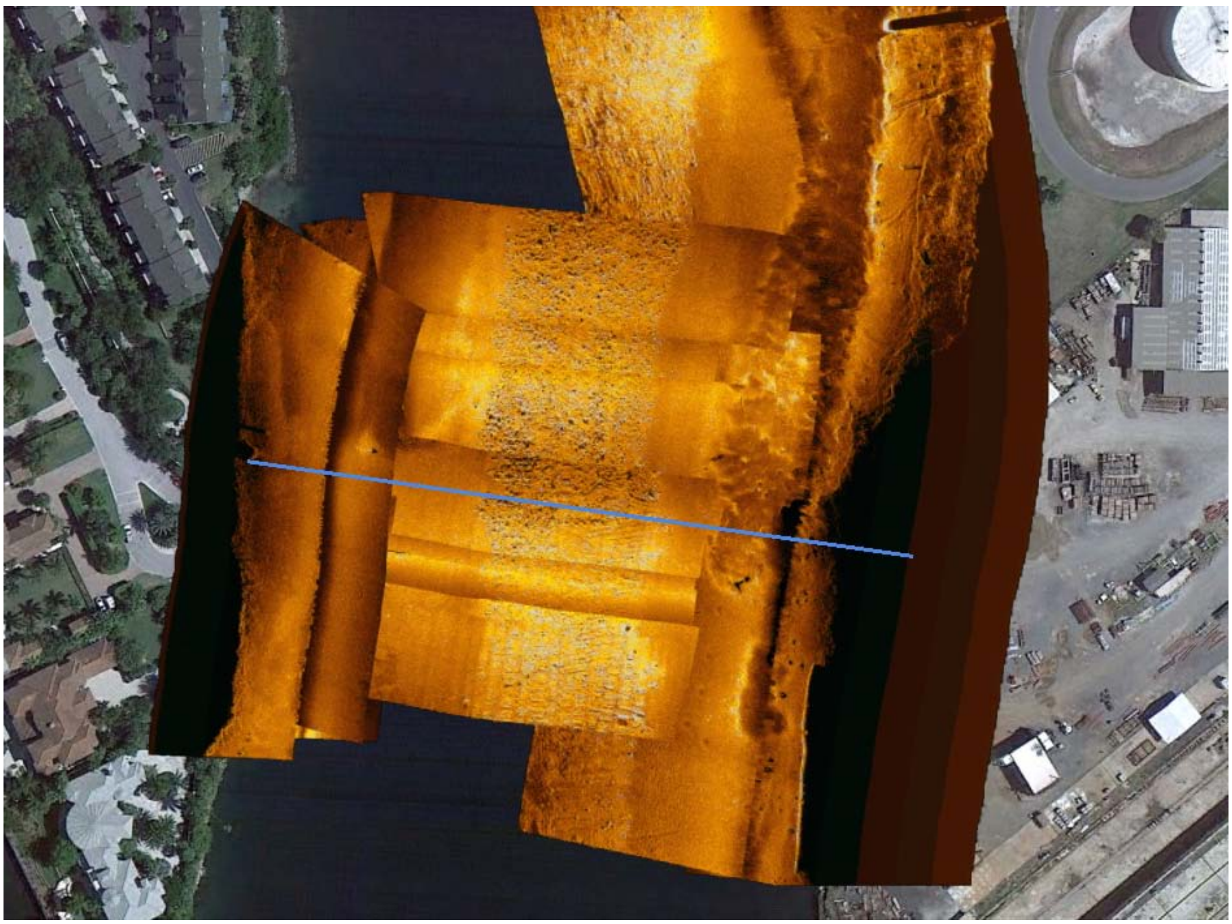


Figure 4 – Sidescan Sonar Image Mosaic of Bottom of Sparkman Channel. The blue line is location of buried force main. Force main is not exposed and therefore not visible.

Figure 5 shows approximately 25 survey vessel tracks crossing the pipeline alignment. Not all of the tracks detected the target pipeline with confidence. On the east side of the channel, the soils are granular, as indicated by the record drawings and the plotted top of rock probing results. Here the pipe was detected with confidence with between 2 and 5 feet of cover. See Figure 6. Where the record drawings indicate the pipe was installed in rock, the pipe was detected with covers ranging from 2 to 3 feet; however, the cover material returns a dense signal implying it consists of rocky material above the pipe/bedding envelope. Rock removed during excavation of the trench may have been placed back on top of the bedded pipeline which may provide excellent protection from erosion or mechanical impacts such as boat anchors. See Figure 7. Along the east side of the channel, the pipe was detected with as little as 1 foot of cover, but generally more. Frequent ship docking and traffic here, as well as shallower water depths, may explain an apparent loss of cover material.

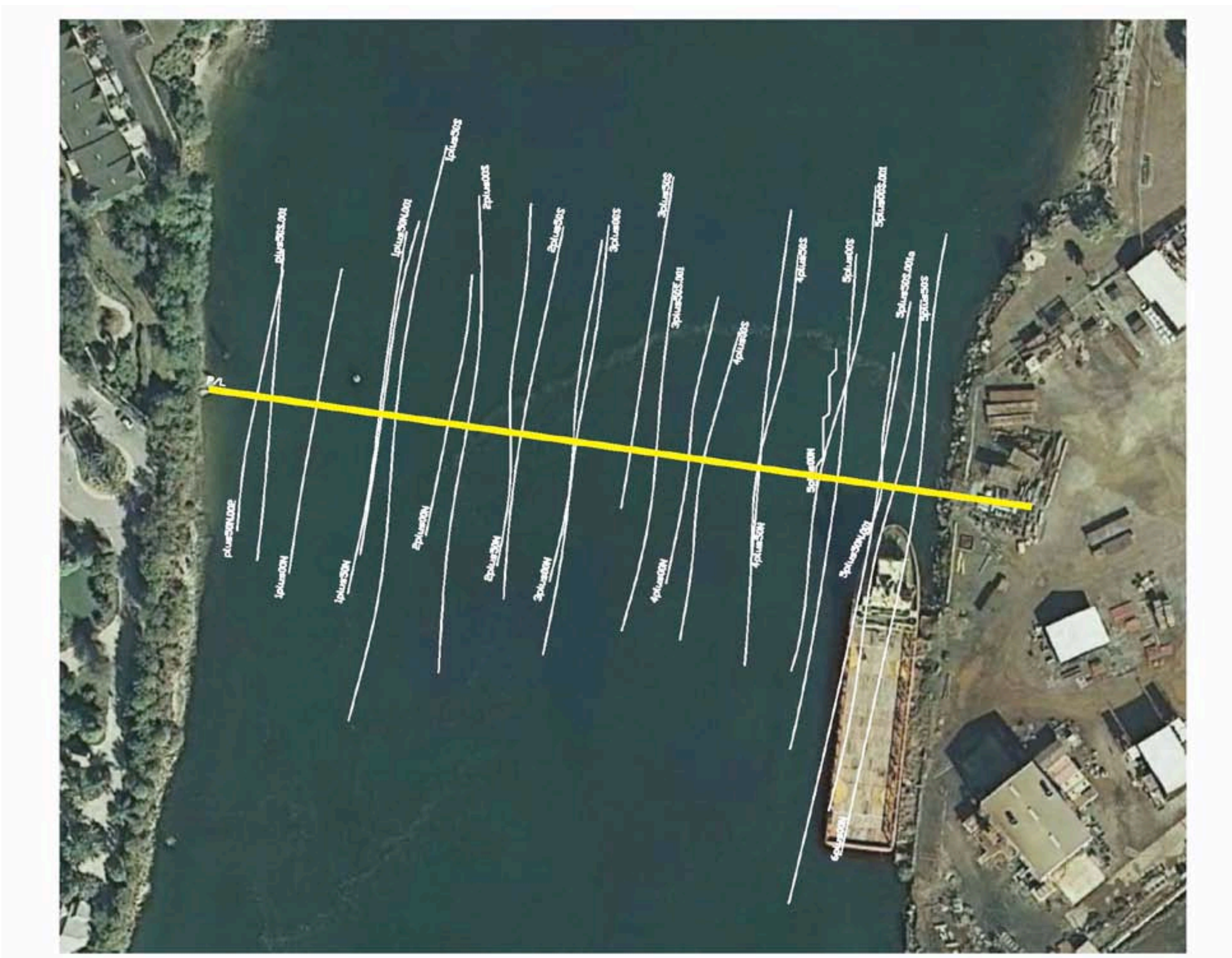


Figure 5 – Survey Vessel Tracks Crossing Pipeline

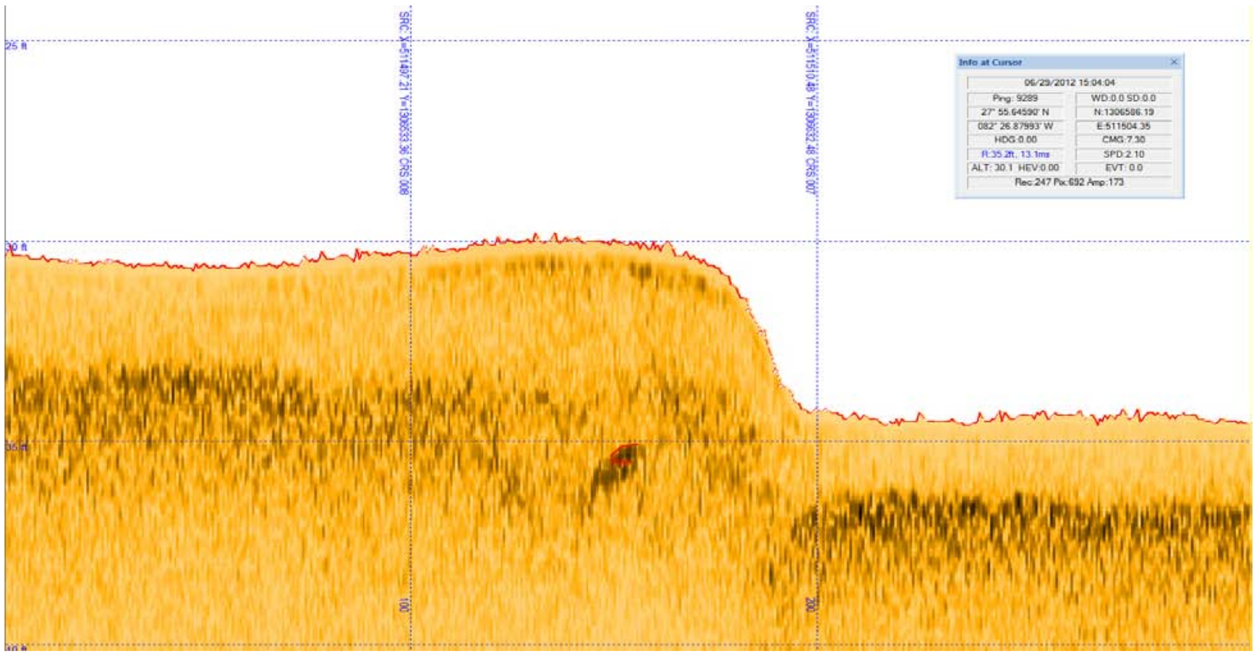


Figure 6 – Track 1plus50N Sub Bottom Sonar Image showing Pipe with 5' of Cover in Granular Soils near West Bank of Channel

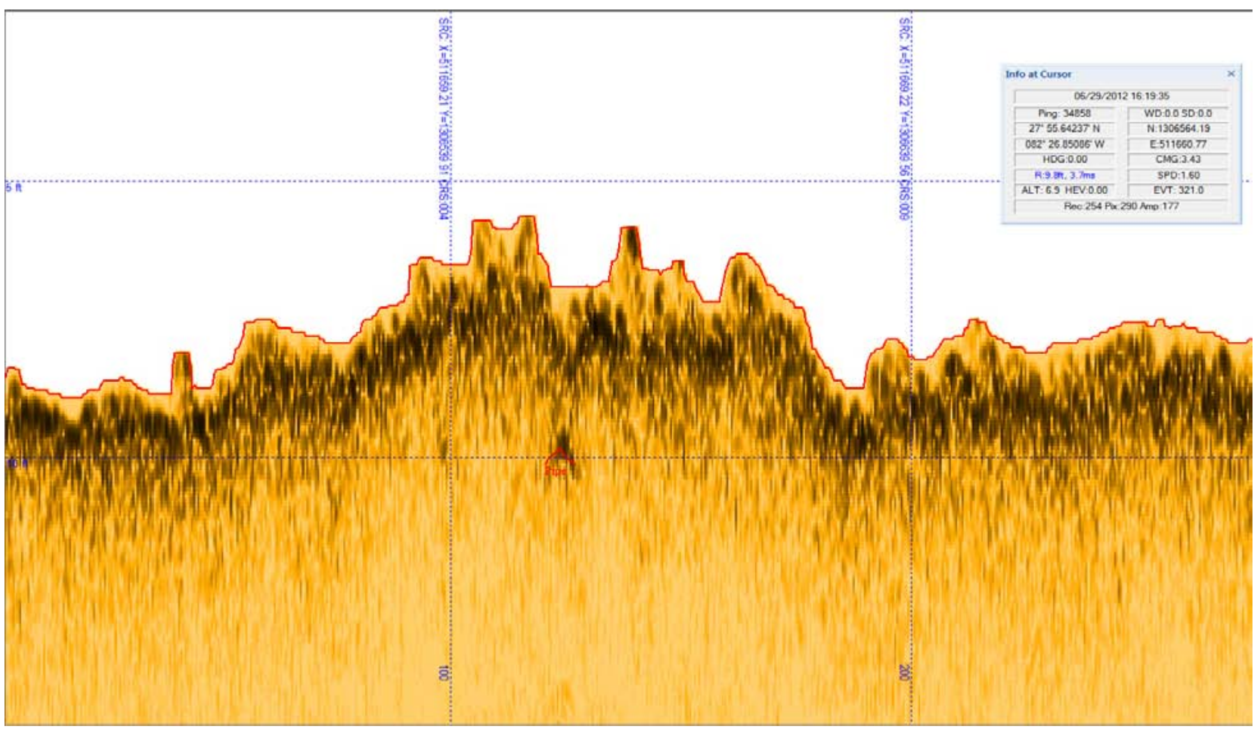


Figure 7 – Survey Track 3plus00N Sub Bottom Sonar Image showing Pipe with 2.8' of Cover in Rocky Soils near Center of Channel

Much of the information collected during sub bottom profiling and sidescan sonar is difficult to display in still pictures. Interactive graphics on CD are provided along with this report. The sidescan sonar is geo-referenced into state plane coordinates and automatically drops into place when using Google Earth aerial photography viewing computer programs. Profiles generated for each of the 25 survey tracks is provided in html format that allows readout of all three coordinate dimensions by moving the pointer over the graphic. This is the tool that allows the cartographer to accurately measure cover. Figure 8 is a cross section of Sparkman Channel prepared by the writer to summarize the data collected.

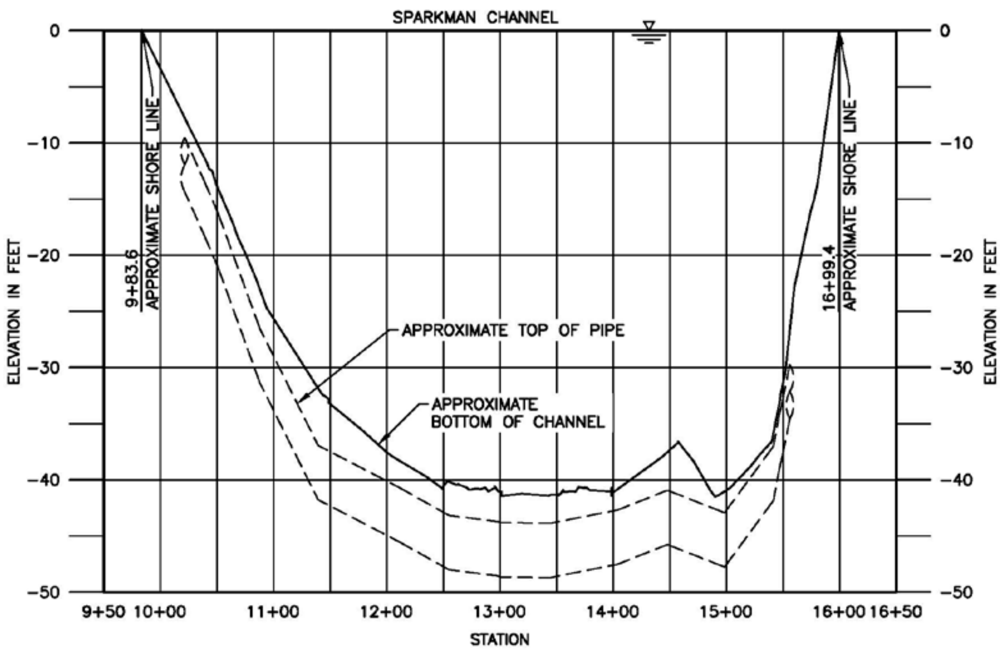


Figure 8 – Profile of Sparkman Channel Showing Pipe According to Sub-bottom Sonar Detection

1.3.4 Geotechnical Conditions

Most of the soils on Harbour Island and Hooker's Point are fill materials dredged up from Tampa Bay and the mouth of the Hillsborough River. Because of their hydraulic placement, the soils may be loose or very soft; however, they reconsolidate over time. The mixing that occurs from dredging operations produces a blend of the characteristics of the sovereign soils and natural strata. This blending tends to dampen the extremes that may have existed before the materials were dredged up. Extreme corrosive conditions such as low pH levels or low electrical resistivities are less likely to be encountered in these blended soils. We did not perform geotechnical borings and testing for this report. The geotechnical investigations report prepared for the initial construction of the City's advanced wastewater treatment plant was not available; however, it was noted that steel pipe piles used were specified with a protective coating while buried concrete pipelines were not specified to have a protective coating. To our knowledge original plant buried concrete pipelines uncovered for various reasons over the last 40 years have not exhibited significant signs of exterior corrosion.

We are more concerned about the pipe beneath Sparkman Channel. The Florida Department of Transportation would consider the high chloride environment likely to exist under Sparkman Channel to be extremely aggressive to reinforced concrete. FDOT also publishes a reinforced concrete pipe Culvert

Service Life Estimator software program but its use requires acquisition of actual parameters such as sulfate concentration, resistivities, pH and Chloride concentration. The tool also assumes carbonation of the reinforced concrete pipe proceeds from both the exterior and interior surfaces of the pipe and the pipe is not under pressure. Using estimated parameters generally indicated an expected service life in excess of 80 years; indicating that high chlorides alone should not aggressively attack the pipeline since it is not exposed to flowing tides. Since the pipe is 62 years old, and under pressure, expecting another 20 years of service life would include elevated risks. It should be noted, that this pipe does not include sensitive high tensile strength wire used in prestressed concrete cylinder pipe.

Section 2 Alternatives

2.1 Critical Role of the Krause Force Main

The Krause Force Main is the final link in the collection/transmission system constructed by the City under the first Wastewater Improvement Program back in 1950. The tributary flow mostly comes from the West River Interceptor and Downtown Tampa. While subsequent Wastewater Improvement Programs have constructed additional, parallel interceptor collection/transmission systems, the Krause Force Main remains the original backbone of the City's collection system. Its current flows represent about one third of the City's average daily total flows. Because of the critical role and the sensitive location of this facility, the City has authorized Greeley and Hansen to assess its condition and consider alternatives to minimize the probability and mitigate the consequences of a failure in this pipeline. This proactive action recognizes that waiting and solely reacting to its first failure would be inappropriate for this critical facility.

2.2 Contingency Operations

We understand that average daily flows in the Krause Force Main are about 20 MGD and that wet weather flows can reach 60 MGD. We also understand there are few available, significant diversions that could be performed upstream in the collection system to reduce this flow. A successful contingency plan should be able to handle 20 MGD flow at a minimum. If a break occurs in the old force main there are several options for managing flow until repairs are completed as follows:

- Break site pool with elevated berms.
- Barging wastewater from Krause Street P.S. located on the Hillsborough River.
- Provide temporary bypass FM.
- Set up temporary pumping facilities on west side of river and pump into the Interbay Force Main.
- Construct permanent redundant or replacement pipeline.

2.2.1 Break Site Pool

This technique was used successfully for a break suffered in the 12th Street Force main in May of 2006. If conditions are amenable, the area around the break can be isolated and surrounded by berms to contain the spill and allow the liquid level to reach a high enough elevation for the head to drive the flow into the downstream open pipeline reaching its intended destination. Unfortunately, the normal liquid level in Junction chamber No. 1 is between elevation 14 and 17. Grade on Harbour Island and Hooker's Point is approximately elevation 8 to 10; meaning berms would have to exceed 8 feet in height above surrounding grade. There is insufficient room in the easement of Harbour Island for such large berms, but this may be possible on Hooker's Point outside the easement limits. Optionally, the flow from the force main could be diverted to the main pump station at the plant, which has a much lower wet well level. This would require that a hot tap, valve and connecting piping be constructed in advance of the emergency.

2.2.2 Barging Flow from Krause Street Pump Station located on the Hillsborough River

The minimum acceptable flows for a contingency plan appear to be too high for this alternative to be favorable. The pump station site is upstream of the Platt Street Bridge which limits how large of a barge could be employed. A standard barge is 135' long by 35 feet wide and can haul approximately 350,000 gallons if the navigation depth is sufficient. To handle a daily flow of 15 MGD, 43 trips per day would be required, which appears to be unreasonable.

2.2.3 Provide Temporary Bypass Force Main

As described earlier in this report, setting up a temporary bypass force main would be challenging to accomplish quickly enough for an emergency condition. One way to bypass would be to employ taps and line stops, which are on the order of $300,000 per pair and a break would likely require two pairs. Custom manufactured tapping saddles (4) would be required to fit the 65-inch outside diameter of the 54-inch RCPP. If the saddles were manufactured in advance, the tapping and line stopping equipment would still be required to be shipped from elsewhere if it were available at all (not already in use). We estimate this would take several weeks and possibly months. Another method would employ temporary pumping equipment that could draw out of the pump station wet well or using existing permanent pumping equipment by pumping through a bypass outlet. Either method would require a very long temporary force main across a minimum of two waterways, railroads, and busy commercial, industrial and residential properties.

2.2.4 Set up Temporary Pumping Facilities on West Side of River and Pump into the Interbay Force Main

For this contingency option, a force main interconnect and hot tapped outlet and would be required to be installed on the Interbay 48-inch diameter ductile iron pipe force main near Bayshore Boulevard in advance of a break. Temporary, diesel driven pumps could be brought to the site and could draw from the upstream chamber of the Krause Street siphon under the Hillsborough River. There is room for such in the City of Tampa's Tony Janus Park. The capacity of the Interbay Force Main to convey flow from its normal service area plus the service area for the Krause Street Pump Station would be limited, but far better than no other option. Implementing this option would require planning of available gravity flow diversions upstream, detailed hydraulic calculations and preliminary design to estimate costs. We understand that the Bayshore Pumping Station was recently diverted from the Krause Street pumping station into the Interbay Force Main so the capacity of the Interbay Force Main may be exhausted. This option would not work during wet weather periods.

2.2.5 Construct Permanent Redundant or Replacement Pipeline

Such a permanent or replacement pipeline could parallel all of the Krause Force Main or just the old portion of force main. Routing of the latter option is a primary subject of this report. Just before the southern end of the Harbour Island Relocation the newer pipeline crosses Knights Run Avenue before reaching the old hot tap site located next to the tennis courts. Knights Run Avenue is a City right of way and would be an acceptable location to tap and line stop the 54-inch PCCP force main and begin the route of the replacement pipeline heading easterly. Two main alternative alignments starting from this point are developed and discussed hereinafter. If this new pipeline is constructed full size, it can completely replace the older pipeline allowing for its abandonment and removal where appropriate. If it is slightly smaller, it could be used to temporarily convey all flow while the older pipeline is rehabilitated perhaps by slip lining which slightly reduces its hydraulic capacity. This loss of capacity would be more than offset by the parallel pipeline. After rehabilitation, both force mains could operate and in the event of a break in either force main, flow could be diverted to the good force main while the other one is repaired. This will require valves be installed in the proper locations including on the old force main.

It should also be mentioned that Junction Chamber No. 1 was constructed with four locations for pipes connecting to the wet well. All four are currently in use. It may be advisable to connect the replacement force main to the old force main shortly before the junction chamber and valves be installed on both force mains just upstream of the connection.

2.3 Replacement Alignment Alternatives

While there are several significant challenges to routing the replacement pipeline, none are greater than crossing Sparkman Channel. To construct a replacement crossing one of the following methods would be required:

- a subaqueous open-cut trench installation;
- a horizontal directional drill (HDD);
- or a tunneled installation.

Subaqueous open-cut trench pipe installation, such as how the original crossing was constructed, appears to be a lost craft. Recent such projects that we have been involved with either used driven steel sheeting extending above water or attempted under water excavation and were unsuccessful. With the shipping traffic of Sparkman Channel and rock bottom, as well as environmental concerns, open cut trenching is not recommended at this time.

Horizontal directional drilling (HDD) using polyethylene pipe is feasible for an inside diameter of approximately 48-inches for this crossing. Polyethylene pipe is only manufactured in this size (54” iron pipe size) with a maximum wall thickness corresponding to DR 17. This pipe would have a wall thickness of 3.18 inches and an inside diameter of 47.27 inches. Modeling a 1,650 foot long crossing using ASTM F 1962 indicates the stresses in the pipe wall would be roughly equal the safe pulling strength of the pipe, indicating an element of risk. To minimize risk, another HDD option would include a DR 13.5 polyethylene pipe in the 36 or 42-inch ductile iron pipe nominal sizes. The reduced hydraulic capacity could be offset by either installing twin 36-inch pipes or the 42-inch pipe in conjunction with renewing the original crossing. Steel pipe would also be feasible, but would require more set-back and staging area that is potentially available only on the Hooker’s Point side. If steel pipe is selected for HDD, it would require an inside coating of epoxy or polyurethane and an exterior coating like polyurethane or proprietary coatings of epoxy polymer concrete such as Powercrete manufactured by Dura-Bond to minimize scarring from installation in rock. A cathodic protection system would also be required.

For the tunnel option, pits constructed onshore (grade 8’ +/-) suitable for launching and receiving a tunnel boring machine (TBM) would need to be 60 feet deep to meet Port Authority minimum cover requirements of 10 feet and the maintained channel navigational depth of 34 feet. The shafts would be extended well into rock. Top of rock on the west side of the Channel is shown at elevation -24 feet while it is -36 on the east side. The shaft bottom would extend at least to elevation -50. Geotechnical investigations would be required to drill deep into the rock to assess its quality and extents. If the bottom of the shaft extends below the rock formation, obtaining a stable shaft with regard to hydrostatic forces would be very expensive and potentially risky.

2.4 Hydraulics

The average daily flow for the force main is about 20 MGD, however, we understand the 25 year old mag meter is not accurate anymore. The City is considering increasing the capacity of Krause Street pumping station under a separate study and project. Since the system serves some of the older parts of Tampa, it has older sewers that are susceptible to infiltration and inflow. Following rain events, modeling indicates the peak flows delivered to the wet well approach 40,000 GPM or about 57.6 MGD. The following table shows velocities and headloss for various pipe material alternatives under various flows. This table assumes all flow is in a single pipeline.

	FLOW	17360	GPM	24305	GPM	31250	GPM	38195	GPM
	FLOW	25	MGD	35	MGD	45	MGD	55	MGD
Pipe Description	I.D. (inches)	Vel. (fps)	HL/1000'	Vel. (fps)	HL/1000'	Vel. (fps)	HL/1000'	Vel. (fps)	HL/1000'
36" Steel, 1/2" wall, Cement Lined	34.25	6.05	3.43	8.46	6.40	10.88	10.20	13.30	14.79
36" DIP, PC 200, Cement Lined	37.21	5.12	2.29	7.17	4.28	9.22	6.81	11.27	9.88
42" DIP, PC 200, Cement Lined	43.31	3.78	1.09	5.29	2.04	6.81	3.25	8.32	4.71
48" DIP, PC 200, Cement Lined	49.51	2.89	0.57	4.05	1.06	5.21	1.69	6.37	2.46
36" HDPE, DIPS, DR 13.5	32.29	6.80	3.94	9.52	7.36	12.24	11.72	14.97	16.99
42" HDPE, DIPS, DR 13.5	37.51	5.04	1.90	7.06	3.55	9.07	5.65	11.09	8.19
48" HDPE, DIPS, DR 17	42.01	4.02	1.09	5.63	2.04	7.23	3.25	8.84	4.72
54" HDPE, DIPS, DR 17	47.27	3.17	0.62	4.44	1.15	5.71	1.83	6.98	2.65
48" RCCP	48.00	3.08	0.66	4.31	1.24	5.54	1.97	6.77	2.86
54" RCCP	54.00	2.43	0.37	3.41	0.70	4.38	1.11	5.35	1.61

It should be noted the first 80 feet of force main out of the pumping station is 36-inch outside diameter steel pipe with cement mortar lining with an inside diameter of 34.25 inches.

2.5 Renewal and Rehabilitation

If a redundant pipeline is constructed, it should be large enough to handle all flows from the pump station even if such flow scenario is not ideal regarding velocities or headloss. This would allow an emergency repair or assessment and rehabilitation of the existing force main. Once isolated from flow, the old pipeline can be internally inspected by many different methods. Robotic equipment can accurately laser profile the interior surfaces of the empty pipeline to quantify wall loss and identify any areas of concern. Much of the pipeline should be in good shape, as internal corrosion should only be significant at areas where gases accumulate. The exterior is more challenging to assess. Again internal robotic equipment can use a technology known as pipe penetrating radar to measure wall thickness at specific locations. This method does not check the entire pipeline, but typically would take measurements at set intervals, say every 10 feet, and sense at the 2, 4, 8 and 10 O'clock positions. Such an intensive assessment might be appropriate in the vicinity of the Sparkman Channel crossing.

Once the deteriorated portions of the pipe are located, many rehabilitation methods are possible. The following methods would likely be effective and cost efficient as follows:

- Slip lining with pressure pipe such as polyethylene or Hobas Pipe
- Swagelining with polyethylene pipe.
- Cured –in-place lining for pressure pipes.

Slip lining with pressure pipe is common and requires adequate space to locate insertion pits. Hobas pipe can only be used in straight pipe segments with no bends or beveled joints. If bends are present where rehabilitation is required, the insertion pit is placed at the bend and the bend reconstructed. Polyethylene pipe can handle beveled joints and sometimes bends up to 11 ¼ degree bends. Insertion pits require adequate room for fusing pipe sections. Successful slip lining requires attention to properly grouting the annulus and terminating the ends of the liner to adhere to the host pipe. Some loss of inside diameter occurs, but this is minimal with hobas pipe. Polyethylene pipe has a thicker wall, but very good friction factors. It should be noted there are two 18 ½ degree bends located deep on each side of the Sparkman Channel Crossing.

Swagelining is a proprietary process where the polyethylene slip line pipe is heated up and pulled through a die to reduce the outside diameter while maintaining tensile forces while pulling the pipe into place. Once set, the tensile forces are relaxed and the pipe returns to its original diameter locking the liner snug to the inside diameter of the host pipe. Grouting the annulus is not required and loss of inside diameter is minimized.

The City is familiar with rehabilitation of large pipelines with cured-in-place liners and recent technology includes super strength resins and options for curing catalysts such as steam, hot water or ultraviolet light (UV). UV curing is popular when pipe sites are remote and access challenging for large steam generating or hot water equipment. UV is limited to CIPP liner wall thicknesses less than ¾ inch.

2.6 Alternative Route Descriptions

2.6.1 Alternative Route A

As shown on Figure 9, the route begins in Knights Run Avenue just north of the tennis courts on Harbour Island, and then proceeds easterly in Knights Run Avenue and thence southerly in Beneficial Drive. Where the pipe reaches the southern boundary of the intersection of Beneficial Drive and Harbour Island Boulevard, it continues southerly in Beneficial Drive, but now in a proposed easement in a private road owned by Harbour Island Community Services Association, Inc. Continuing southerly in a proposed easement, the road changes into South Beneficial Drive and reaches a roundabout intersection with Renaissance Way. Here the proposed route leaves the roadway and joins the old force main in an existing, 20-foot wide, landscaped utility easement. The underlying fee simple land owner is Harbour Island Community Services Association, Inc. Fortunately; the old pipe is deep here. Access is poor and a construction or parallel permanent easement would be required, but this segment of the route is only about 650 feet long before reaching the shore of Sparkman Channel. At the shore, additional easement would be required from Harbourside at Harbour Island Home Owners Association, Inc. and access to this easement for equipment would be from Sparkman Channel via barge or boat. A deep shaft is required here to function as a receiving pit for a microtunnel boring machine. The shaft would be about 60 feet deep and approximately 15 feet in diameter. From this shaft, the route crosses Sparkman Channel parallel to, and just to the north of, the old force main channel crossing. On the Hooker’s Point side, additional permanent easement would be required for the microtunnel launch pit as well as construction easement for staging and microtunnel support equipment including slurry separation equipment, power station, mud tanks and spoil piles. From this shaft, the route generally follows the old force main easement in a proposed parallel easement along its north-eastern side to its terminus at junction chamber no. 1. With the exception of the railroad crossings and Maritime Boulevard crossing, all land here is owned by the Tampa

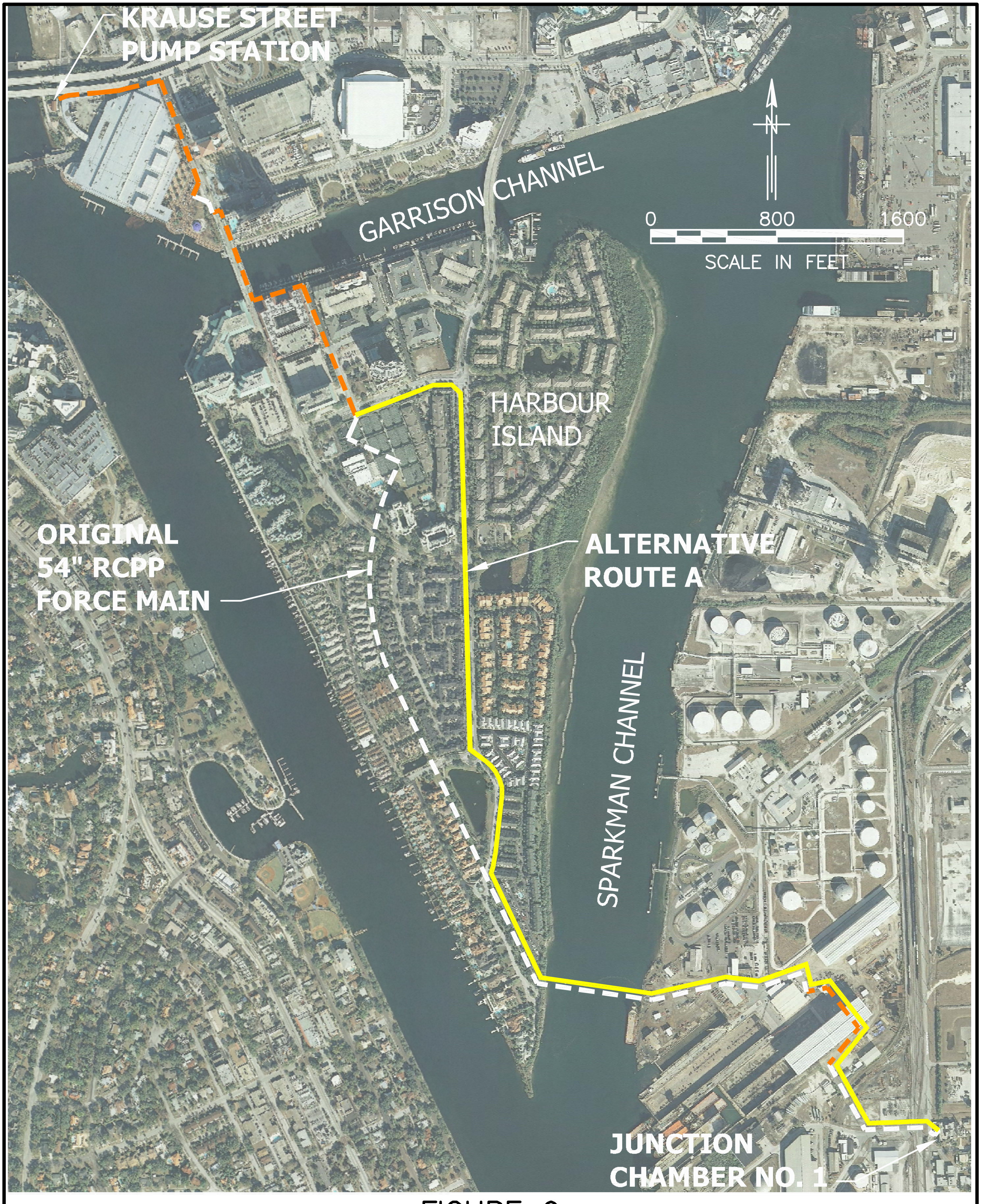


FIGURE 9
ALTERNATIVE ROUTE A

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CERTIFICATE OF AUTHORIZATION NO. 37

KRAUSE FORCE MAIN ASSESSMENT
AND REPLACEMENT ALIGNMENT STUDY
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Port Authority and occupied by Tampa Ship LLC. Coordination with land owners/lessee will be extensive. Some of the existing route appears to go under the building, but the accuracy of pipeline location here is questionable. Larger scale plans for this alternative route are shown on six 11" x 17" plans included in Appendix B.

2.6.2 Alternative Route B

As shown on Figure 10, the route begins in Knights Run Avenue just north of the tennis courts on Harbour Island, and then proceeds easterly in Knights Run Avenue and thence southerly in Beneficial Drive. Where the pipe reaches the southern boundary of the intersection of Beneficial Drive and Harbour Island Boulevard, it continues southerly in Beneficial Drive, but now in a proposed easement in a private road owned by Harbour Island Community Services Association, Inc, but only for about 110 feet until the route turns east into a storm water retention area also owned by the Harbour Island Community Services Association. An easement is proposed along the southern boundary of this property. It is proposed to fill a portion of the open water retention pond to provide a working area for HDD equipment and a HDD entry point located about 150 feet east of the western boundary of this parcel. From this HDD entry point, the route heads east across two more parcels owned by the Harbour Island Community Services Association before reaching Sparkman Channel. One is a mitigation site encumbered by a Hillsborough County Environmental Protection Commission conservation easement and the other is submerged land. A subsurface easement is all that would be required across these parcels. No impact to the surface of these parcels is required. After crossing Sparkman Channel, the route enters a proposed easement on Flacem LLC, Mule Pen Quarry Corporation property and parallels its southern boundary along a drainage ditch for about 1,000 feet before reaching McClosky Boulevard, a private road. From this point the route continues east in McClosky Boulevard on the same parcel of land about 650 feet, thence crossing CSX property and railroad tracks before entering Maritime Boulevard. Maritime Boulevard is a private road belonging to the Tampa Port Authority that already has four major utilities within its right-of-way including a 54-inch sanitary sewer, a 54" sanitary force main, a 48-inch sanitary force main and a 20-inch water main. Other utilities include 8" petroleum line, railroad and power poles. The writer was involved with the design of the most recent force main installed just inside the east edge of pavement. It appears the same corridor is available just inside the west edge of pavement. Temporary pavement may be required for traffic during construction. The route terminates where Maritime Boulevard reaches junction chamber no. 1. Larger scale plans for this alternative route are shown on six 11" x 17" plans included in Appendix C.

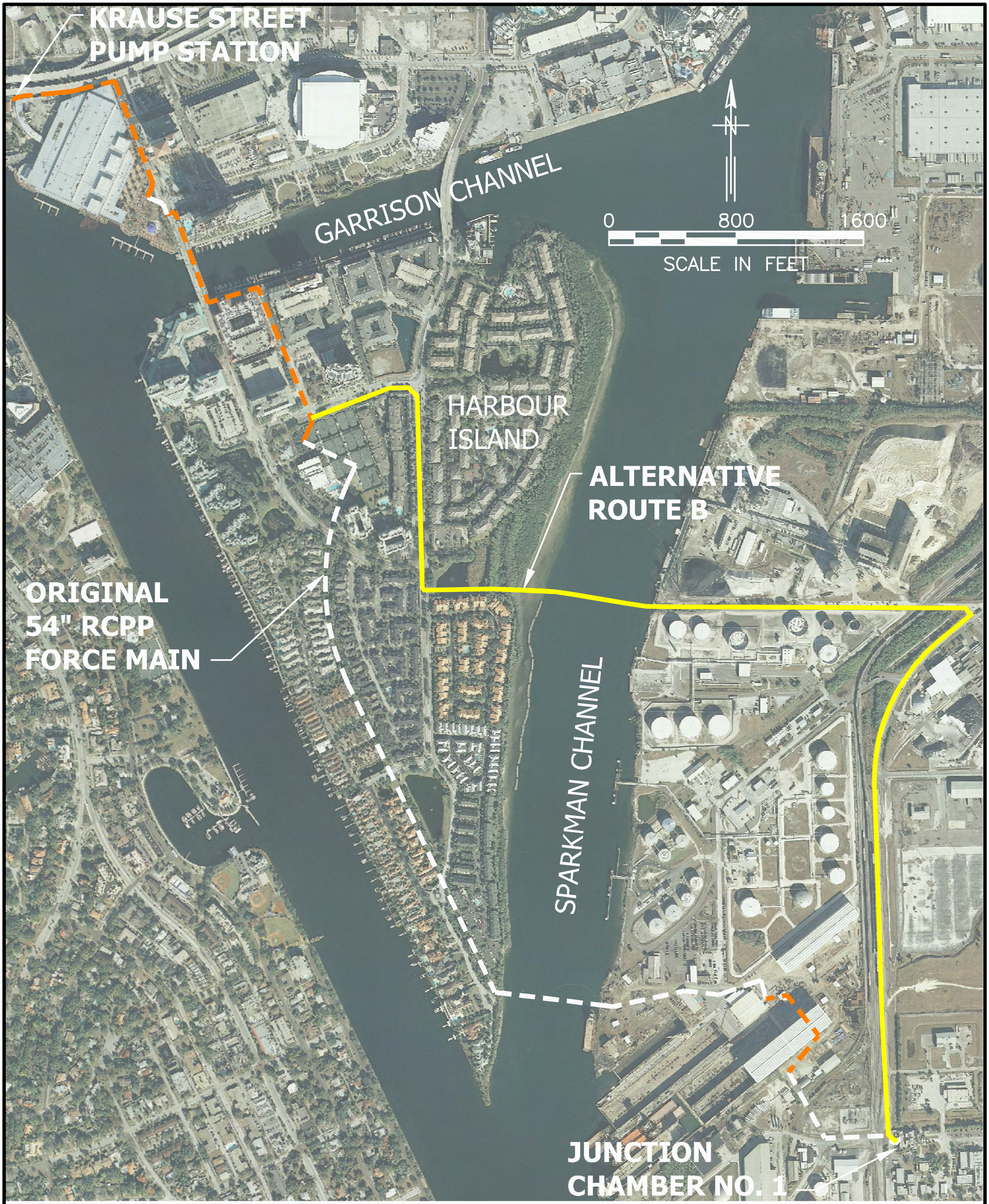

FIGURE 10
ALTERNATIVE ROUTE B

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KRAUSE FORCE MAIN ASSESSMENT AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012

2.7 Alternative Route Comparison

2.7.1 Alternative Route A

Alternative Route A is approximately 8,135 feet long, which is 850 feet shorter than Alternative Route B. Alternative Route A includes 2,750 feet of pipe in proposed easement on Harbour Island and 2,425 feet of pipe in proposed easement from the Tampa Port Authority, not including Port Authority owned roads for which previous pipelines have not been granted specific easements, but allowed by license agreement. Alternative Route A utilizes a tunneled crossing of Sparkman Channel and would likely include two jack and augured crossings of railroad tracks and license agreements with CSX Railroad, Inc. Harbour Island residents and Tampa Ship, LLC are expected to oppose this route. Environmental regulators are not expected to oppose this route. There is an element of risk associated with deep shaft construction adjacent to the Channel. This risk and the cost of construction could be better quantified by performing geotechnical investigations including soil borings with rock drilling and sampling.

2.7.2 Alternative Route B

Alternative Route B is longer than Alternative Route A, but requires less easement acquisition. Alternative Route B includes 675 feet of pipe in proposed landward easements and 300 feet of submerged land easements from Harbour Island Community Services Association and 1,650 feet of pipe in proposed easement from Flacem LLC, Mule Pen Quarry Corporation. True easements on Tampa Port Authority owned roads are not required. In the past, pipelines have been granted a license type agreement. Alternative Route B utilizes an approximately 1,600 linear foot horizontal directional drilled crossing of Sparkman Channel. The risk associated with this crossing is significantly less than for the tunneled crossing in Alternative Route A. The tunnel option can accommodate any diameter in the range without changing the risk level. The HDD option is less risky with the 42" HDPE, DR 13.5 size than the 54" HDPE, DR 17 size. Geotechnical conditions are not expected to significantly change cost or risk of the HDD crossing, but geotechnical investigations are still required for proper design and construction. This route also includes two jack and augered crossings of railroads, but one of the crossings is for four parallel sets of tracks.

2.8 Regulatory Requirements and Permits

2.8.1 Tampa Port Authority

The Tampa Port Authority marine construction permit requires a subaqueous utility crossing under a secondary navigation channel to have a minimum of 10 feet of cover below the permitted dredge depth. The permitted dredge depth for Sparkman Channel is 34' at both alternative route crossings. Approval for a waiver of this requirement is possible, but it typically delays the review significantly. Without geotechnical information, meeting this requirement is suggested. Because the proposed crossings include little or no disruption to the bottom or shores of the Channel, the permit and application should be rather routine. We suggest scheduling to allow a 3 month review period as legal notice and board approval is required.

Both alternative routes would also require a sovereign submerged lands easement. This easement is reviewed and granted by the Tampa Port Authority under delegation by the State of Florida. A legal description and sketch identifying mean high water is required.

2.8.2 Environmental Resource Permit (ERP)

A joint application for an Environmental Resource Permit is required for both alternative routes. This application will address Florida Department of Environmental Protection (FDEP), the U.S. Army Corps of Engineers (USACE) Federal Dredge and Fill requirements as well as U.S. Fish and Wildlife and State Historical Resources among other agencies. For alternative Route A, shoreline impacts from barge access to the shaft site on Harbour Island will require a "Standard General" version of the ERP. Otherwise this crossing could be exempt or authorized under the "Noticed General" version of the ERP. Some requirement to restore habitat at the shoreline is expected.
Similarly, Alternative Route B will require a "Standard General" version of the ERP because of modifications required to the storm water retention facility located on Harbour Island. These modifications could be temporary, but permanent modification is preferred. The treatment volume of the pond must be maintained and this can be accomplished by removal of a portion of an existing island in the pond to compensate for the loss of volume from filling the HDD working area. To compensate for temporal impacts, improvement to the littoral shelf in the retention pond could be included. Such positive benefits from the project may be advantageous to improve public perception of the project.

2.8.3 FDEP Application for Constructing a Domestic Wastewater Collection/Transmission System

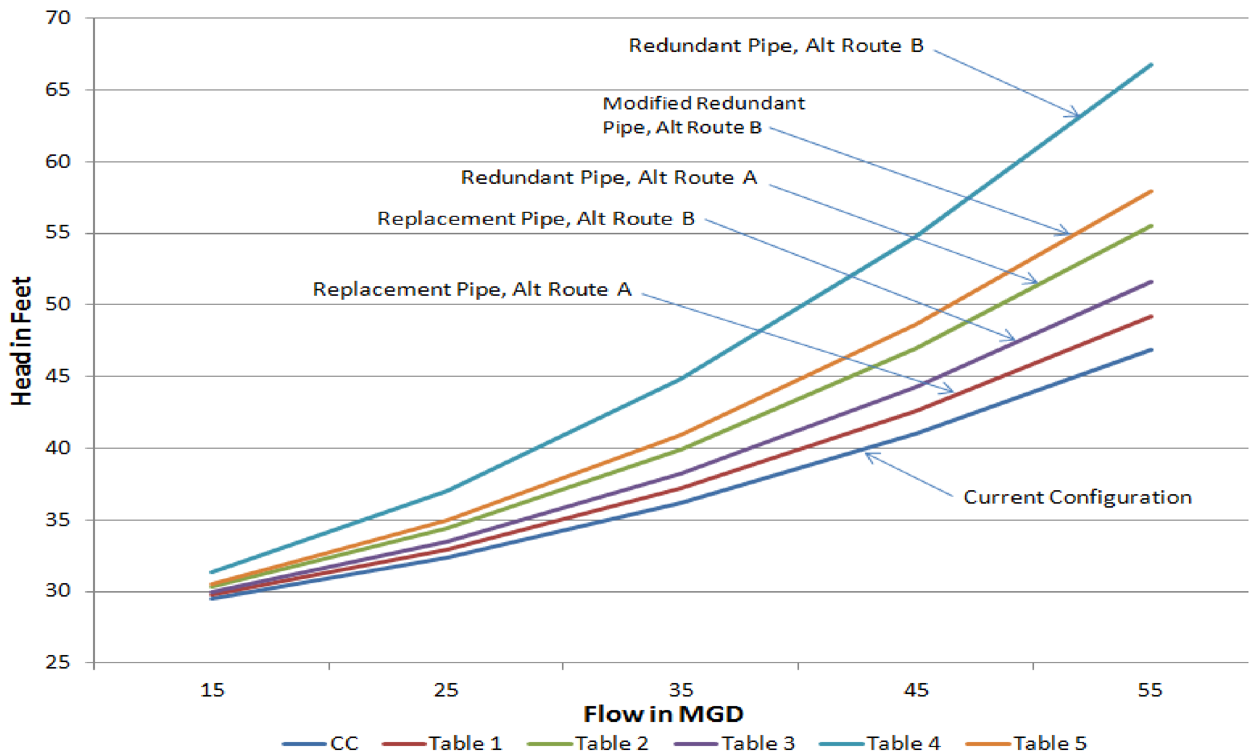
This standard permit is required and will be quite routine as the project does not add any new customers or additional flows to the system. The project simply improves reliability. An "Individual" version of this permit is recommended as opposed to the "General" version. The "General" version requires the entire project, and all conforming aspects of it, to be depicted on a single page.

2.8.4 Other Permits

A Notice of Intent to use the General NPDES Permit will be required to be acquired by the Contractor. This notice also requires development of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP will also be required for the ERP, so it should be developed by the Engineer of Record for the design. Standard City of Tampa underground utility licenses, or similar, are required of the Contractor.

2.9 Project Alternatives

Four project alternatives are considered. First is to employ Alternate Route A and use the same pipe sizes as the original configuration. This is termed a "replacement" alternative. Second is to employ Alternate Route A and use generally one size smaller pipe sizes. This is termed a "redundant" alternative. The intent is to normally pump through both the original pipeline and the redundant pipeline, except as required for emergencies, assessment or rehabilitation. Two similar project alternatives were developed employing Alternative Route B. After viewing cost estimates and hydraulics associated with each of the four project alternatives, it was apparent that the smaller inside diameter of the HDD crossing of Sparkman Channel had too much friction head loss for the higher flow scenarios. A fifth project alternative was developed using all of the components of "Redundant Pipe using Alternative Route B", except up sizing the HDD crossing of Sparkman Channel to approximately 48 inch inside diameter. Figure 11 shows the relative hydraulics associated with each of the project alternatives. The static head between Krause Street Pumping Station and Junction Chamber No. 1 is estimated at 28 feet.



Because the tunnel shafts and using DR 17 HDPE pipe for the HDD have elevated risks compared to the remainder of the project, a 30% contingency has been applied to these cost components. The remainder of the project alternative components have a 15% contingency applied. . Details regarding pipe sizes and total estimated costs are shown in Tables 1 through 5. Total Estimated costs are summarized as follows:

Table 1 – Replacement using Alternative Route A	$13,810,000
Table 2 – Redundant Pipe using Alternative Route A	$12,870,000
Table 3 – Replacement using Alternative Route B	$13,850,000
Table 4 – Redundant Pipe using Alternative Route B	$11,420,000
Table 5 – Modified Redundant Pipe using Alt. Route B	$12,860,000

It should be noted that the costs above do not include assessment/inspection or rehabilitation of the old force main for the redundant alternatives. Just assessment/inspection would likely exceed $1,000,000 and continued use of the old force main without condition assessment and likely some necessary rehabilitation includes elevated risk.

2.10 Recommendations

Various alternative costs are not significantly different, indicating that the selection of the best alternative should consider non-cost identifiable criteria such as public acceptance, safety, maintenance accessibility, use of existing public right-of-way, environmental impacts, permitting complexity, traffic impacts, and potential for encountering contaminated soil or groundwater.

Considering hydraulics and risk, as well as condition assessment costs for the redundant alternatives, it is recommended to replace the force main along route A or B pending a detailed route study including public outreach, geotechnical investigations, environmental evaluation, regulatory permitting discussions and property records research to form a basis for route selection and easement acquisition; and then immediately move forward with easement acquisition. Final design and permit acquisition can follow easement acquisition or start shortly before its conclusion. The detailed route study should take approximately 8 months to complete; extensive easement acquisition could take up to 2 years or longer if it has to proceed to eminent domain; final design and permitting could take 2 years; bidding and award about 4 months and construction approximately 2 more years bringing the total to 7 years. This represents an efficient schedule rate. If a break were to occur or pipe was discovered in perilous condition, this timeline could be compressed to between 5 and 6 years at a cost.

Due to the age of the older portions of this force main (62 years), the critical role it provides as the central urban backbone of the collection/transmission system, the difficulty in containing, bypassing or repairing an emergency break in this unique pipe, and the long estimated schedule to replace it (7 years), we recommend the City move forward now with initial steps to replace this old force main despite the fact that this cursory assessment did not uncover signs of advanced degradation. This report does describe that the consequences of a failure would be unacceptable from many viewpoints.

TABLES

CITY OF TAMPA WASTEWATER DEPARTMENT

Krause Force Main Assessment and Replacement Alignment Study

September 2012

Table 1 - Total Estimated Cost for Replacement using Alternative Route A

AUGUST 2012 ENR CCI= 9351

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	QUANTITY	COST UNIT		COST TOTAL
1	**SANITARY FORCE MAIN IN OPEN-CUT TRENCH**					
	Furnish & Install 54" Sanitary FM	LF	7,275	$ 580	$	4,220,000
	Furnish & Install 48" Sanitary FM	LF	0	$ 495	$	-
	48" Plug Valves	EA	3	$ 110,000	$	330,000
2	**SPECIAL CROSSINGS**					
	Sparkman Channel Crossing via Tunnel, 48" FM	LF	700	$ 3,000	$	2,100,000
	Tunnel Shafts	EA	2	$ 400,000	$	800,000
	Jack and Auger at Railroads/Maritime Blvd., 54" FM	LF	160	$ 2,600	$	416,000
	Jack and Auger Shafts	EA	4	$ 35,000	$	140,000
3	**HOT TAPS AND LINE STOPS**					
	48" X 54" Hot Tap	EA	2	$ 90,000	$	180,000
	36" x 54" Line Stop	EA	2	$ 120,000	$	240,000
4	**PAVEMENT/RIGHT-OF-WAY RESTORATION**					
	Rebuild Lane and Overlay Road	LF	4,170	$ 95	$	396,000
	Restore Parking Lot/ Driveway	LF	2,400	$ 55	$	132,000
5	Maintenance of Traffic	%	2		$	179,080
6	Mobilization	%	5		$	447,700
	ESTIMATED CONSTRUCTION COST (TO NEAREST $1,000)				**$**	**9,580,780**
	Design, Permitting and Const. Engineering	%	15		$	1,437,117
	Easement Acquisition, Harbour Island	LF	2,750	$210	$	578,000
	Easement Acquisition, Hooker's Point	LF	2,425	$140	$	340,000
	Contingency, Channel Crossing	%	30		$	870,000
	Contingency, remainder of project	%	15		$	1,002,117
	OPINION OF PROJECT COST (TO NEAREST $10,000)				**$**	**13,810,000**

CITY OF TAMPA WASTEWATER DEPARTMENT

Krause Force Main Assessment and Replacement Alignment Study

September 2012

Table 2 - Total Estimated Cost for Redundant FM using Alternative Route A

AUGUST 2012 ENR CCI= 9351

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	QUANTITY	COST UNIT		COST TOTAL
1	**SANITARY FORCE MAIN IN OPEN-CUT TRENCH**					
	Furnish & Install 54" Sanitary FM	LF	0	$ 580	$	-
	Furnish & Install 48" Sanitary FM	LF	7,275	$ 495	$	3,601,000
	48" Plug Valves	EA	3	$ 110,000	$	330,000
2	**SPECIAL CROSSINGS**					
	Sparkman Channel Crossing via Tunnel, 48" FM	LF	700	$ 3,000	$	2,100,000
	Tunnel Shafts	EA	2	$ 400,000	$	800,000
	Jack and Auger at Railroads/Maritime Blvd., 48" FM	LF	160	$ 2,250	$	360,000
	Jack and Auger Shafts	EA	4	$ 35,000	$	140,000
3	**HOT TAPS AND LINE STOPS**					
	48" X 54" Hot Tap	EA	2	$ 90,000	$	180,000
	36" x 54" Line Stop	EA	2	$ 120,000	$	240,000
4	**PAVEMENT/RIGHT-OF-WAY RESTORATION**					
	Rebuild Lane and Overlay Road	LF	4,170	$ 95	$	396,000
	Restore Parking Lot/ Driveway	LF	2,400	$ 55	$	132,000
5	Maintenance of Traffic	%	2		$	165,580
6	Mobilization	%	5		$	413,950
	ESTIMATED CONSTRUCTION COST (TO NEAREST $1,000)				**$**	**8,858,530**
	Design, Permitting and Const. Engineering	%	15		$	1,328,780
	Easement Acquisition, Harbour Island	LF	2,750	$210	$	578,000
	Easement Acquisition, Hooker's Point	LF	2,425	$140	$	340,000
	Contingency, Channel Crossing	%	30		$	870,000
	Contingency, remainder of project	%	15		$	893,780
	OPINION OF PROJECT COST (TO NEAREST $10,000)				**$**	**12,870,000**

CITY OF TAMPA WASTEWATER DEPARTMENT

Krause Force Main Assessment and Replacement Alignment Study

September 2012

Table 3 - Total Estimated Cost for Replacement using Alternative Route B

AUGUST 2012 ENR CCI= 9351

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	QUANTITY	COST UNIT	COST TOTAL
1	**SANITARY FORCE MAIN IN OPEN-CUT TRENCH**				
	Furnish & Install 54" Sanitary FM	LF	7,075	$ 580	$ 4,104,000
	Furnish & Install 48" Sanitary FM	LF	0	$ 495	$ -
	48" Plug Valves	EA	3	$ 110,000	$ 330,000
2	**SPECIAL CROSSINGS**				
	Sparkman Channel Crossing via HDD, 48" ID FM	LF	1,600	$ 1,850	$ 2,960,000
	Jack and Auger at Railroads., 54" FM	LF	310	$ 2,600	$ 806,000
	Jack and Auger Shafts	EA	4	$ 35,000	$ 140,000
3	**HOT TAPS AND LINE STOPS**				
	48" X 54" Hot Tap	EA	2	$ 90,000	$ 180,000
	36" x 54" Line Stop	EA	2	$ 120,000	$ 240,000
4	**PAVEMENT/RIGHT-OF-WAY RESTORATION**				
	Rebuild Lane and Overlay Road	LF	5,510	$ 95	$ 523,000
	Restore Parking Lot/ Driveway	LF	200	$ 55	$ 11,000
5	Maintenance of Traffic	%	2		$ 185,880
6	Mobilization	%	5		$ 464,700
	ESTIMATED CONSTRUCTION COST (TO NEAREST $1,000)				**$ 9,944,580**
	Design, Permitting and Const. Engineering	%	15		$ 1,491,687
	Easement Acquisition, Harbour Island	LF	950	$210	$ 200,000
	Easement Acquisition, Hooker's Point, incl. RR	LF	2,000	$140	$ 280,000
	Contingency, Channel Crossing	%	30		$ 888,000
	Contingency, remainder of project	%	15		$ 1,047,687
	OPINION OF PROJECT COST (TO NEAREST $10,000)				**$ 13,850,000**

CITY OF TAMPA WASTEWATER DEPARTMENT

Krause Force Main Assessment and Replacement Alignment Study

September 2012

Table 4 - Total Estimated Cost for Redundant FM using Alternative Route B

AUGUST 2012 ENR CCI= 9351

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	QUANTITY	COST UNIT		COST TOTAL
1	**SANITARY FORCE MAIN IN OPEN-CUT TRENCH**					
	Furnish & Install 54" Sanitary FM	LF	0	$ 580	$	-
	Furnish & Install 48" Sanitary FM	LF	7,075	$ 495	$	3,502,000
	48" Plug Valves	EA	3	$ 110,000	$	330,000
2	**SPECIAL CROSSINGS**					
	Sparkman Channel Crossing via HDD, 36" ID FM	LF	1,600	$ 1,400	$	2,240,000
	Jack and Auger at Railroads., 48" FM	LF	310	$ 2,250	$	698,000
	Jack and Auger Shafts	EA	4	$ 35,000	$	140,000
3	**HOT TAPS AND LINE STOPS**					
	48" X 54" Hot Tap	EA	2	$ 90,000	$	180,000
	36" x 54" Line Stop	EA	2	$ 120,000	$	240,000
4	**PAVEMENT/RIGHT-OF-WAY RESTORATION**					
	Rebuild Lane and Overlay Road	LF	5,510	$ 95	$	523,000
	Restore Parking Lot/ Driveway	LF	200	$ 55	$	11,000
5	Maintenance of Traffic	%	2		$	157,280
6	Mobilization	%	5		$	393,200
	ESTIMATED CONSTRUCTION COST (TO NEAREST $1,000)				**$**	**8,414,480**
	Design, Permitting and Const. Engineering	%	15		$	1,262,172
	Easement Acquisition, Harbour Island	LF	950	$210	$	200,000
	Easement Acquisition, Hooker's Point, incl. RR	LF	2,000	$140	$	280,000
	Contingency	%	15		$	1,262,172
	OPINION OF PROJECT COST (TO NEAREST $10,000)				**$**	**11,420,000**

CITY OF TAMPA WASTEWATER DEPARTMENT

Krause Force Main Assessment and Replacement Alignment Study

September 2012

Table 5 - Total Estimated Cost for Modified Redundant FM using Alternative Route B

AUGUST 2012 ENR CCI= 9351

ITEM NO.	DESCRIPTION	UNIT OF MEASURE	QUANTITY	COST UNIT		COST TOTAL	
1	**SANITARY FORCE MAIN IN OPEN-CUT TRENCH**						
	Furnish & Install 54" Sanitary FM	LF	0	$	580	$	-
	Furnish & Install 48" Sanitary FM	LF	7,075	$	495	$	3,502,000
	48" Plug Valves	EA	3	$	110,000	$	330,000
2	**SPECIAL CROSSINGS**						
	Sparkman Channel Crossing via HDD, 48" ID FM	LF	1,600	$	1,850	$	2,960,000
	Jack and Auger at Railroads., 48" FM	LF	310	$	2,250	$	698,000
	Jack and Auger Shafts	EA	4	$	35,000	$	140,000
3	**HOT TAPS AND LINE STOPS**						
	48" X 54" Hot Tap	EA	2	$	90,000	$	180,000
	36" x 54" Line Stop	EA	2	$	120,000	$	240,000
4	**PAVEMENT/RIGHT-OF-WAY RESTORATION**						
	Rebuild Lane and Overlay Road	LF	5,510	$	95	$	523,000
	Restore Parking Lot/ Driveway	LF	200	$	55	$	11,000
5	Maintenance of Traffic	%	2			$	171,680
6	Mobilization	%	5			$	429,200
	ESTIMATED CONSTRUCTION COST (TO NEAREST $1,000)					**$**	**9,184,880**
	Design, Permitting and Const. Engineering	%	15			$	1,377,732
	Easement Acquisition, Harbour Island	LF	950		$210	$	200,000
	Easement Acquisition, Hooker's Point, incl. RR	LF	2,000		$140	$	280,000
	Contingency, Channel Crossing	%	30			$	888,000
	Contingency, Remainder of Project	%	15			$	933,732
	OPINION OF PROJECT COST (TO NEAREST $10,000)					**$**	**12,860,000**

APPENDIX A

SONOGRAPHICS *Remote Sensing Excellence*

Geophysical Survey & Data Processing
Seddon Island Force Main, Tampa, Florida 2012

Prepared for:
Thomas Y. Wilson, P.E.
Associate
GREELEY AND HANSEN
June 2012

2317 N Andrews Ave, Ft. Lauderdale, FL 33311 Telephone: (954) 566-0620 Fax: (954) 564-6882
fhorgan@ aol.com

Geophysical Survey – Seddon Island Force Main

REPORT of RESULTS

CONTENTS

2317 N Andrews Ave, Ft. Lauderdale, FL 33311 Telephone: (954) 566-0620 Fax: (954) 564-6882
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1. Introduction.

Sonographics, Inc. was tasked by Greeley and Hansen Engineering, Llc. to provide a geophysical survey and post processing of remote sensing data collected Seddon Island Force Main in Hillsborough Bay, Tampa, Florida. The objective of the seismic investigation was to detect the depth of burial of the pipeline at various locations along the underwater route. The survey comprised continuous seismic reflection profiling with a "chirp" surface tow seismic source. The sub-bottom survey data was taken on June 29, 2012.

2. Equipment.

Sub-Bottom Profiler

The X-Star Full Spectrum Sonar is a versatile wide-band FM sub-bottom profiler that generates cross sectional images of the seabed and collects digital normal incidence reflection data over many frequency ranges. X-Star transmits an FM pulse that is linearly swept over a full spectrum frequency range (also called a ‘chirp pulse’). The tapered wave form spectrum results in images that have virtually constant resolution with depth. Another X-Star advantage is the reduction of side lobes in the effective transducer aperture. The tow-fish utilized in the survey was the Edge Tech model SB 424. The sub-bottom imagery was geo-encoded using the tow-fish position supplied by the Hypack Navigation Computer and stored in the Edge Tech native – jsf format on the X-Star System hard drive.

Side-scan Sonar

The side-scan system was the EdgeTech dual frequency (600 kHz and 1600 kHz) chirp side-scan sonar. The model used was the 4125-T. The side-scan sonar is capable of producing sonic images of the bottom with the resolution to display small objects if they are exposed and not completely buried. The limitations of the side-scan sonar are that it cannot penetrate the bottom and detect a buried object. The sub-bottom imagery was geo-encoded using the tow-fish position supplied by the Hypack Navigation Computer and stored in the Edge Tech native – jsf format on the X-Star System hard drive.

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Electronic Navigation

The navigation equipment used for the survey, a Trimble DSM 232 – Real Time Differential Global Positioning System (GPS) interfaced with the Coastal Oceanographic (HYPACK) Hydrographic Data Collection and Processing System was programmed for the line spacing and coverage required.

The Trimble DSM 232 – is designed for moderate precision static and dynamic position applications, provides time and three dimensional station coordinates and velocity measurements at once per second rate. The DSM 232 - automatically determines time, latitude, and longitude, height and velocity, at a rate of once per second. The Trimble DSM 232 – accuracy with differential as used in this survey provides for a position accuracy of approximately 1 meter. The grid used for all data is the Florida State Plane Transverse Mercator -Projection Coordinate System, West Zone (NAD 83).

3. Survey Methods

On June 29, 2012, the 25' vessel was mobilized with the Sub-bottom Profiler and Trimble DGPS Navigation System. The Navigation computer with Hypack Navigation Software was installed to interface the GPS and output tow-fish coordinates to the Sub-bottom computer topside. The Navigation computer was loaded with preplanned survey lines through the length of the survey areas and provided visual guidance to the helmsman for navigation of each line. The DGPS system received differential corrections from a U.S. Coast Guard beacon.

The Sub-bottom profiler was deployed at the side of the vessel. The distance from the GPS antenna to the center of the transducers was also measured. The layback and offset were calculated by the navigation software, which enabled tow-fish coordinates to be sent to the Sub-bottom computer in real time. The Sub-bottom profiler lines were run perpendicular to the pipeline at 50 foot intervals. The Side-scan sonar was deployed in a similar manner but the track-lines were parallel to the pipeline crossing and perpendicular to image the shorelines.

4. Bathymetry.

A bathymetry survey was not performed during this survey. We cannot provide elevations of the detected pipeline locations without bathymetry. We can only provide depth of burial.

5. Seismic Reflection

An example seismogram is presented in Figures 1 and 2 from data obtained during the survey. Scale lines on the sections are recorded at 5 foot intervals and assuming a seismic velocity of 1640m/s for the sediments. The raw data was processed using Chesapeake Technology SonarWiz5 program to provide the following products. Html / jpeg files were produced which allow viewing of the data in standard browser programs by clicking on the “index” html file which then opens the browser and displays the list of profile lines. Clicking on a file opens a jpeg file with annotation and active local grid, geographic coordinates and depth features. Two complete sets of Html / jpeg files were produced. One set with no annotation and one set with sub-bottom features annotated.

Sub-bottom features or reflectors occur when the density of the sediment changes and acoustic energy is reflected back to the towfish. The profiles were annotated with Sub-bottom reflectors “Pipe” in red to designate detection of the pipeline. They were annotated with “PPL” (Possible Pipeline) in cyan to designate a possible but not certain detection of the pipeline. There were 7 locations where the profiles detected the pipeline and 9 locations where there was a possible detection. A DXF file of the navigation data in the JSF files was extracted to a produce a track map (Figure 3).

6. Discussion.

The strength of a seismic reflection is dependant upon the acoustic impedance contrast between the reflecting sediments. The pipeline was easily detected in the silty sediment on the west side of the crossing. Detection in the rocky area along the deep water mid-section was challenging. The sediment on the east side appeared to be strewn with rocks or other debris and the pipeline was not easily detected there either. All detections of the pipeline were at least 1.7 ft. deep in sediment and none were at the surface. Side-scan sonar was used to image the bottom to confirm that the pipeline is not exposed at any location along the crossing. A side-scan mosaic is being provided so show the resolution of this result.

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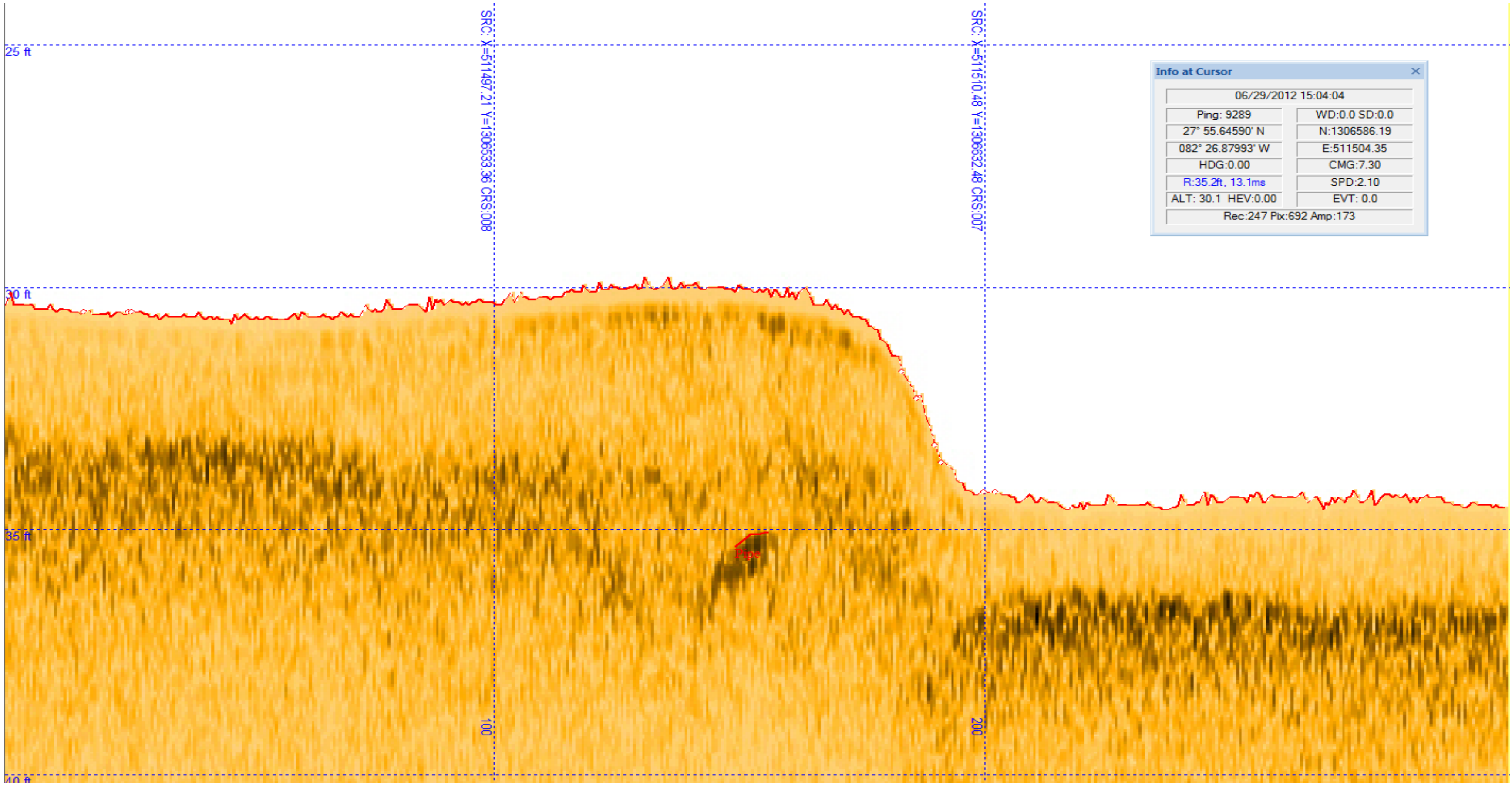

Figure 1. Line 1Plus50N:

Dark mass in the center of the image is the pipeline. It is marked with red as "Pipe" (difficult to see without zooming). The annotation is purposely small to avoid masking the target. This is in the silt near the west side. Vertical annotation includes FL State Plane Coordinates, course made good and depth in feet from the transducer based on assumed sediment velocity of 1640 meters / second. Depth of burial at this detection is 5.1 ft.

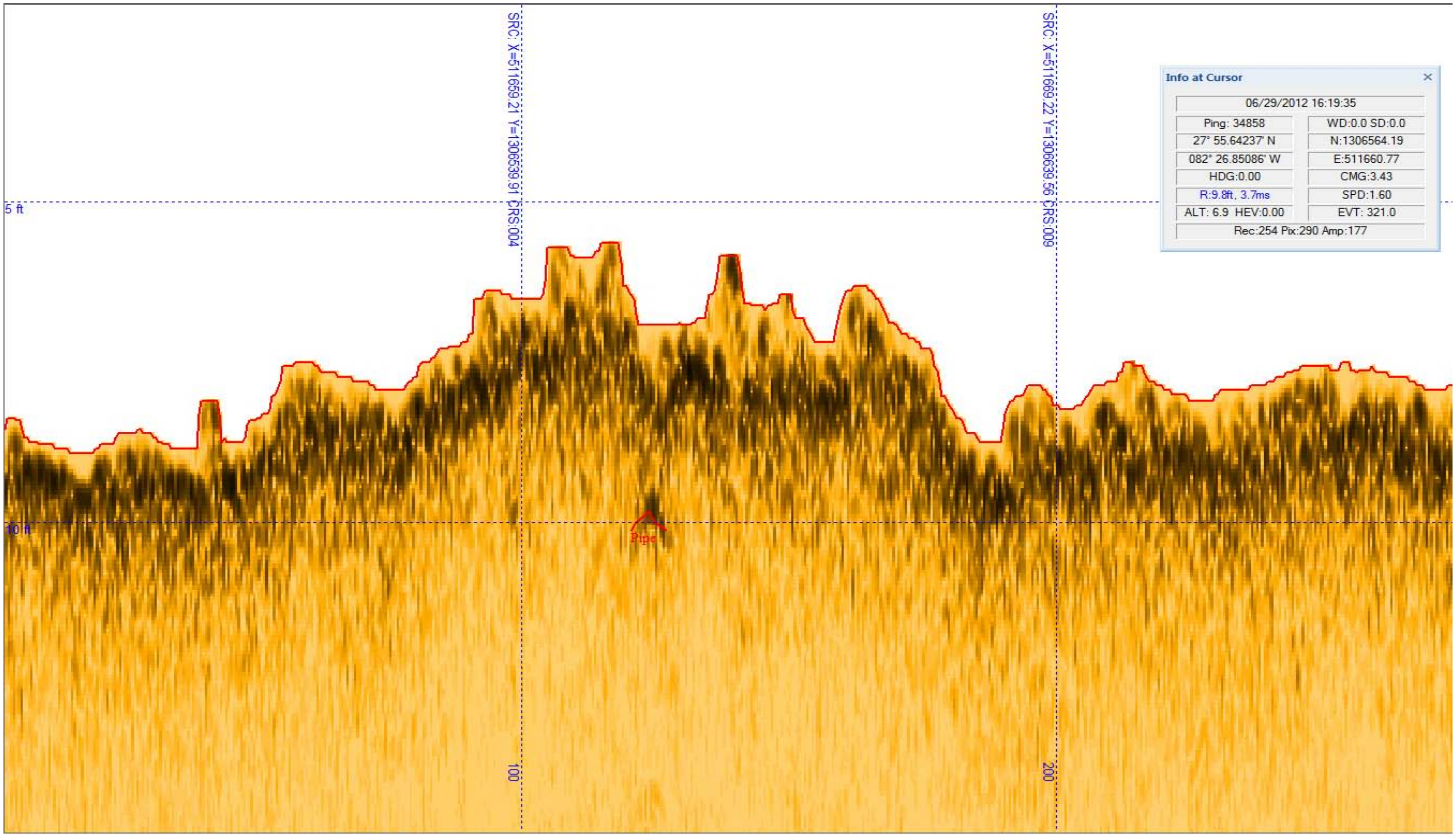

Figure 2. Line 3Plus00N:

Dark mass in the center of the image is the pipeline. It is marked with red as "Pipe" (difficult to see without zooming). The annotation is purposely small to avoid masking the target. This is in rocky bottom near the middle of the crossing. Note the rugged bottom profile. Vertical annotation includes FL State Plane Coordinates, course made good and depth in feet from the transducer based on assumed sediment velocity of 1640 meters / second. Depth of burial at this detection is 2.8 ft.

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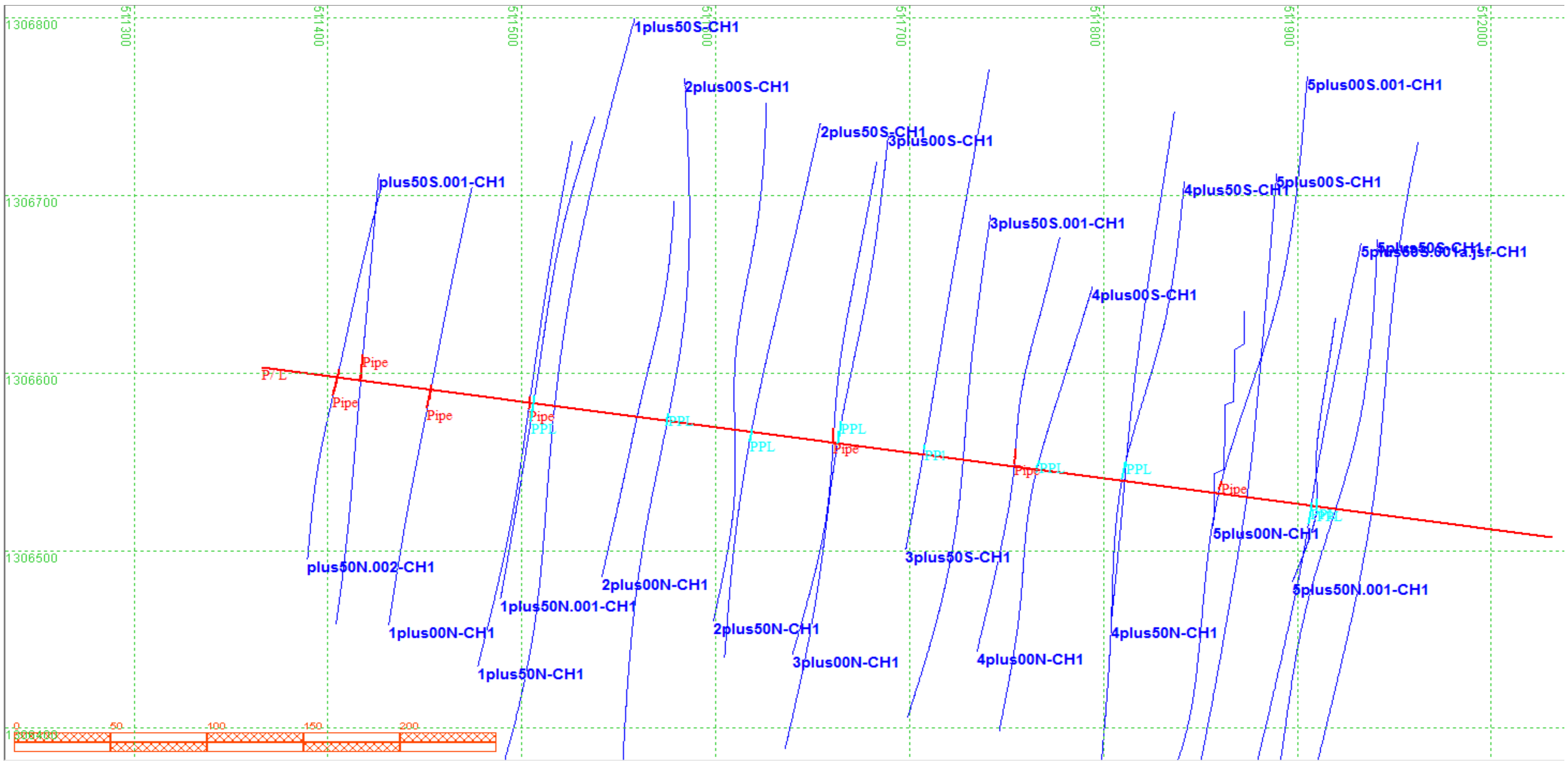

Figure 3. Track Map Survey Lines:

Pipe detections in red, Possible Pipe detections (PPL) in cyan, survey track lines in blue, pre-plot of pipeline (P/L) from the as built drawing is in red. Green grid is FL State Plane West Zone, U.S Feet, NAD83.

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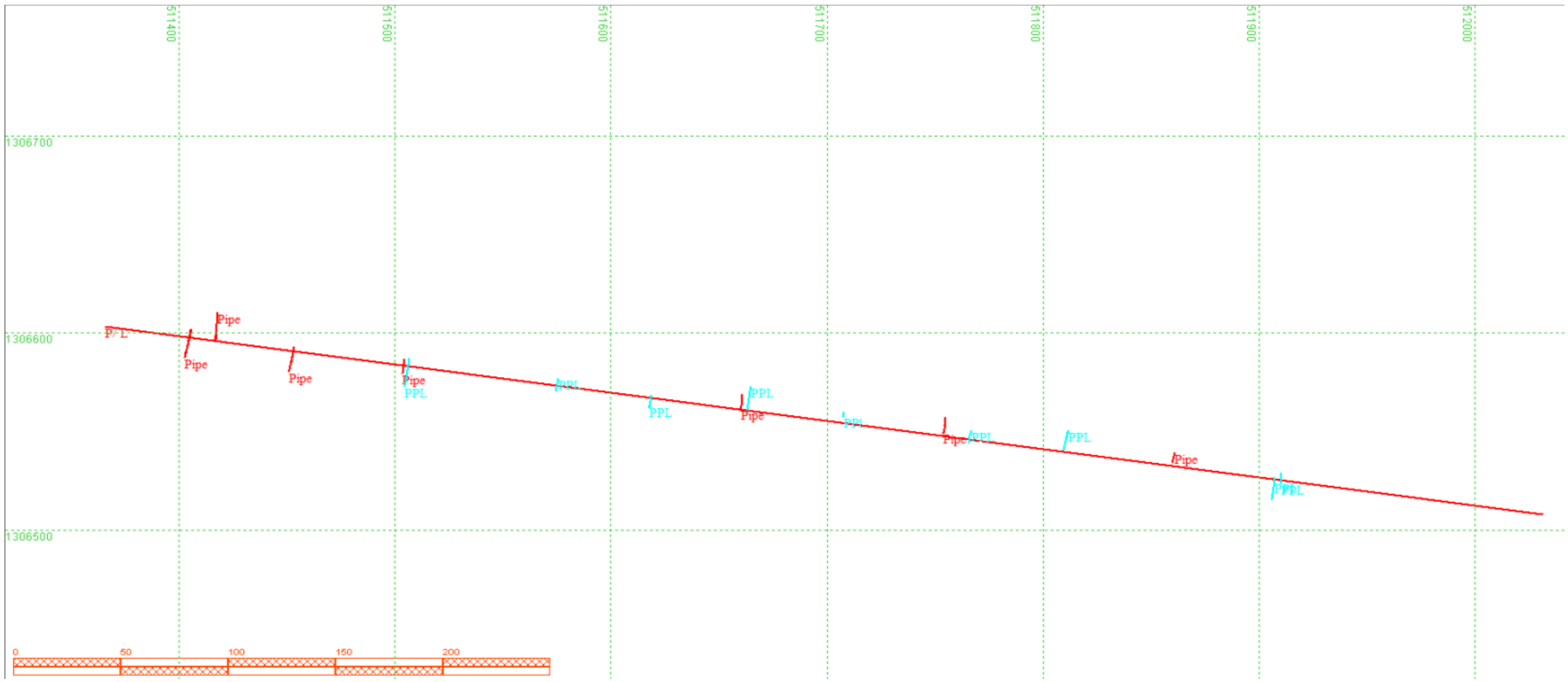

Figure 4. Pipe and Possible Pipeline detections:

Pipe detections in red, Possible pipe detections (PPL) in cyan and pre-plot of pipeline (P/L) from the as built drawing is in red. Green grid is FL State Plane West Zone, U.S Feet, NAD83.

Table of Results

Line name	Contact	Depth ft.	Confidence	North Latitude	West Longitude	FL SP west Easting	NAD83 Northing
0P50N	?						
P50S	?						
P50N.002	Pipe	2.1	low	27.92747	82.448305	511405.6	1306601.3
P50S.001	Pipe	2.2	high	27.92746	82.44827	511417	1306597.7
1P00N	Pipe	3.5	high	27.92745	82.448156	511453.6	1306593.1
1P50S	?						
1P50N	Pipe	5.1	high	27.92743	82.447999	511504.4	1306586.6
1P50N.001	PPL	2.5		27.92743	82.447992	511506.6	1306587
2P00S	PPL	2.4		27.9274	82.44778	511575	1306572.6
2P00N	?						
2P50N	?						
2P50S	PPL	3		27.92737	82.447648	511617.6	1306561.9
3P00S	PPL	2.7		27.92739	82.447503	511664.5	1306570.4
3P00N	Pipe	2.8	high	27.92738	82.447514	511660.9	1306565
3P50S	PPL	2.5		27.92736	82.447369	511707.7	1306559.4
3P50S.001	?						
4P00S	PPL	1.85		27.92733	82.447188	511766.1	1306547.9
4P00N	Pipe	1.7	Low	27.92734	82.447225	511754.3	1306551.3
4P50N	?						
4P50S	PPL	3.4		27.92733	82.447049	511811	1306547
5P00S	?						
5P00S.001	Pipe	1.9	high	27.92731	82.446894	511861	1306539.2
5P00N	?						
5P50S	?						
5P50S.001a	PPL	1		27.92727	82.44675	511907.4	1306526.8
5P50N.001	PPL	1.4		27.92727	82.446741	511910.4	1306524.1
6P00N	?						

DATA FILES

The following files were generated to illustrate the results of the survey:

HTML raw **HTMl / JPEG files of all survey lines without annotation except for cores.**

HTML **HTML/JPEG files of all annotated profiles including “Pipe” in red and “PPL” in cyan.**

DXF / DWG **Dxf and DWG files (Seddon_Is.dxf) and (Seddon_Is.dwg) of the Navigation tracks of the towfish for all survey lines.**

XLSX **Excel file (Detection_Log_Seddon_Island_Force_Main.xlsx) Table from this report.**

KMZ **KMZ file (HarborIsland_00.kmz) mosaic of the 1600kHz side-scan images for viewing in Google Earth.**
KMZ file (PIPE.kmz) A line representing the Pipeline crossing as located in the as built drawing for viewing in Google Earth.
KMZ file (HarborIsland_600.kmz) mosaic of the 600kHz side-scan images for viewing in Google Earth.
KMZ file (HarborIsland_01.kmz) mosaic of the combination (hybrid) of 1600kHz and 600kHz side-scan images for viewing in Google Earth.

TIF **Geo-Tiff file (HarborIsland_00.tif/tfw) mosaic of the 1600kHz Side-scan images. For use in GIS.**
Geo-Tiff file (HarborIsland_600.tif/tfw) mosaic of the 600kHz Side-scan images. For use in GIS.
Geo-Tiff file (HarborIsland_01.tif/tfw) mosaic of the combination (hybrid) of 1600kHz and 600kHz Side-scan images. For use in GIS.

APPENDIX B

MATCHLINE SEE SHEET NO: 2

PROPOSED ALTERNATIVE ROUTE A

GREELEY AND HANSEN
CERTIFICATE OF AUTHORIZATION NO. 37

KRAUSE FORCE MAIN ASSESSMENT
AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012
SHEET NO: 1

MATCHLINE SEE SHEET NO: 1

MATCHLINE SEE SHEET NO: 3

PROPOSED ALTERNATIVE ROUTE A

GREELEY AND HANSEN

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KRAUSE FORCE MAIN ASSESSMENT AND REPLACEMENT ALIGNMENT STUDY

SEPTEMBER 2012

SHEET NO: 2

PROPOSED ALTERNATIVE ROUTE A

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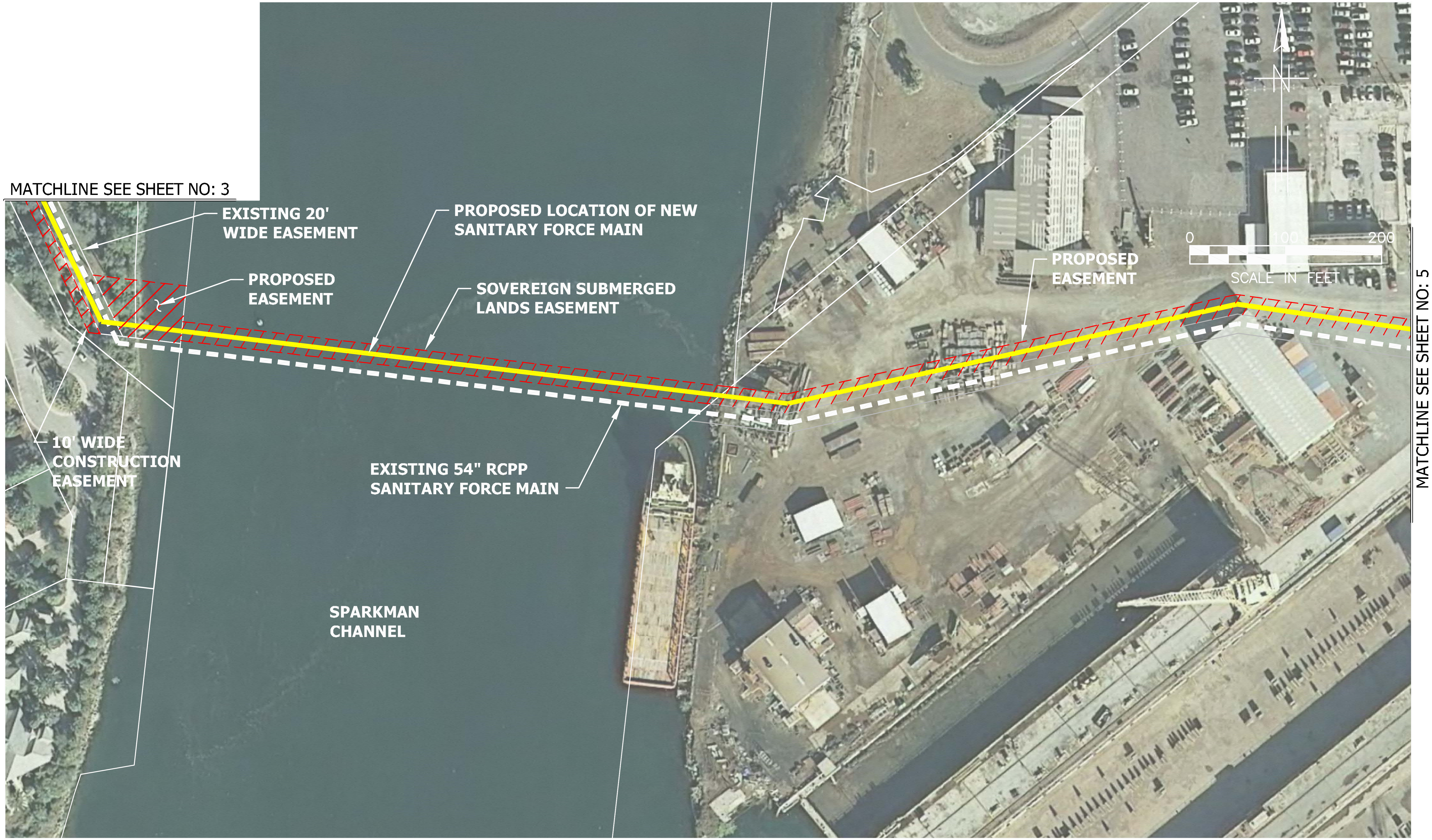
KRAUSE FORCE MAIN ASSESSMENT
AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012
SHEET NO: 3



PROPOSED ALTERNATIVE ROUTE A

GREELEY AND HANSEN

CERTIFICATE OF AUTHORIZATION NO. 37

KRAUSE FORCE MAIN ASSESSMENT AND REPLACEMENT ALIGNMENT STUDY

SEPTEMBER 2012

SHEET NO: 4

PROPOSED ALTERNATIVE ROUTE A

GREELEY AND HANSEN
CERTIFICATE OF AUTHORIZATION NO. 37

KRAUSE FORCE MAIN ASSESSMENT AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012
SHEET NO: 5

APPENDIX C

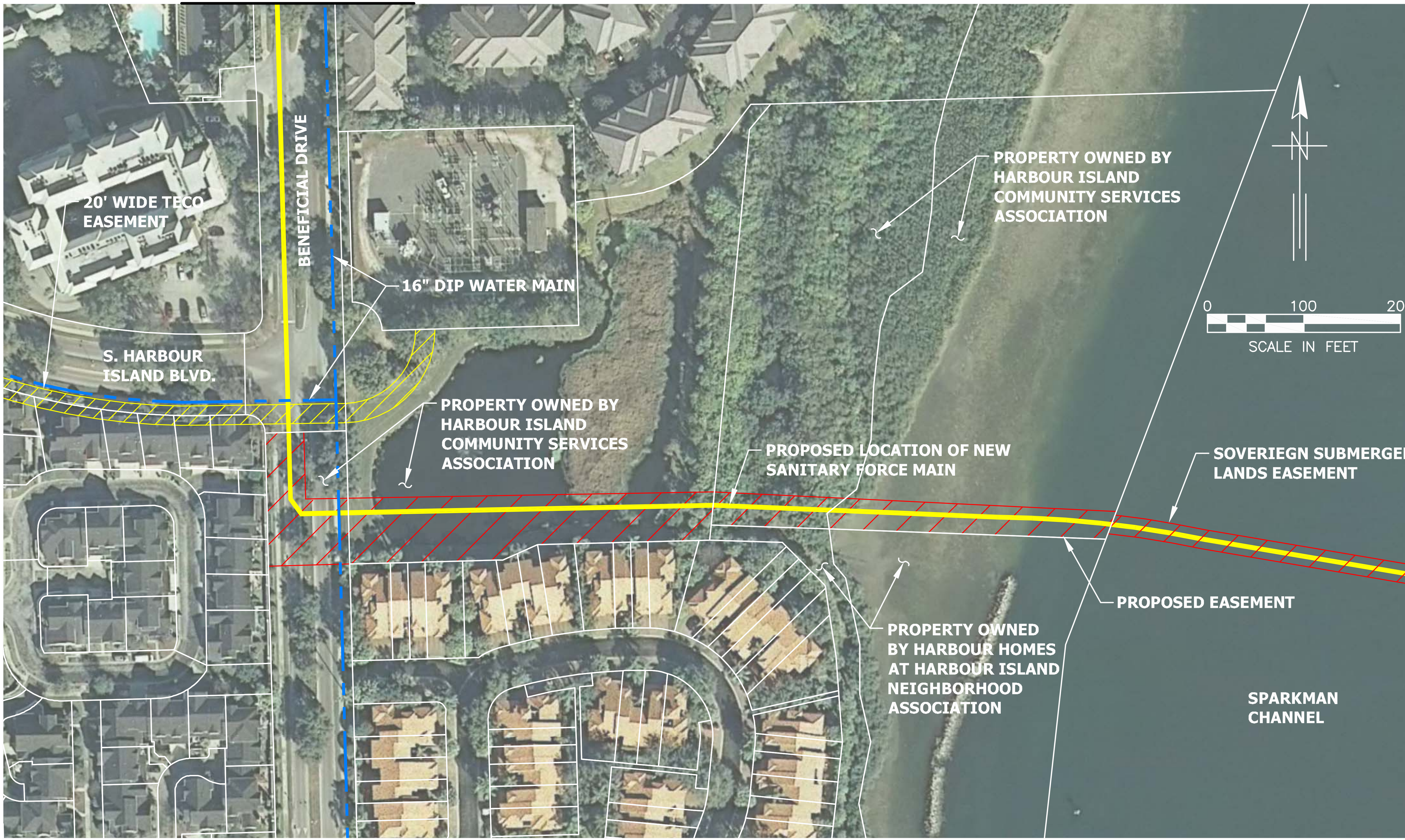
MATCHLINE SEE SHEET NO: 2

PROPOSED ALTERNATIVE ROUTE B

GREELEY AND HANSEN
CERTIFICATE OF AUTHORIZATION NO. 37

KRAUSE FORCE MAIN ASSESSMENT AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012
SHEET NO: 1

MATCHLINE SEE SHEET NO: 1



MATCHLINE SEE SHEET NO: 3

PROPOSED ALTERNATIVE ROUTE B

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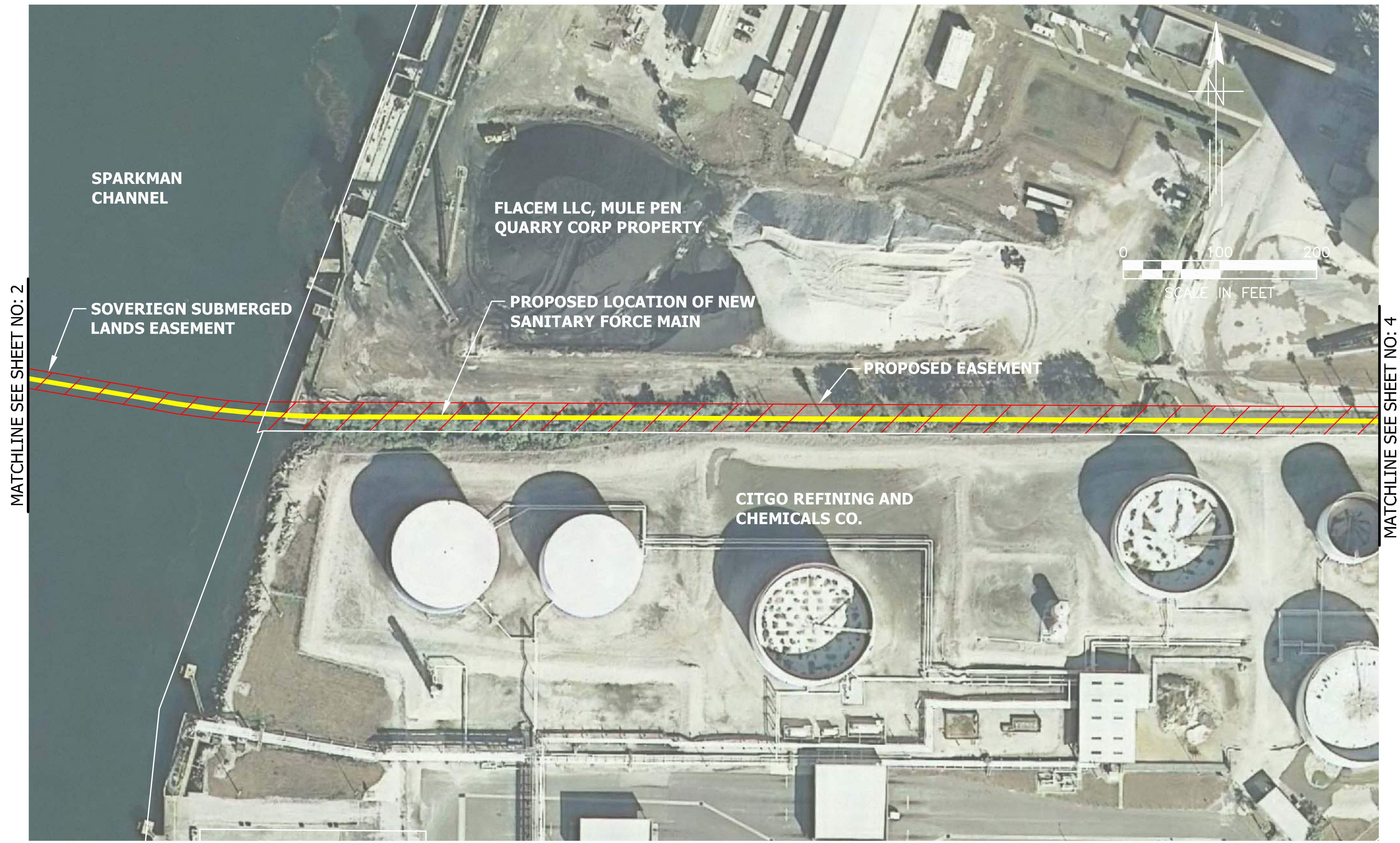
KRAUSE FORCE MAIN ASSESSMENT AND REPLACEMENT ALIGNMENT STUDY
SEPTEMBER 2012
SHEET NO: 2



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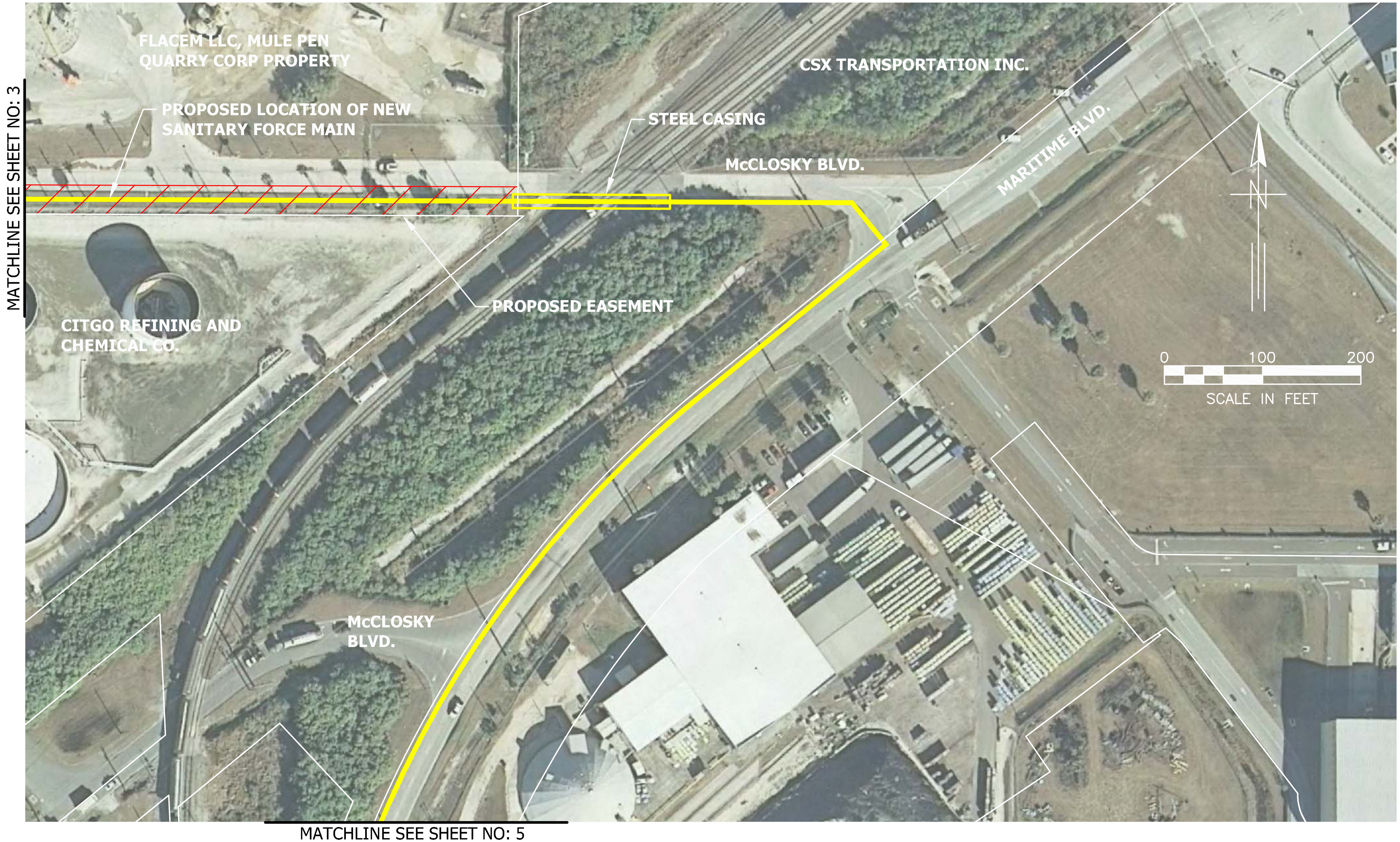

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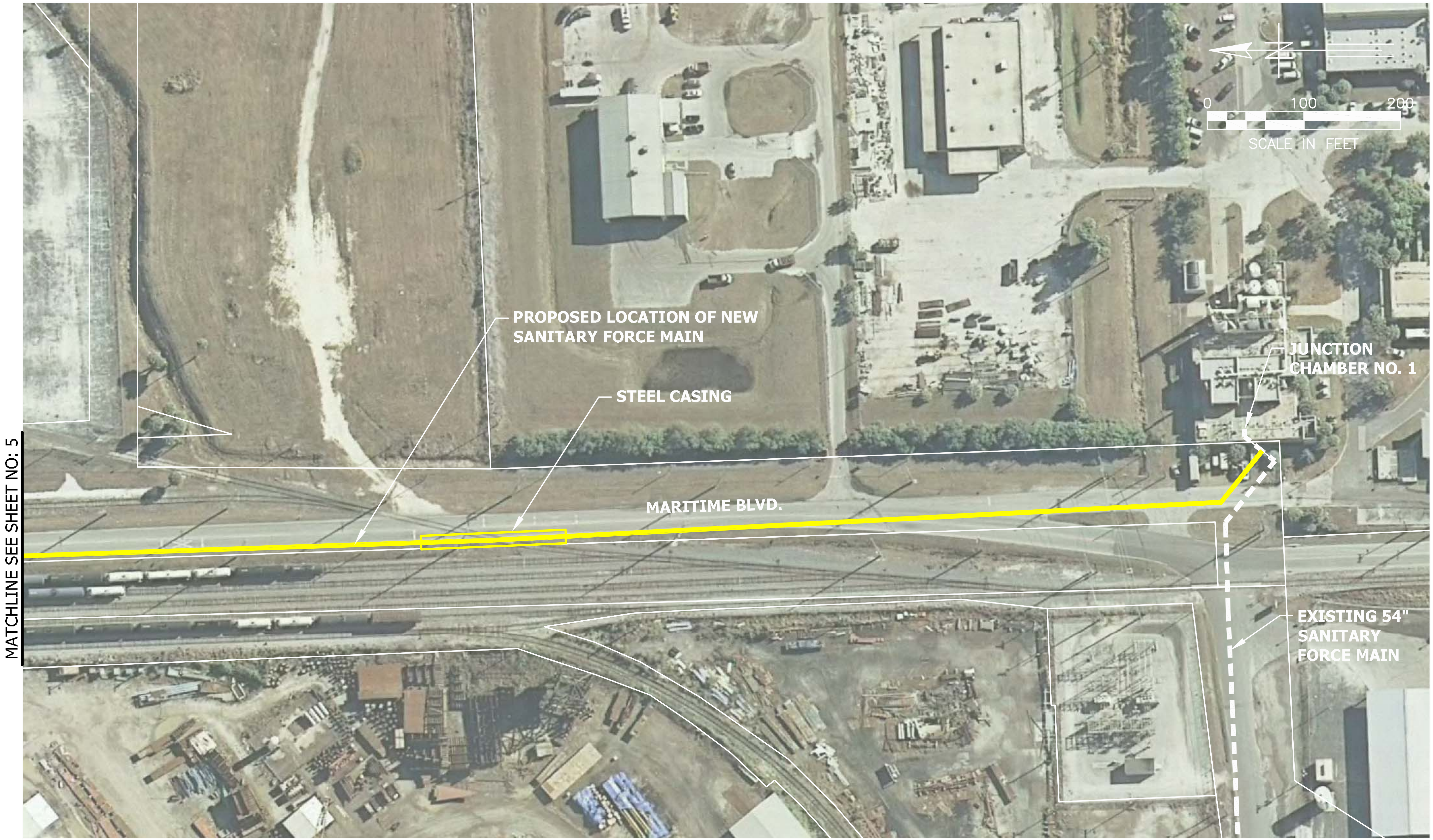
SHEET NO: 5



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SHEET NO: 6

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