To: **Erin Smith, PE**

From: **Andrew Augustine, PE**

CC: **Dan Matthies, PE; Cheng Soo, PE**

Date: **December 5, 2022**

Project Name: Chuck Corica Golf Course Drainage

Subject: Project Technical Memorandum

1 INTRODUCTION

The Chuck Corica Golf Course (Golf Course) is a municipally-owned 300 acre public golf course complex located in the City of Alameda on Bay Farm Island in the East Bay region of San Francisco Bay. It has been operating since 1927, with two 18-hole courses (North Course and South Course), a 9-hole par three course, and a driving range. See Figure 1.

The Golf Course's drainage is served by two sloughs, the West Slough and the East Slough. The sloughs collect untreated rainfall and irrigation runoff from the Golf Course, surrounding roads, residential neighborhoods, and shallow groundwater. The West Slough collects runoff from the western portion of the Golf Course, and from several storm sewers discharging runoff from residential neighborhoods adjacent to Fitchburg Avenue, Melrose Avenue, Flower Lane, and Maitland Drive. The East Slough collects runoff from the eastern portion of the Golf Course, and from Harbor Bay Parkway. No runoff from the Port of Oakland's property (east of Harbor Bay Parkway) enters the slough system. Both sloughs drain from south to north, ultimately discharging into a retention pond near State Highway 61 (Doolittle Drive), where it is pumped by two 60 horsepower pumps into the San Leandro Bay at the Golf Course Storm Drain Pump Station (Golf Course SDPS). See Figure 2 and Figure 3. Shallow groundwater keeps a constant depth of water in the downstream portions of the sloughs. This depth can range from between three to four feet in the northern (downstream) portion of the sloughs, to a few inches in the southern (upstream) portions. See Figure 4.

Over the past two years, reports of flooding in residential neighborhoods adjacent to the Golf Course have been brought to the attention of the City of Alameda (City) Public Works Department. Concerned citizens on Maitland Drive and Garden Road have observed a significant increase in the frequency of property flooding during rainfall events (Figure 5), while City crews have also observed frequent flooding on Harbor Bay Parkway (Figure 6), sometimes resulting in the closure of the street.

The Golf Course is currently leased to a third-party operator with defined maintenance responsibilities. This technical memorandum will not detail these maintenance responsibilities, but will instead focus on Wood Rodgers' (WR) investigation of the flooding and their proposed solutions.

Figure 1 – Vicinity Map

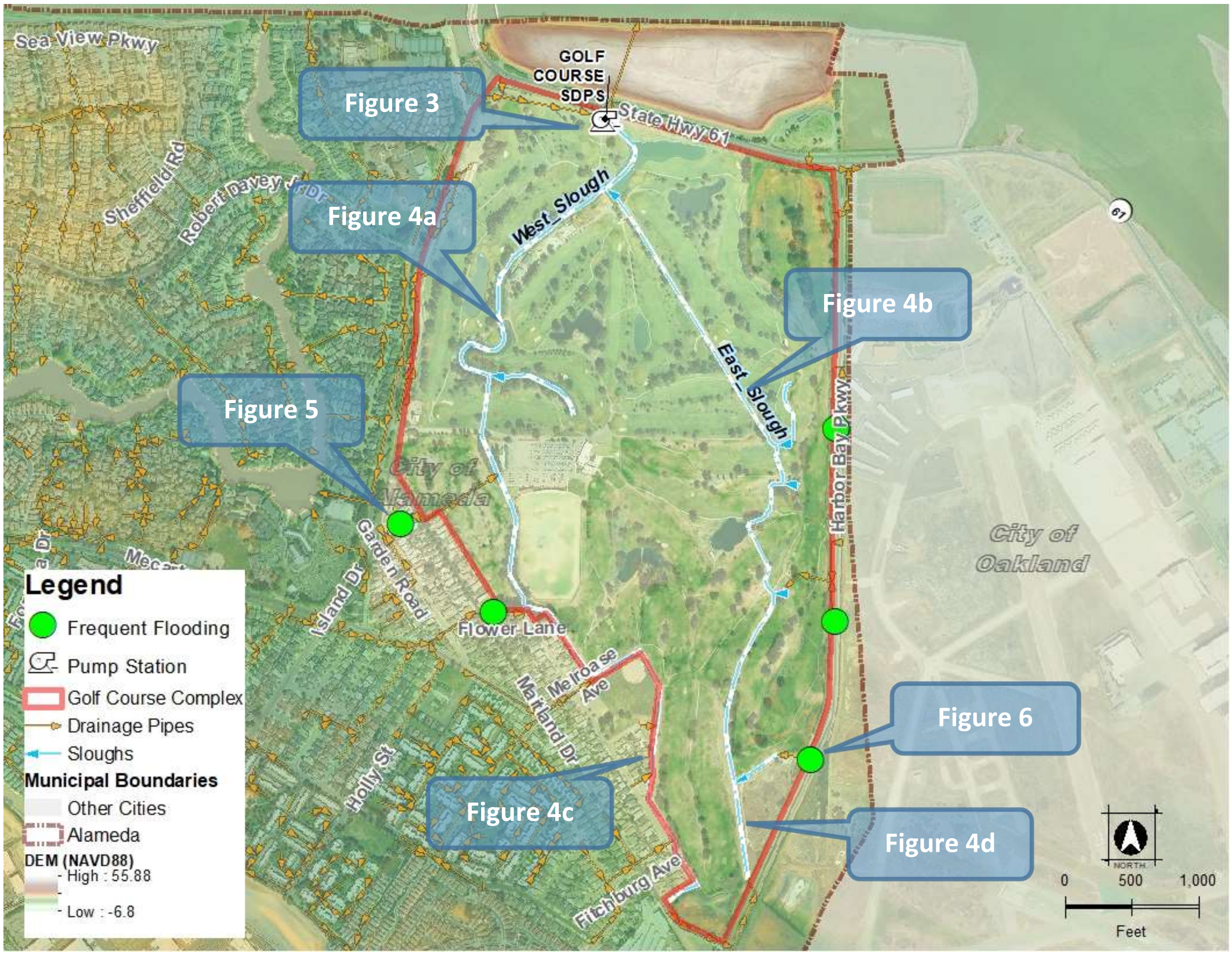
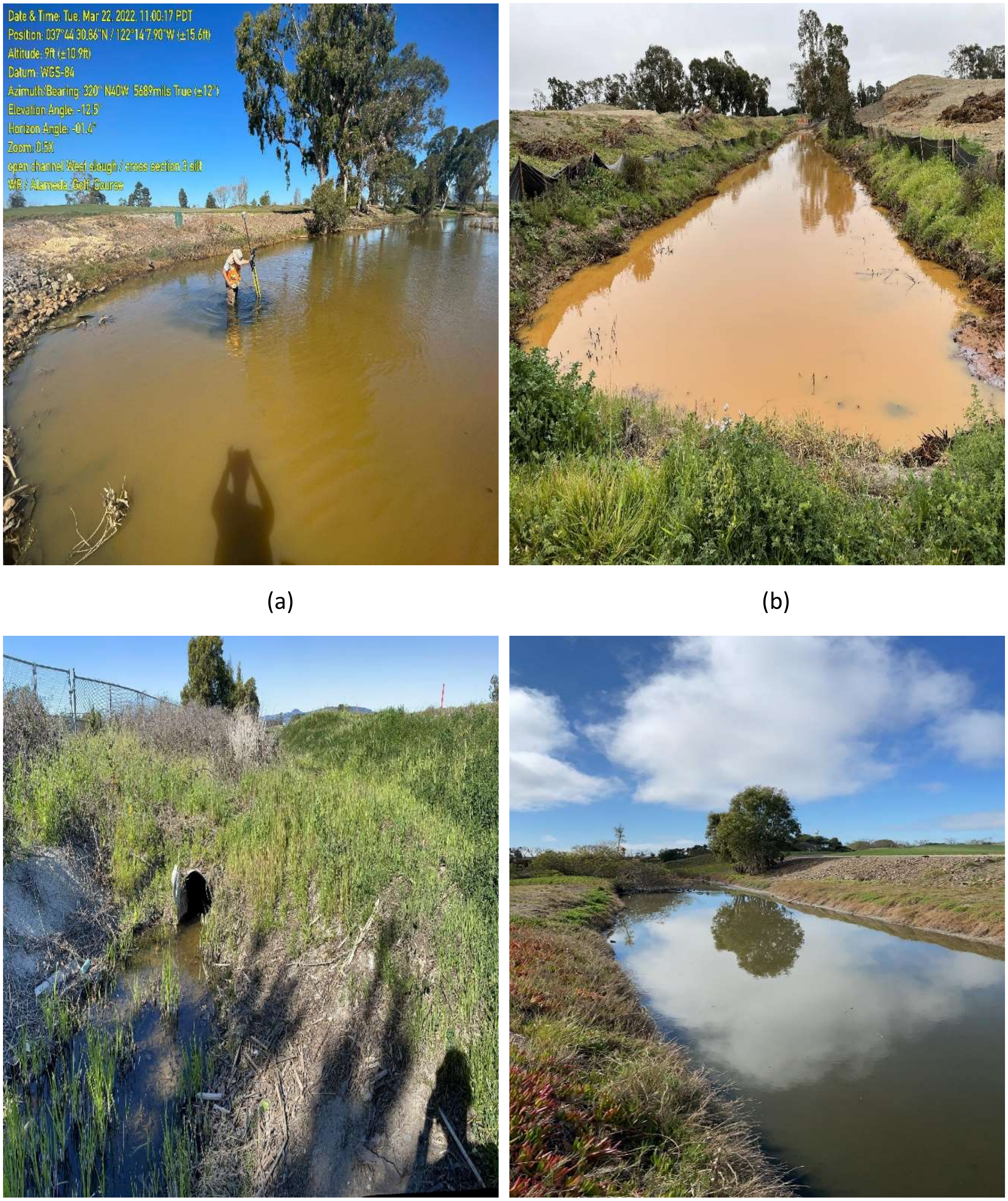


Figure 2 – Golf Course Drainage and System

Figure 3 – Golf Course SDPS



(a) (b)

(c) (d)

Figure 4 – Golf Course Drainage System Photos (a) Downstream West Slough (b) Downstream East Slough (c) Upstream West Slough (d) Upstream East Slough

Figure 5 – December 2021 Property Flooding at 3 Garden Road

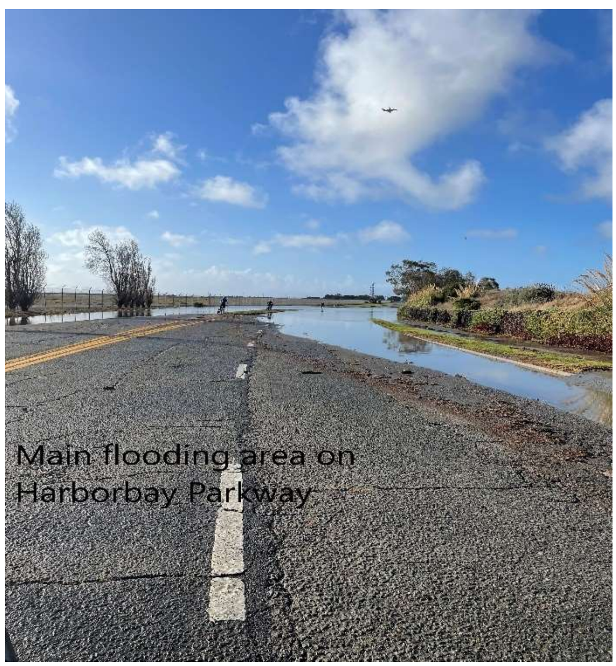


Figure 6 – December 2021 Flooding of Harbor Bay Parkway 1,500 feet North of Maitland Drive

2 PURPOSE

The purpose of this project is to:

1. Determine the probable cause of the frequent flooding reported by residents and City crews;
2. Propose maintenance activities and immediate action rehabilitation work to mitigate the frequent flooding;
3. Identify next steps to solidify flood mitigation.

3 BACKGROUND

Residents on Maitland Drive and Garden Road have stated they believe flooding on their properties during recent storms would not have occurred two or more years ago. This suggests a recent change to the storm sewer drainage system draining the area or to the downstream boundary conditions.

4 APPROACH

WR first requested information on the storm sewers and slough system to understand the unique drainage properties of the Golf Course and the surrounding residential neighborhoods.

Data describing the storm sewer infrastructure in the Golf Course, however, is limited. Therefore, information to fill these gaps was collected from three additional sources: staff interviews, field surveys, and condition assessments. To accomplish the purpose of this project the following approach was proposed:

1. Interview City and Golf Course staff. Each entity had firsthand knowledge of the flooding shown in Figure 2 - Figure 6, and can provide crucial information on the Golf Course drainage system. Desired information included field observations, operations and maintenance (O&M) logs, photos, and Golf Course construction history.
2. Conduct a field survey of missing drainage system assets. A field survey fills in the data gaps provided to WR by the City. A survey of drainage assets provides a complete picture of the Golf Course complex drainage. The survey collected information such as diameters, invert elevations, and material. Cross sections of the East and West Sloughs were also collected.
3. Conduct an in-depth, above ground, inspection of the Golf Course drainage system. An inspection was conducted to observe the structural and operational and maintenance conditions of the drainage assets (storm sewers, culverts, sloughs, Golf Course SDPS, etc.). Observations of structurally compromised assets, clogged assets, reduced slough capacity, or Golf Course SDPS reduced capacity were valuable information to help WR determine a probable cause of flooding.
4. Determine the probable cause of flooding with this information using engineering judgement.
5. Determine a solution to reduce flooding using engineering judgement.

5 PREVIOUS PROJECTS & STUDIES

5.1 1995 Channel Dredging

The City provided an asbuilt titled "*Drainage Improvements, Chuck Corica Municipal Golf Complex*" dated May 24, 1995. The asbuilt details a survey and proposed dredging to improve the West Slough, south of Clubhouse Memorial Road, and the northern half of the East Slough. See Figure 7.

The West Slough's survey included flow line and top of bank elevations. Typical sections were provided detailing the depth of dredging. See Figure 8. The East Slough's survey included top of bank elevations and typical dredging exhibits; no flow line elevations were provided. See Figure 9.

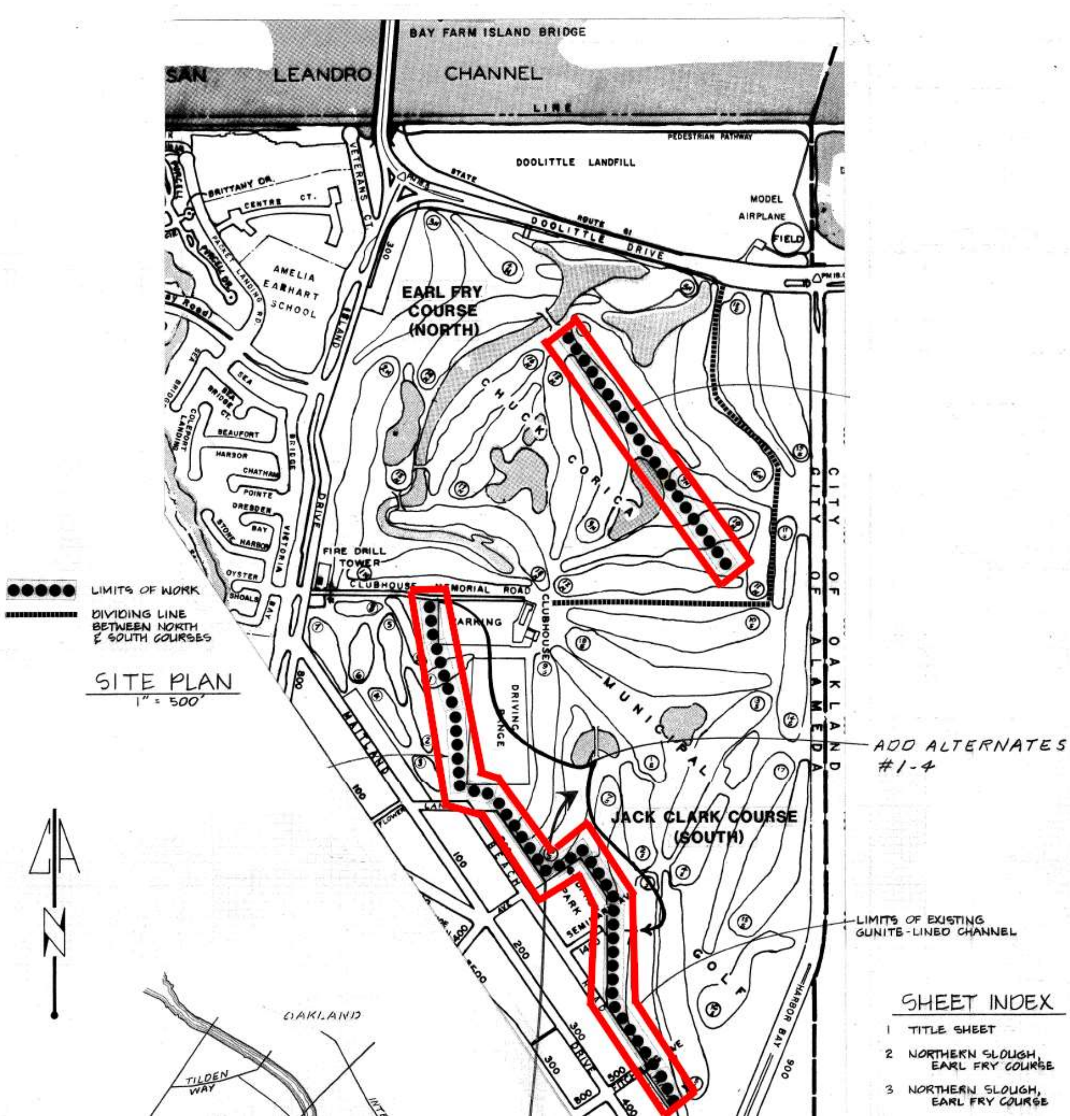


Figure 7 – Asbuilt "Drainage Improvements, Chuck Corica Municipal Golf Complex" Improvement Extents (red)

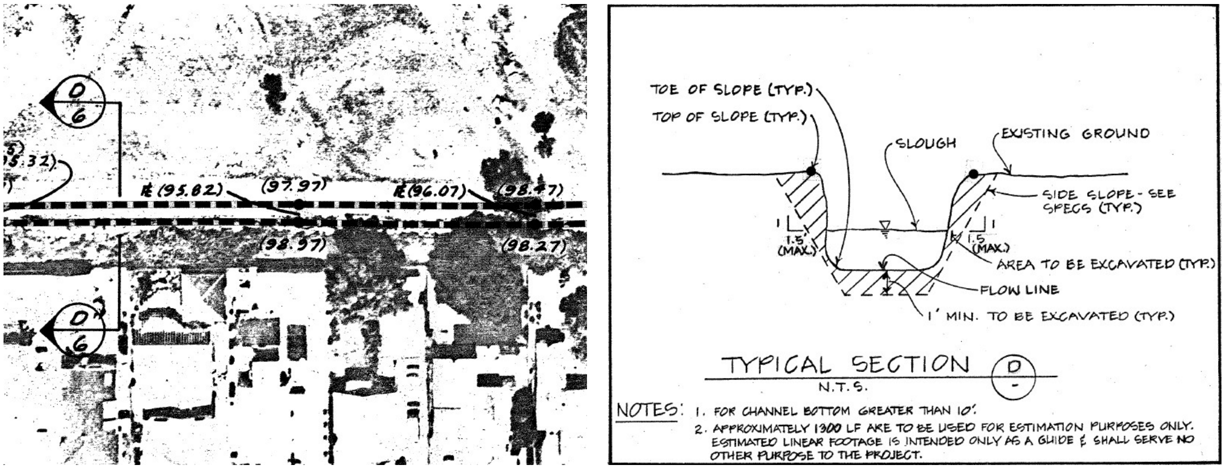


Figure 8 – Typical West Slough Bankline and Flow Line Elevation Callouts (Left) and Dredging Detail (Right)

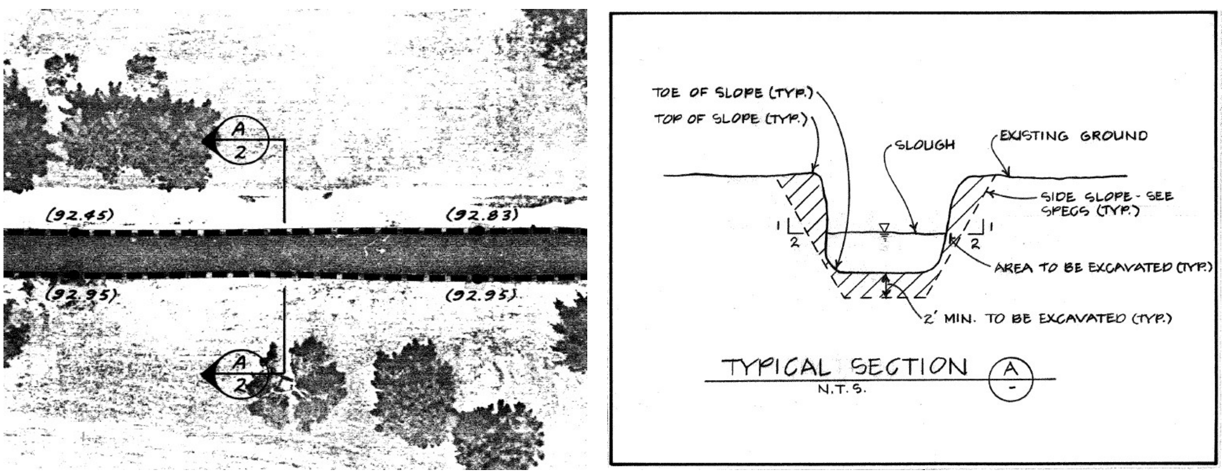


Figure 9 – Typical East Slough Bankline Elevation Callouts (Left) and Dredging Detail (Right)

5.2 City of Alameda Groundwater Study

In September 2020, Silvestrum Climate Associates detailed the effects of sea-level rise on the City's shallow groundwater and contaminants in a report titled "*The Response of the Shallow Groundwater Layer and Contaminants to Sea Level Rise*". Pertinent information from the report to this study include detailed graphs of depth to groundwater at various locations across the City observed over the past 17 years (Figure 10), and project the impact of sea-level rise on the shallow groundwater (Figure 11).

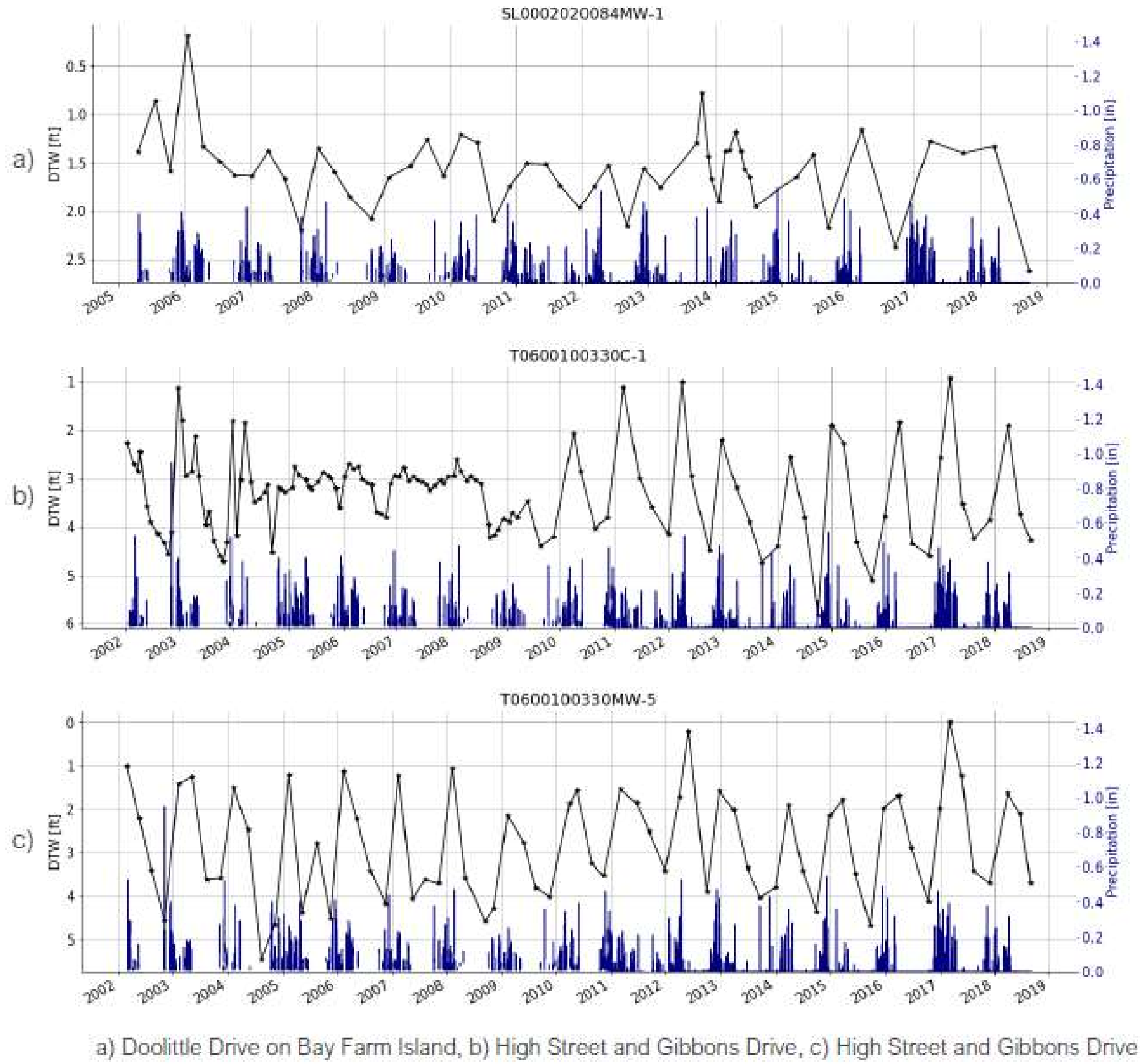


Figure 10 – Depths to Groundwater Over Time at Various Locations in the City (black) with Precipitation (blue)

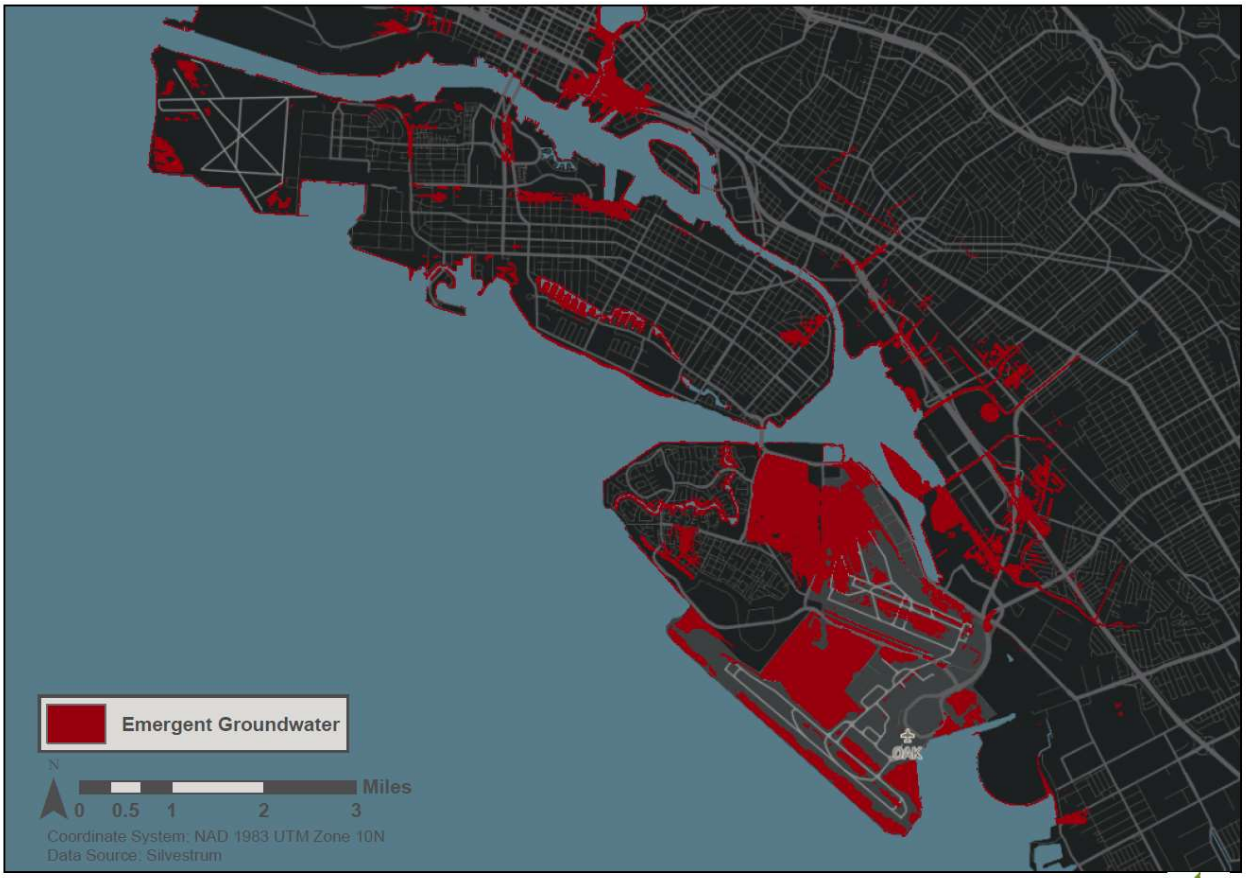


Figure 11 – Shallow Groundwater with 12" of Sea-Level Rise

6 DATA COLLECTION

Requested data included an inventory of the City's drainage system (storm drains, culverts, manholes, pump stations, etc.), logs of the City's maintenance activities, asbuilts, and plan sets. The City provided information they had, including an ArcGIS Geodatabase of their drainage system, asbuilts and plan sets pertinent to the Golf Course drainage, and a verbal discussion of their typical drainage system maintenance activities. These data were comprehensive in areas outside of the Golf Course complex, however, there was little to no data inside. Several locations along the sloughs had no information describing the drainage system. Furthermore, maintenance activities on drainage assets inside the Golf Course complex was unknown.

6.1 Staff Interviews

6.1.1 Erin Smith & Manny Rios

Erin Smith is the Public Works Director for the City of Alameda, and Manny Rios is the Public Works Supervisor for the City of Alameda. Both Erin and Manny were interviewed on February 14, 2022, and shared the following information:

1. Manny stated there are two pipes from the Port property that enter the Golf Course.
    a. Update – When Manny and his crew investigated the City's storm sewers in March of 2022 on Harbor Bay Parkway, he determined no storm sewers from the Port enter the Golf Course.
2. The North course is still under construction.
3. The Maitland storm sewer system is cleaned once a year prior to the wet season. It was inspected with CCTV about three years ago. Nothing wrong with the storm sewer was observed.
4. Manny's crew observed the Golf Course SDPS turning off during the December 2021 storm when Harbor Bay Parkway was still flooded.
5. Manny's crew observed a chokepoint in the slough system at the culvert draining into the pump station retention pond from the east slough. There is a noticeable sinkhole in the culvert. Crew observed water backing up on the upstream side, but water was barely trickling out of the culvert at the downstream side. Marc Logan, the Golf Course Maintenance Supervisor, has informed the City the sink hole will be fixed in May or June of 2022.
6. A picture of the Harbor Bay flooding was provided to WR. It was taken the day after the rainfall event in December 2021. Manny stated it took approximately 3 days to drain.
7. Resident complaints on Maitland Drive started approximately 3 – 5 years ago.
8. City would like the following big-picture questions answered: "Were the sloughs designed to have water in them at all times?", "Should the City drain the sloughs in the winter?" and "Do the sloughs have enough capacity?"
9. Manny's crew, when verifying a storm system, verifies the manholes, pop the manholes or inlets, and verifies flow directions.

10. WR requested Manny, when draining culverts/pipes, to observe sediment depths and water surface elevations.
11. Manny said there has been flooding on Flower Lane, but no property damage.

6.1.2 Marc Logan – Golf Course Maintenance Supervisor

Marc Logan worked at the Golf Course from September of 2012 to April of 2022 and has intimate knowledge of its drainage system. Marc was interviewed on March 1, 2022 by Andrew Augustine of WR, with Erin Smith and Emanuel Rios from the City in attendance. Marc shared the following information:

1. Marc observed flooding at Harbor Bay Parkway and Ron Cowan Parkway in the December 2014 event.
2. In general, a storm event less than 3 inches does not cause flooding issues.
3. In general, runoff takes 24 – 48 hours to move through the system.
4. Marc observed Maitland Drive flooding in winter of 2014, 2018 and 2021. Observed the sloughs were at capacity.
5. Marc has not observed a noticeable chokepoint within the sloughs.
6. In August of 2021, the City drew down the system using the Golf Course SDPS. Within 60 hours the system was back to its previous conditions. Marc estimates 12 acre-feet came back into the system after pumping.
7. The Golf Course SDPS is turning on during summer months.
8. Observes Golf Course SDPS pumping continuously, not intermittently during storms.
9. Renovations to the Par 3 course started September 2013, ended May 2014. Renovations to the south course started December 2014, ended June 2018. Renovations to the north course started mid July 2018 and are ongoing.

6.2 Field Survey

On March 22 and March 23 of 2022, staff from WR conducted a field survey of the Golf Course storm system. A Global Positioning System (GPS) survey and spot inspections with a three-person crew consisting of two experienced engineers and a licensed surveyor was performed. The process recorded spatial locations, elevations, and storm drainage facility types. RTK (Real-Time-Kinematic) GPS surveying was used, which uses a network of satellites that communicate with receivers on the ground to determine the horizontal coordinates (x, y) and elevations (z). The surveying method provides a horizontal and vertical accuracy up to 0.1 feet. The field inspector or engineer utilized several standard inspection tools to document pipe/structure information (diameter, shape, material, depth, etc.).

6.3 Condition Assessment

In conjunction with the field survey, a condition assessment was conducted. A condition assessment is a technical assessment of the data collected in Section 6.2. The assessment provides standard ratings of the structural and maintenance conditions of the inspected facilities and the corresponding rehabilitation and replacement recommendations. The Environmental Protection Agency's (EPA) "*Asset Management Handbook*" and the National Association of Sewer Service Companies (NASSCO) *Pipeline Assessment Certification Program (PACP)* condition grading systems guidelines were used to provide a standard condition rating system for each facility.

Experienced inspectors assessed the pipe/structure conditions, and record any observed performance issues (plugging, erosion, sedimentation, overtopping, etc.). The inspection tools include electronic devices (digital tablets, GPS enabled cameras, and manhole inspection cameras), measurement devices (sediment probes and steel or vinyl tape measures), and standard access tools (manhole picks, sledgehammers, ratchet and sockets, and bolt hole alignment tools). The digital tablet is loaded with the ArcGIS Survey123 application to aid the inspection. Survey123 allows the inspector to take geo-located photographs, and asses the structural and O&M deficiencies of the asset, as shown in Figure 12. A typical inspection setup is displayed in Figure 13.

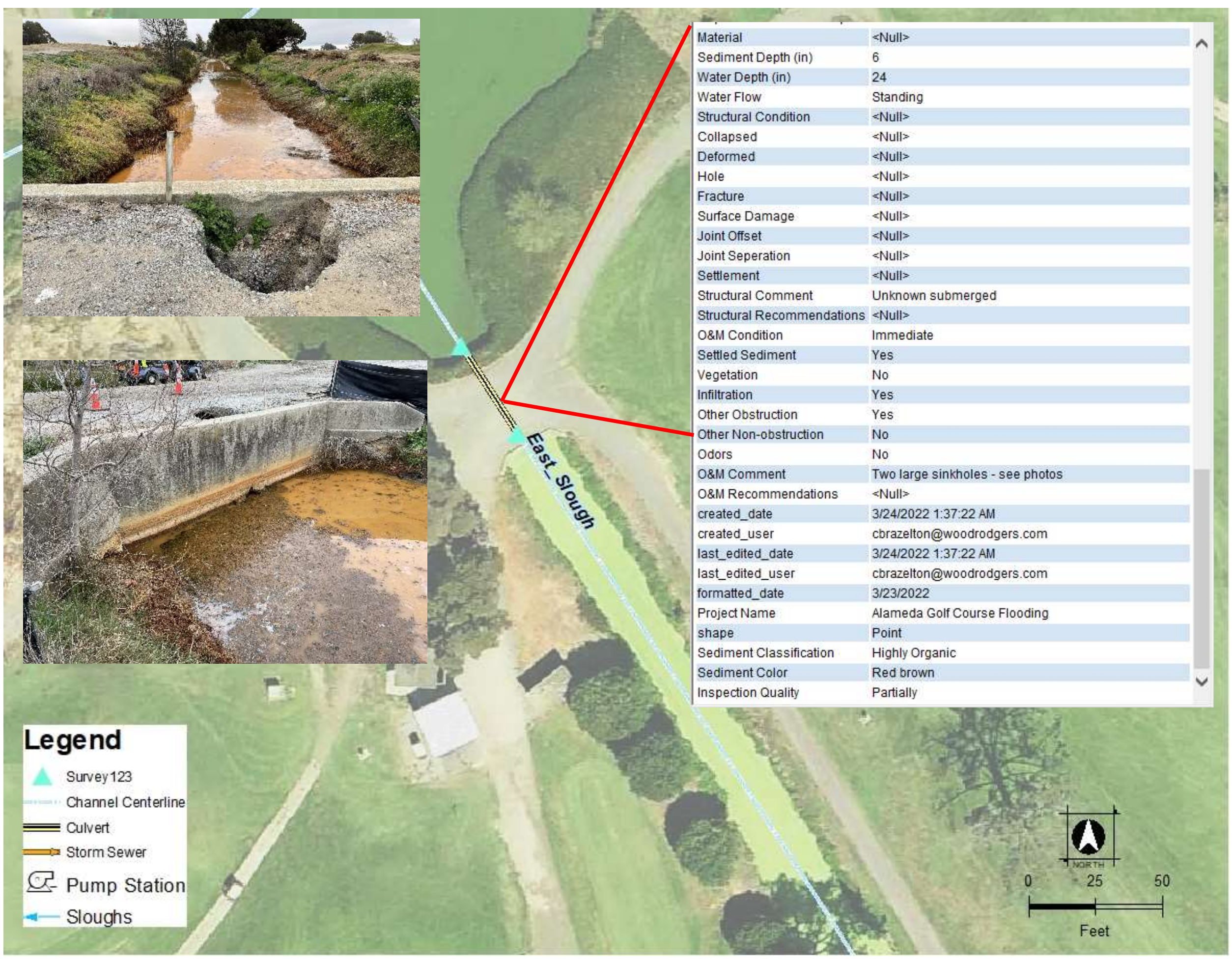


Figure 12 – Example of Survey123 Application for Structural and O&M Deficiencies

Figure 13 – Typical Inspection Setup

7 RESULTS

Information gathered in Section 6 was processed and described below.

7.1 Survey Results

Survey data of the Golf Course's storm sewer system was post-processed into a GIS GeoDatabase. Surveyed assets were built into a featrueclasses, such as storm sewers, culverts, and channel centerlines. Additional information such as diameter, invert, and material were populated into the asset's attribute table, as shown in Figure 14. A summary of all surveyed locations is shown in Figure 15.

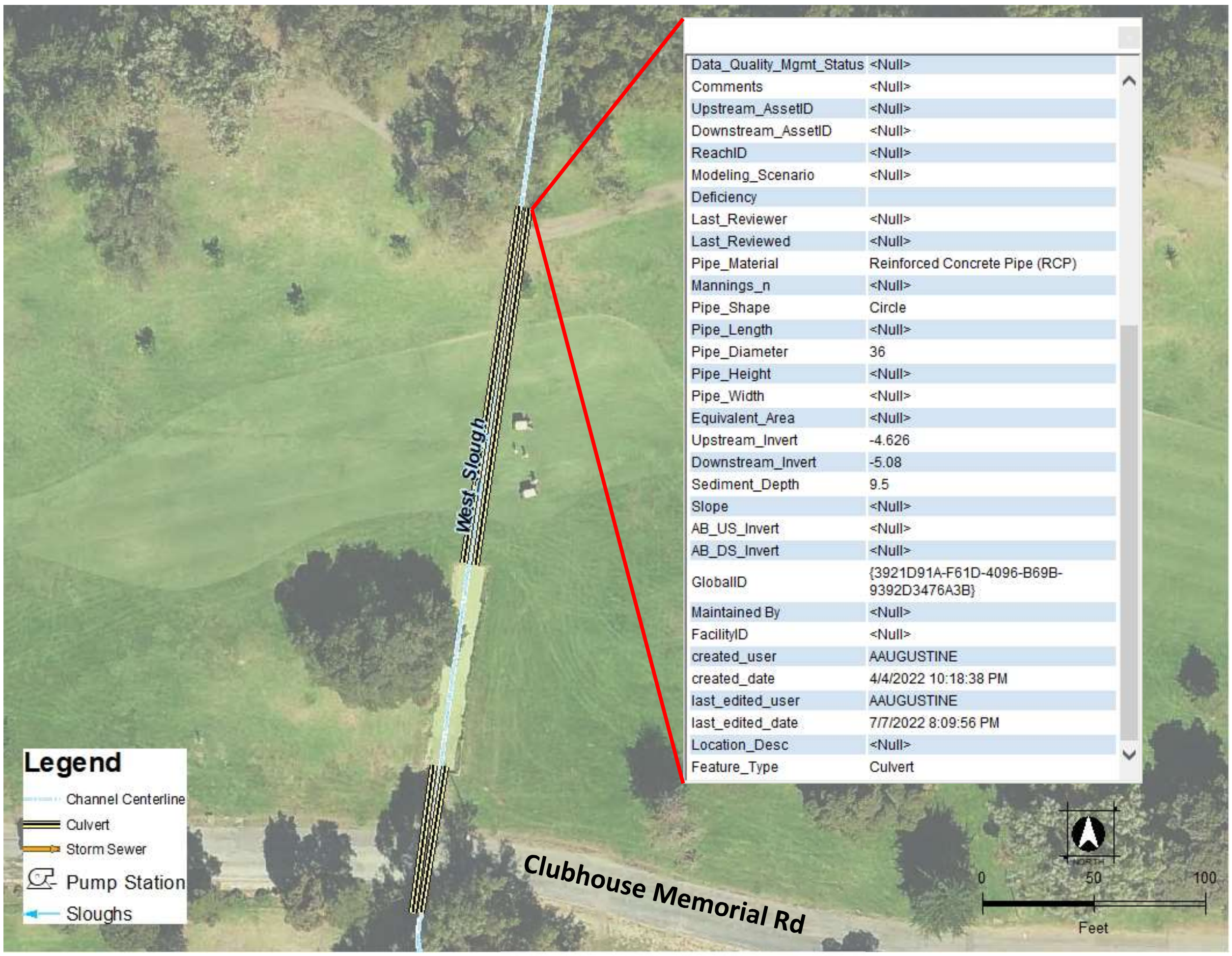


Figure 14 – Surveyed Culvert with Attributes

Figure 15 – Survey Locations

Profiles of the East and West Sloughs was created to display the existing slough centerline, culverts, storm sewers discharging into the sloughs, and the 1995 slough centerline as described Section 5.1. Profiles for the East and West Slough is in Appendix A.

7.2 Condition Assessment Results

Information gathered using the Survey123 application was used to inventory the structural and O&M deficiencies of the Golf Course storm sewer system. For each storm sewer asset, comments regarding the structural integrity and the O&M condition were provided. Geo-located pictures of the asset were also taken. All assets examined for structural deficiencies are shown in Figure 16. Those assets assigned a "poor" rating are called out in the figure. Similarly, all assets examined for O&M deficiencies are shown in Figure 17 and Figure 18. Those assets assigned an "immediate" rating are called out in the figures.

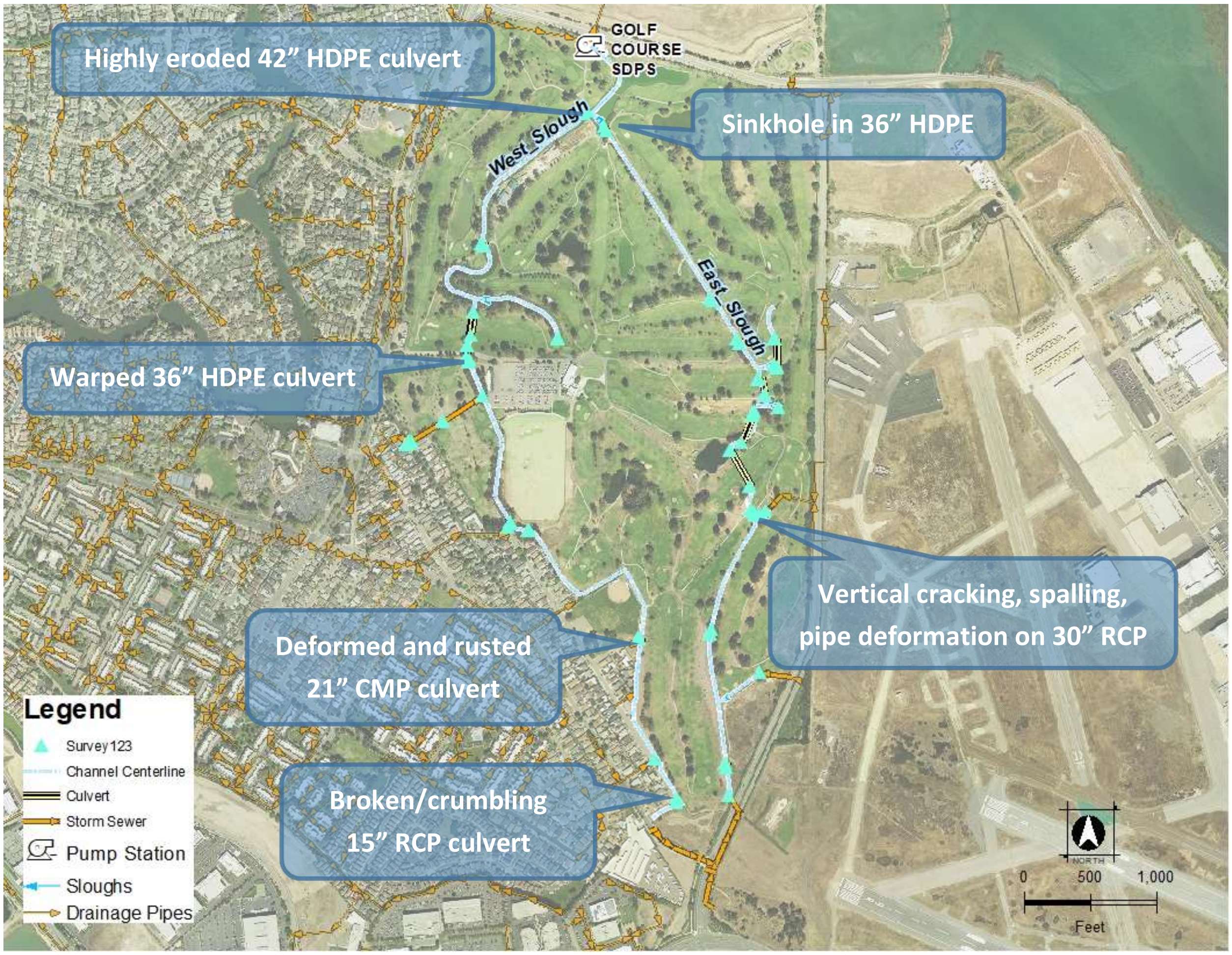


Figure 16 – Survey123 Structural Assessment Locations (Poor Condition Rating Called Out)

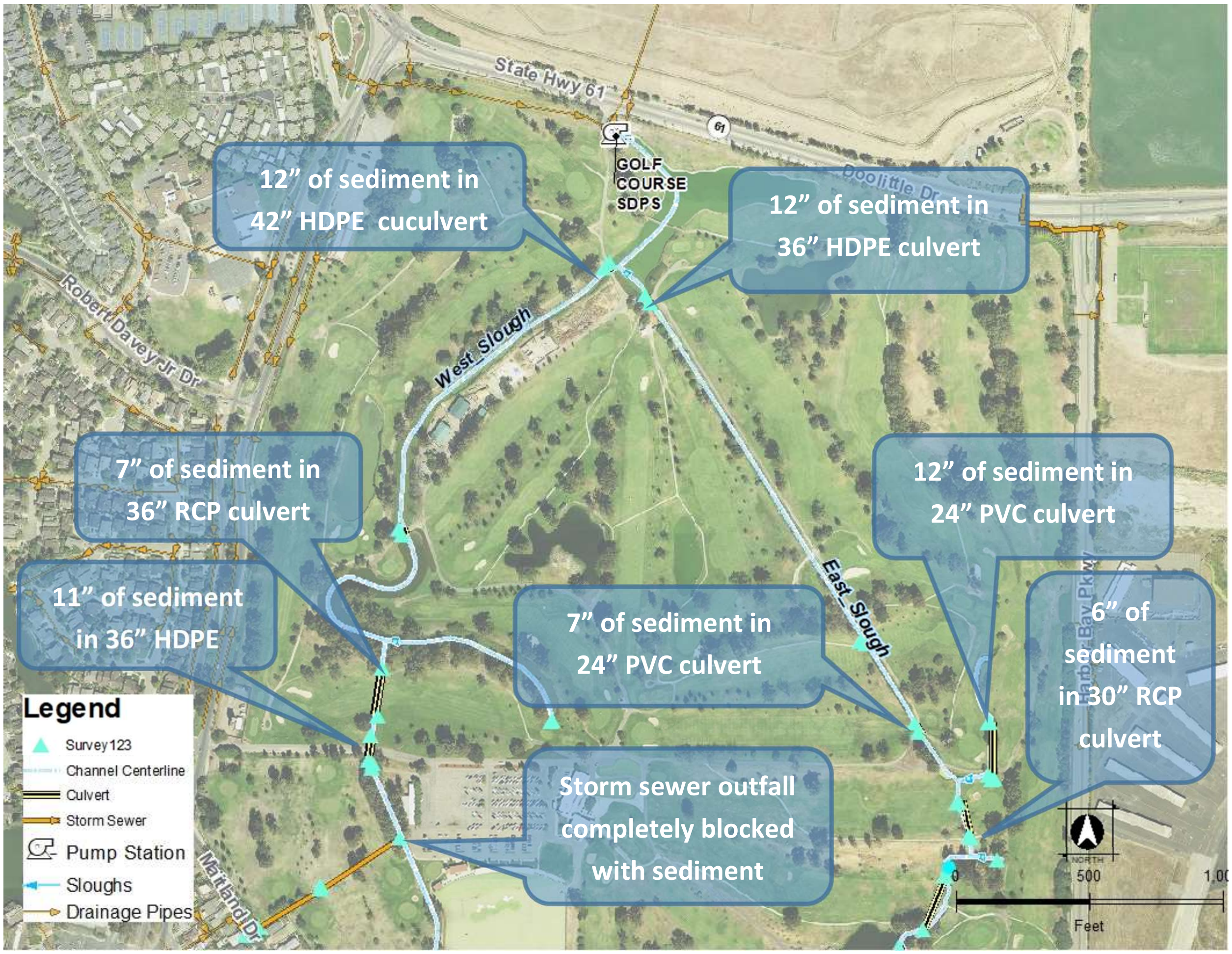


Figure 17 – Survey123 O&M Assessment Locations - North (“Immediate” O&M Condition Rating Called Out)

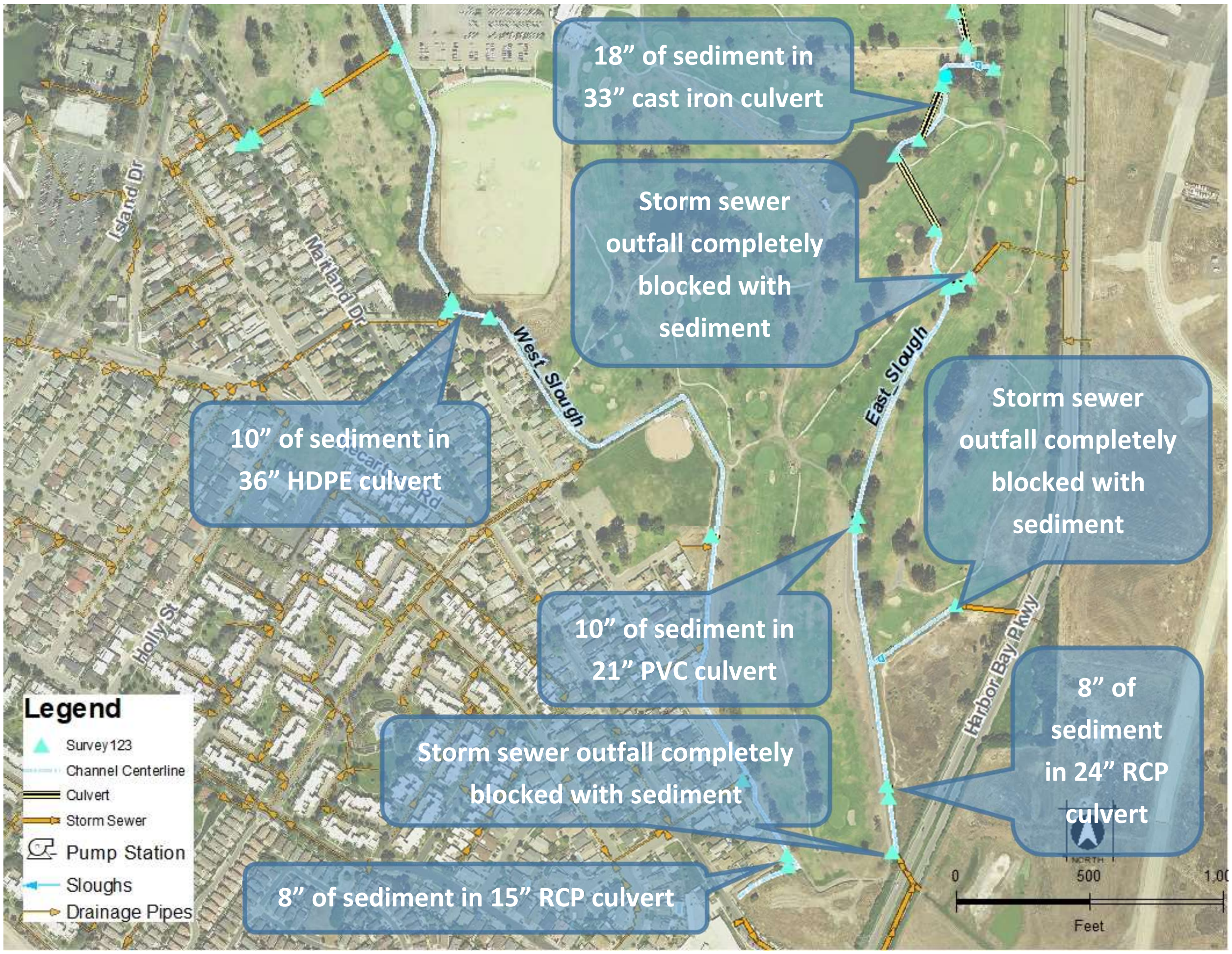


Figure 18 – Survey123 O&M Assessment Locations - South (“Immediate” O&M Condition Rating Called Out)

8 DISCUSSION

By analyzing the data collected in Section 6 and the results in Section 7, it appears likely that flooding witnessed on Maitland Drive and Harbor Bay Parkway was caused mostly by accumulated sediment in the system.

The sloughs are prone to sediment collecting at the bottom of the channel due to multiple low points in the slough's profile (Appendix A), and standing water caused by backwater from the Golf Course SDPS (Figure 4). Referencing the 1995 slough dredging plan (Section 5.1) and Appendix A, approximately 1.5 ft – 2 ft of sediment has accumulated in the sloughs over the past 27 years.

Sedimentation effects the ability of the Golf Course storm sewer system to drain runoff to the Golf Course SDPS in three ways: reducing the slough's hydraulic capacity, reducing the hydraulic capacity of the slough's culverts, and blocking storm sewer outfalls discharging into the sloughs.

Sediment accumulation in the slough decreases its hydraulic capacity, reducing the quantity of runoff it can safely drain to the Golf Course SDPS. The reduced capacity causes higher hydraulic grade lines (HGL), which can back up into storm sewer systems draining into the sloughs. Low-lying areas draining to the Golf Course sloughs are particularly susceptible. The storm sewer system draining the Maitland Drive neighborhood has approximately 2 feet of elevation difference to the slough's bank. The slough's higher HGLs can reduce Maitland Drive's ability to drain into the sloughs.

As shown in Figure 17 and Figure 18, sedimentation accumulated inside the slough's culverts, reducing the hydraulic capacity by 20% to 50%. This has a similar effect as the reduced slough capacity described above. HGLs upstream of the culvert will increase, potentially affecting low-lying areas adjacent to the culvert.

Storm sewers draining residential and street drainage from Maitland Drive and Harbor Bay Parkway were observed to be partially or completely blocked with sediment at their outfall to the Golf Course sloughs. Figure 19 shows the location of the outfalls, while Figure 20 show their images (Images in Figure 20 were taken after exploratory excavation by City staff in early March of 2022. The drawn red line shows the approximate level of sediment prior to excavation). The ability of the outfall to discharge the runoff collected by storm sewers upstream is severely reduced by the sediment. Observations by City staff of the ponding on Harbor Bay Parkway draining in 3+ days is explained by Figure 20 (b), (c), and (d). The runoff cannot get into the sloughs because the sediment blocking the outfall.

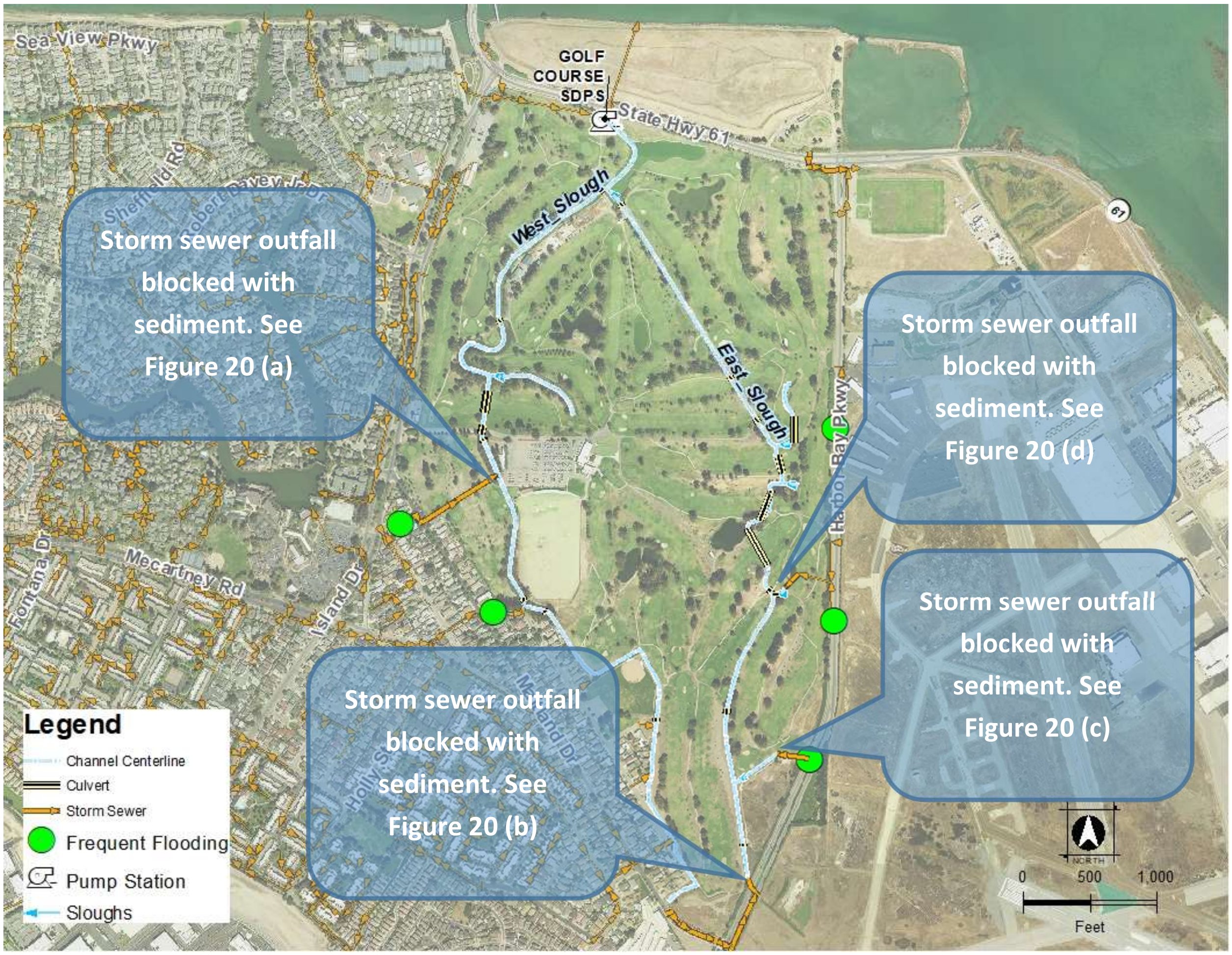


Figure 19 – Locations of Storm Sewers Outfalls Blocked with Sediment

(a) (b)

(c) (d)

Figure 20 – Images of Storm Sewer Outfalls Blocked with Sediment (Red Line Shows Approximate Level of Sediment Prior to Excavation)

To a lesser extent, other factors such as groundwater and structurally compromised assets contribute to the Golf Course storm system's flooding. The 2020 groundwater report published by Silvestrum Climate Associates (Section 5.2) concluded the City is highly susceptible to shallow groundwater. Figure 21, taken from their report, shows the depth to shallow groundwater adjacent to Doolittle Drive on Bay Farm Island can range between 0.5 feet and 2.5 feet, depending on the time of year. Any location in the slough with a depth larger than 2.5 feet below its bank will most likely experience groundwater intrusion throughout the calendar year. In fact, water surface elevations measured in the field were shown to be within the depth tolerance of Figure 21, concluding the standing water observed in the northern portion of the sloughs is most likely from shallow groundwater intrusion. The consequence of groundwater draining into the sloughs is that the capacity is further reduced. Groundwater is occupying hydraulic capacity and storage which, if not present, could be used to convey and store storm runoff.

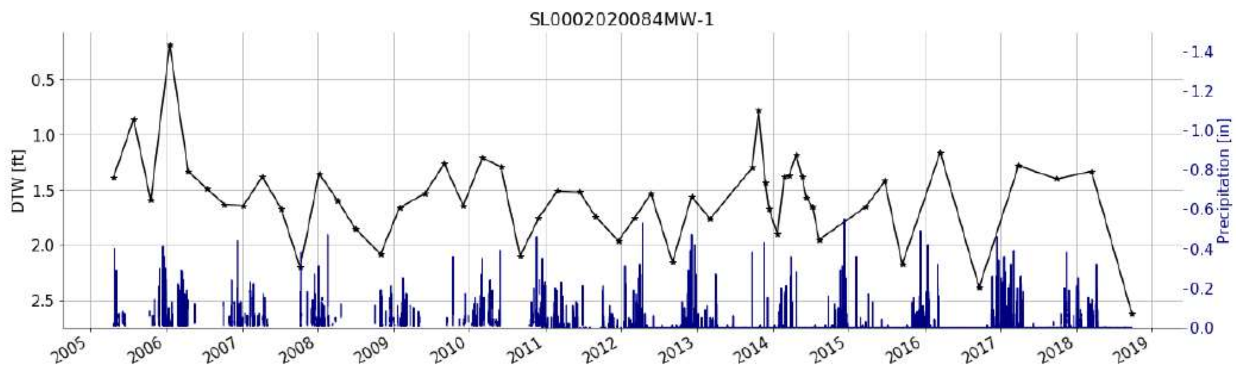


Figure 21 – Depth to Groundwater (DTW) at Doolittle Drive on Bay Farm Island[1]

Lastly, several slough culverts were observed to have structural deficiencies (Section 7.2). Sinkholes and deformations reduce a culverts hydraulic capacity resulting in increased HGLs upstream. See Figure 22. Spalling concrete and rusting corrugated metal pipes can result in a complete failure of the culvert, resulting in sinkholes and increased upstream HGLs.

[1] City of Alameda, The Response of the Shallow Groundwater Layer and Contaminants to Sea Level Rise, September 2020, Silvestrum Climate Associates

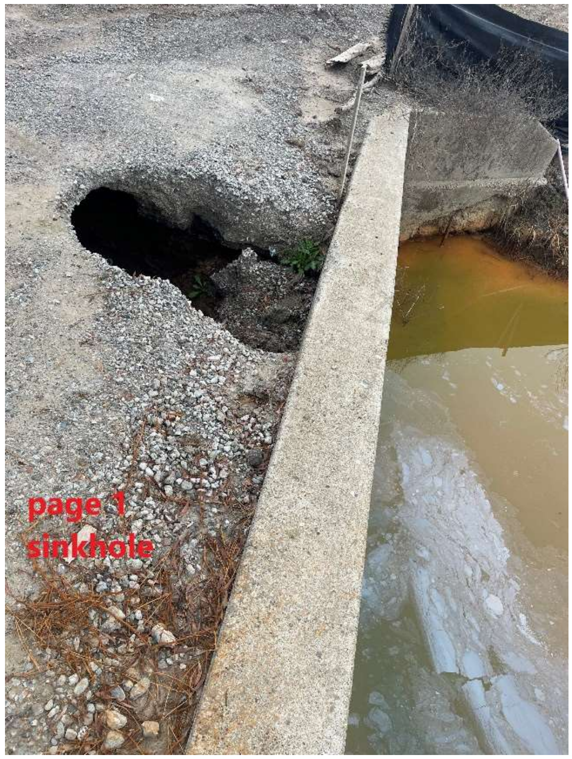


Figure 22 – Sinkhole in 36" PVC Culvert Just Upstream of the Golf Course SDPS Retention Pond on the East Slough

9 RECOMMENDATIONS

The following recommendations were made to reduce the flooding observed on Maitland Drive and Harbor Bay Parkway.

Immediate actions will help alleviate flooding, but the reduction cannot be quantified. Next step actions include the construction of a hydrologic and hydraulic (H&H) model, which can be used to quantify the near-term recommendations and other potential solutions.

Immediate actions (in order of importance):

1. Remove sediment blocking the outfalls of storm sewers discharging into the sloughs. In March of 2022, City crews have already completed this task, but it is stated in this report to signify its importance.
2. Remove sediment from slough culverts. As shown in Figure 17 and Figure 18, several slough culverts have significant sediment accumulation, reducing its conveyance capacity from 20% to 50% less than design capacity. Removing the sediment will allow runoff to drain through the culverts in a more hydraulicly efficient manner, thus reducing the HGL upstream.
3. Lower the Golf Course SDPS "pump-on" elevation. As stated in Section 8, groundwater drains into the sloughs, reducing its hydraulic capacity. Lowering the pump-on elevation will continuously pump the groundwater out of the sloughs, leaving more conveyance and storage for runoff during storm events. This new pump station operation can be seasonally implemented in the winter, or before known rainstorms. During summer months, the pump station can be operated as it is now to keep standing water in the sloughs for aesthetic purposes.
4. Repair structurally compromised culverts. Like sediment-filled culverts, structurally compromised culverts have a reduced hydraulic capacity. It is recommended culverts called out in Figure 16 be replaced or repaired.
5. Install duck-billed flap gates at outfalls of storm sewers discharging into the sloughs. The flap gates will prevent sediment from collecting inside City-owned storm sewers, reducing the annual maintenance of the asset.

Next step actions:

6. Develop a H&H model of the Golf Course storm system. An H&H model is beneficial because it can be used to:
    a. Quantify the benefits of the immediate action recommendations (1-5). Immediate action recommendations will alleviate the existing flooding extent but won't be able to quantify the benefit or reduction without an H&H model.
    b. Verify slough dredging. The H&H model would quantify the amount of dredging required to keep HGLs low enough to not effect adjacent low-lying areas and storm sewer systems.
    c. Develop a long-term maintenance plan. An H&H model can simulate the reduction of slough and culvert conveyance by sedimentation and recommend a maintenance plan to avoid flooding.

   d. Develop Golf Course storm system improvements to reduce maintenance activities and increase flood protection. Examples of improvements include, but not limited to: larger pump station, paved sloughs, wider sloughs, bypass pipe system to the pump station, and identify locations to elevated the outfall of storm sewers discharging into the sloughs.

7. Determine the impacts of sea-level rise. According to the September 2020 groundwater report by Silvestrum Climate Associates, sea-level rise will have a direct impact on the City's shallow ground water. Sea level rise would increase the amount of ground water flowing to the Golf Course SDPS and reduce its efficiency due to increased water surface elevations in San Leandro Bay. Predicted groundwater elevations can be coupled with the H&H model to assess the impacts and the necessary mitigation.

City of Alameda
Chuck Corica Golf Course

Slough Stationing

Alameda County, California
July 2022

Legend

- Channel Centerline
- Culvert
- Storm Sewer
- Pump Station

NORTH

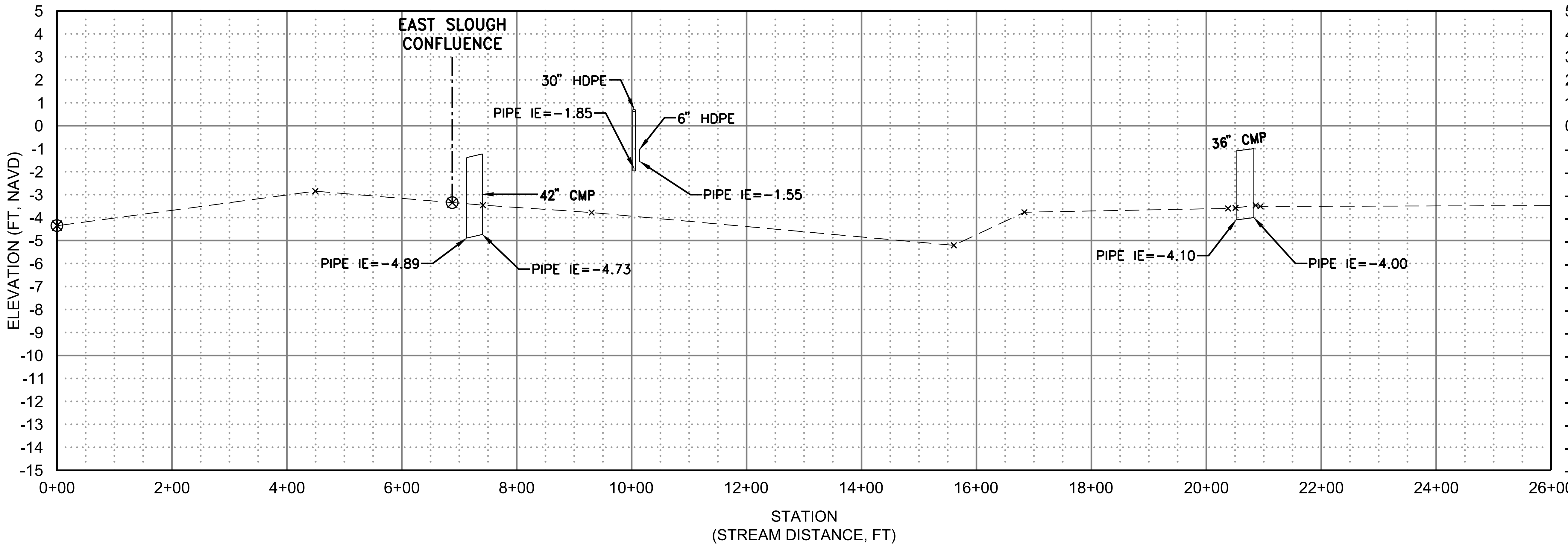
0 500 1,000
Feet

PRELIMINARY

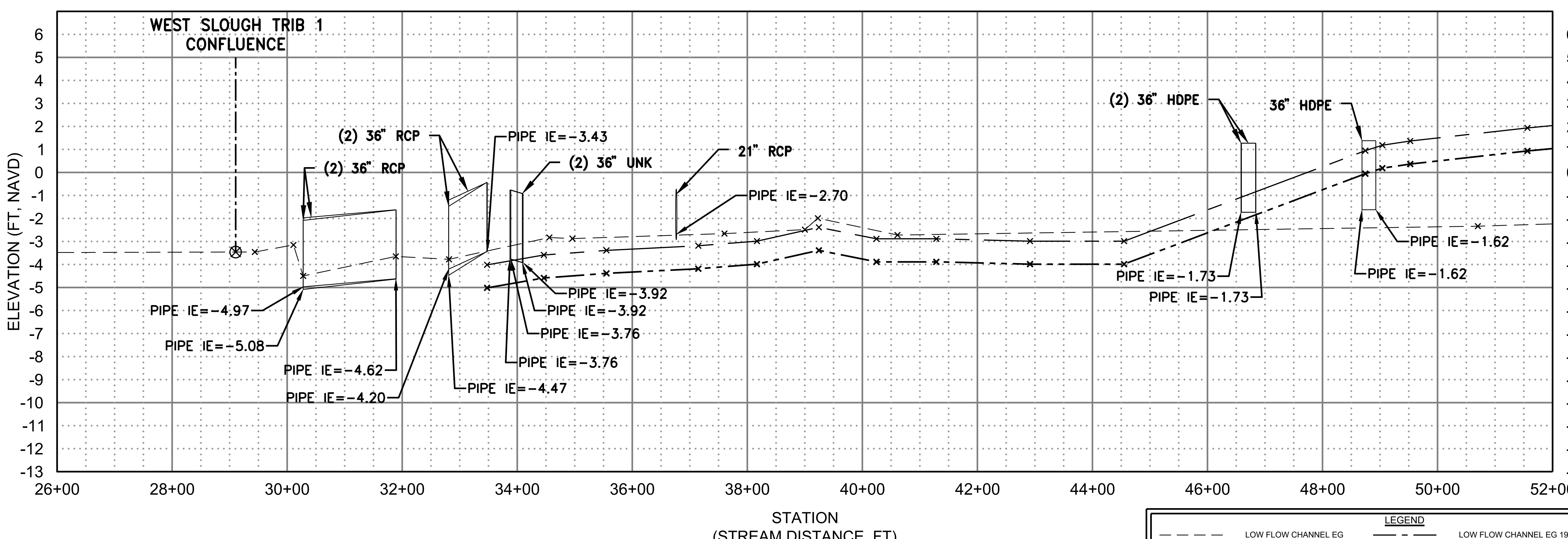
Appendix A

WOOD RODGERS

WEST SLOUGH STA 0+00 TO STA 26+00



WEST SLOUGH STA 26+00 TO STA 52+00



LEGEND

LOW FLOW CHANNEL EG
LOW FLOW CHANNEL FG
LOW FLOW CHANNEL EG 1995
LOW FLOW CHANNEL FG 1995
× SURVEY POINT LOCATION

WOOD RODGERS
BUILDING RELATIONSHIPS ONE PROJECT AT A TIME
3301 C ST, BLDG. 100-B TEL 916.341.7760
SACRAMENTO, CA 95816 FAX 916.341.7767

CHUCK CORICA GOLF COURSE

WEST SLOUGH PROFILE

ALAMEDA COUNTY CALIFORNIA

DATE: 05/31/2022

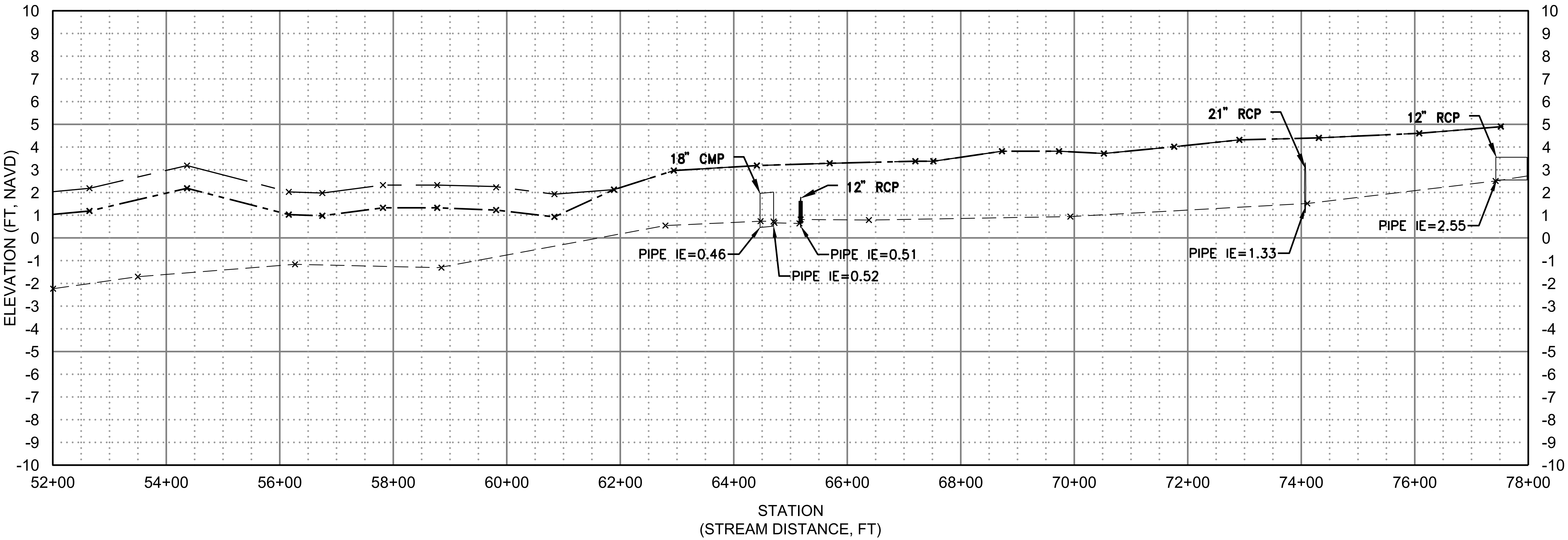
SCALE: VERT: 1" = 5' HORIZ: 1" = 200'

PROJECT NO: ----

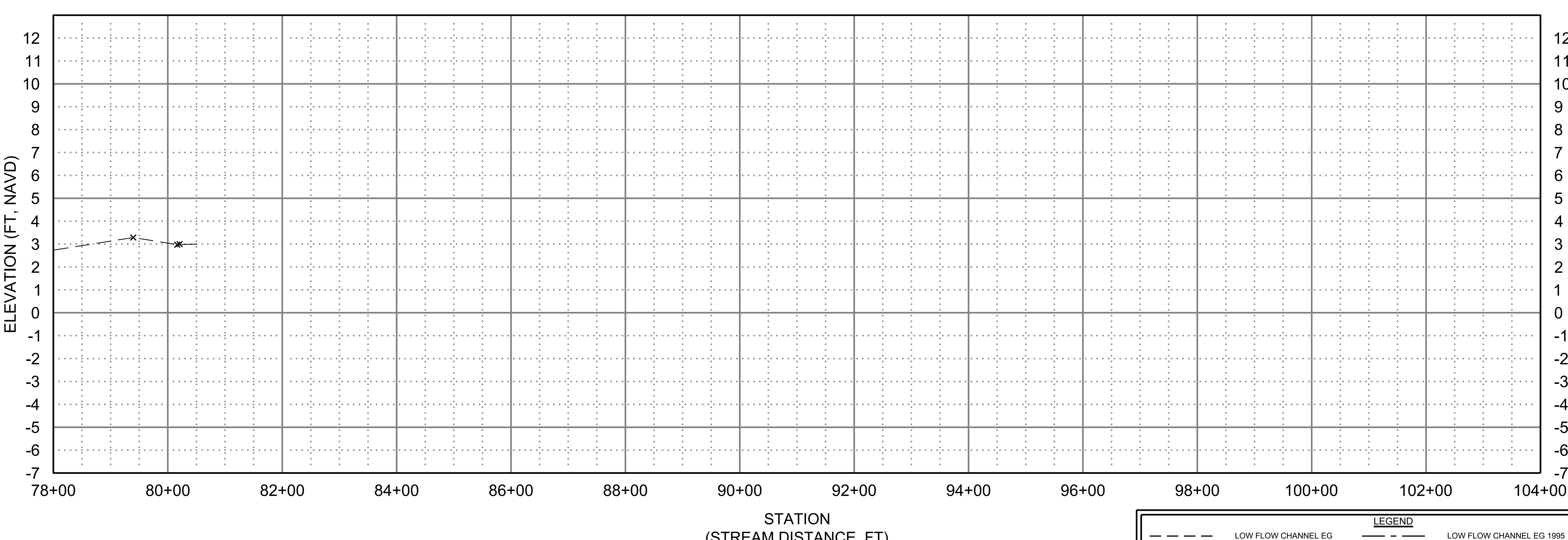
DRAWING: ----

SHT 1 OF 4

WEST SLOUGH STA 52+00 TO STA 78+00



WEST SLOUGH STA 78+00 TO STA 104+00



LEGEND

LOW FLOW CHANNEL EG
LOW FLOW CHANNEL FG
LOW FLOW CHANNEL EG 1995
LOW FLOW CHANNEL FG 1995
× SURVEY POINT LOCATION

WOOD RODGERS
BUILDING RELATIONSHIPS ONE PROJECT AT A TIME
3301 C ST, BLDG. 100-B TEL 916.341.7760
SACRAMENTO, CA 95816 FAX 916.341.7767

CHUCK CORICA GOLF COURSE

WEST SLOUGH PROFILE

ALAMEDA COUNTY CALIFORNIA

DATE: 05/31/2022

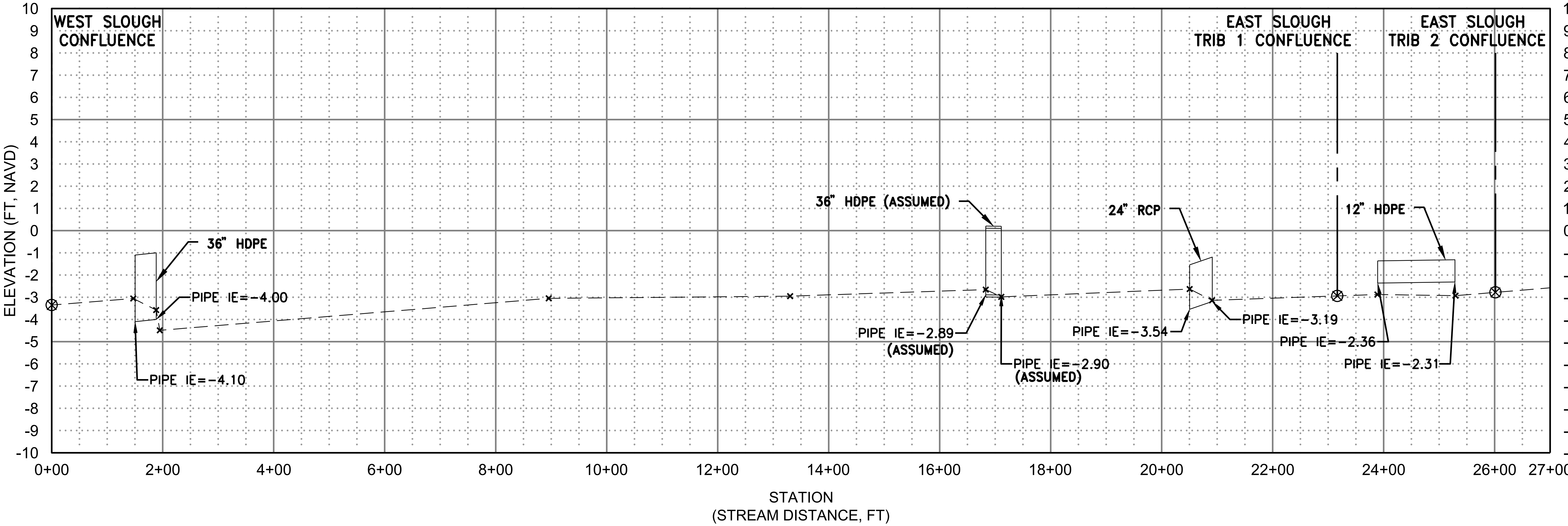
SCALE: VERT: 1" = 5' HORIZ: 1" = 200'

PROJECT NO: ----

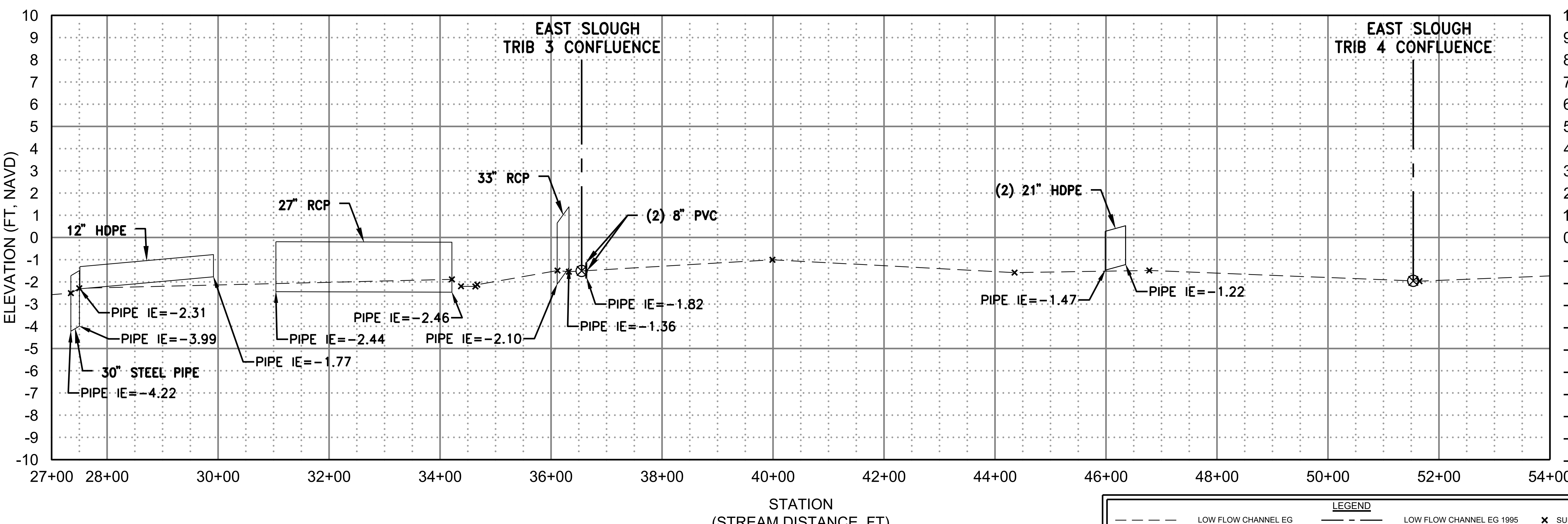
DRAWING: ----

SHT 2 OF 4

EAST SLOUGH STA 0+00 TO STA 27+00



EAST SLOUGH STA 27+00 TO STA 54+00



LEGEND

LOW FLOW CHANNEL EG	LOW FLOW CHANNEL EG 1995
LOW FLOW CHANNEL FG	LOW FLOW CHANNEL FG 1995
× SURVEY POINT LOCATION	

WOOD RODGERS
BUILDING RELATIONSHIPS ONE PROJECT AT A TIME
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SACRAMENTO, CA 95816 FAX 916.341.7767

CHUCK CORICA GOLF COURSE

EAST SLOUGH PROFILE

ALAMEDA COUNTY CALIFORNIA

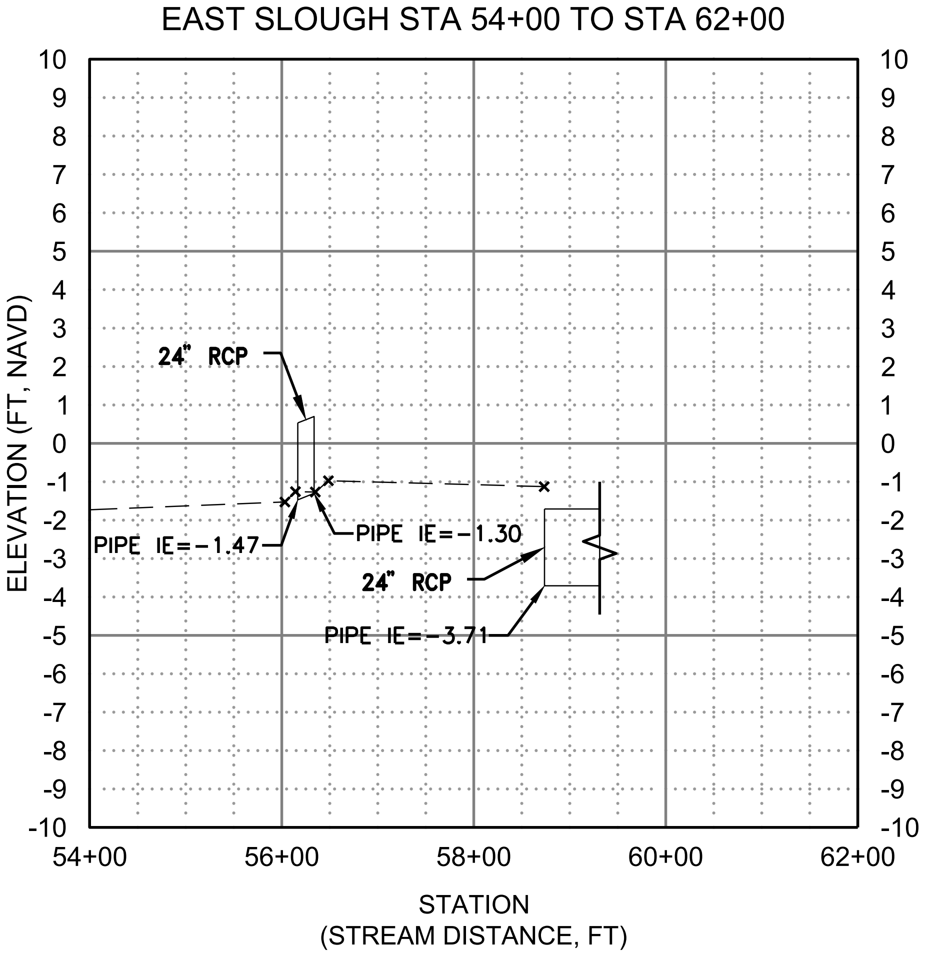
DATE: 05/31/2022

SCALE: VERT: 1" = 5' HORIZ: 1" = 200'

PROJECT NO: ----

DRAWING: ----

SHT 3 OF 4



LEGEND

— — — LOW FLOW CHANNEL EG	—— - —— LOW FLOW CHANNEL EG 1995	× SURVEY POINT LOCATION
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CALIFORNIA

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SHT 4 OF 4

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