Sea Level Rise Vulnerability Assessment and Adaptation Strategy for Initial Operating Segment (IOS)-1 South and Haystack Landing Bridge Replacement

Prepared for

San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, California 94612

Prepared by

Rich Walter, Principal, ICF International
Leslie Allen, Environmental Regulatory Specialist, ICF International
Richard Jorgensen, Senior Civil Engineer, GHD

January 2014

Contents

Acronyms and Abbreviations

ADC	adaptive design criteria
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
ICF	ICF International
MHHW	Mean Higher High Water
SMART	Sonoma-Marin Area Rail Transit
SWRCB	State Water Resources Control Board

Sea Level Rise Vulnerability Assessment and Adaptation Strategy for Initial Operating Segment (IOS)-1 South and Haystack Landing Bridge Replacement

On behalf of the Sonoma-Marin Area Rail Transit (SMART) District, ICF International (ICF) has prepared this preliminary assessment of vulnerability to sea level rise, evaluation of associated water quality impacts due to project design and changing tide levels and flows, and a proposed adaptation strategy for the track bed and bridges and culverts along the IOS-1 South project alignment. This assessment and strategy were developed specifically in response to a request from the San Francisco Bay Regional Water Quality Control Board (Water Board) in relation to the pending Clean Water Act (CWA) Section 401 Water Quality Certification/Waste Discharge Requirement permit application for the proposed project.

Background

State Guidance on Sea Level Rise Adaptation

Executive Order S-13-08[1] requires all state agencies planning construction projects in areas vulnerable to sea level rise to consider a range of sea level rise scenarios for the years 2050 and 2100. The Sea Level Rise Task Force issued its final guidance in March 2013.[2]

The final guidance recommends the following:

- Consider a range of specific sea level projections and select values based on agency and context-specific considerations of risk tolerance and adaptive capacity. The guidance presents sea level rise projections for the area south of Cape Mendocino as follows (relative to 2000 base year):
    - 2 to 12 inches (mid-point of 7 inches) by 2030;
    - 5 to 24 inches (mid-point of 14 inches) by 2050; and
    - 17 to 66 inches (mid-point of 41 inches) in 2100.
- The guidance also recommends consideration of a wide range of other factors such as local trends, adaptive capacity, and risk tolerance when selecting estimates of sea level rise.

The guidance is only binding on state agencies and SMART is not a state agency.

Porter-Cologne Water Quality Control Act

The Water Board's authority to regulate water quality is related to the Porter-Cologne Water Quality Control Act. The statute itself provides no specifics in terms of addressing sea level rise as part of water quality permitting. No state guidance or policy related to the statute and sea level rise could

[1] http://gov.ca.gov/news.php?id=11036.

[2] http://www.opc.ca.gov/webmaster/ftp/pdf/docs/Memo_OPC_Council_2013meeting_FINAL.pdf.

be located. In absence of formal guidance, Water Board staff identified several State Water Resources Control Board (SWRCB) Resolutions as relevant in general including: Res No. 2005-0006, Res. No. 2007-0059: Res. No. 2008-011; and Res. No. 2008-030.

Water Board staff described their regulatory nexus as this:

- Creek crossings may constrain storm flows which could result in increased upstream or downstream flooding or erosion that could result in discharge of sediment or other pollutants into state waters. Thus, the Water Board is concerned about flood design criteria to protect current and future water quality where designs may constrain storm flow.
- Future sea level rise will contact more of the railbed and ballast resulting in future water quality effects of rail facilities and operations.
- The Water Board is charged with protecting beneficial uses of water, which in their opinion includes allowing opportunity for future wetland migration landward with sea level rise.

Water Board staff identified the following concerns for this project:

- Concerns regarding existing areas of State waters (e.g., creek crossings) within the tidally influenced zone.
- Concerns regarding future water quality impacts related to sea level rise and the SMART rail corridor as a whole.
- Concerns regarding "wetland migration" at specific locations including Miller Creek and San Antonio Creek.

Clean Water Act/U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (Corps) project design guidance includes consideration of sea level rise. The current Corps guidance is EC 1165-2-212 (10/1/11, expires 09/30/13[3]). The Corps guidance requires that planning studies and engineering designs over the project life cycle, for both existing and proposed projects, consider alternatives that are formulated and evaluated for the entire range of possible future rates of sea level change. This is for the design of Corps projects and is not related to the Corps' regulatory jurisdiction relative to the CWA Section 404.

FEMA Floodplain Mapping and Sea Level Rise

FEMA's current floodplain maps are focused on current flooding risks and thus do not presently include consideration of future sea level rise. However, the Biggert-Waters Flood Insurance Reform Act of 2012 requires a technical advisory group to make recommendations concerning future updates of floodplain maps in relation to sea level rise.[4]

---

[3] Available: http://planning.usace.army.mil/toolbox/library/ECs/EC11652212Nov2011.pdf.

[4] See: http://www.floods.org/ace-files/ documentlibrary/2012_NFIP_Reform/ 2012_NFIP_Reform_Act_ASFPM_Summary_of_Contents.pdf

Sea Level Rise Scenarios

The design life of the IOS-1 South project has been identified as 50 years with an in-service date of 2015. Thus, the design year is 2065.

For current tidal levels, the following assumptions were used for this assessment (all in NAVD):

- Mean Higher High Water (MHHW) +6.3 feet
- 100-year Tide (Gallinas Creek): +9.5 feet
- 100-year Tide (all other areas): +9.0 feet[5]

The current MHHW level was provided in the project H&H report (HDR/Winzler & Kelley March 2011). The 100-year tide is based on FEMA FIRMs. It should be noted that these tide levels are generic; a site-specific investigation of tide levels at specific creeks and crossings was not performed and actual tide levels could be higher or lower than those used in this assessment.

No site-specific projections of sea level rise in the project area were identified and thus the state guidance projections were used. Using the state guidance on projected sea level rise scenarios and interpolation between 2050 and 2065, the following sea level rise projections were identified for use in this assessment (all relative to 2000 levels):

- 2030: + 7” (+0.6’) (midpoint of state guidance);
- 2050: + 12” (+1.0’) (midpoint of state guidance); and
- 2065: + 22” (+1.8’) (midpoint of state guidance).

Using these rise projections, the following assumptions were used for this assessment (all in NAVD):

- Mean Higher High Water (MHHW)
  - 2030: +6.9 feet
  - 2050: +7.3 feet
  - 2065: +8.1 feet
- 100-year Tide (Gallinas Creek):
  - 2030: +10.1 feet
  - 2050: +10.5 feet
  - 2065: +11.3 feet
- 100-year Tide (all other areas, including Haystack Landing):
  - 2030: +9.6 feet
  - 2050: +10.0 feet
  - 2065: +10.8 feet

[5] Based on FEMA’s published FIRM maps showing 100-year stillwater tide level of 9.0 feet (NAVD 88). It should be noted that FEMA’s Revised Preliminary Flood Insurance Study for Sonoma County (June 2013) identifies 100-year Stillwater tide elevation for San Pablo Bay of 9.1 feet and for San Pablo Bay at the mouth of the Petaluma River of 9.2 feet, but this was a preliminary study.

Current Hydrologic Design Criteria

The project's hydrologic criteria SMART Design Criteria Manual December 2012) are as follows:

- Design Requirements
  - The track structure shall accommodate the 100-year, 24-hour storm event with a maximum water surface elevation at the structure soffit. Alternative criteria for flood frequencies and maximum elevations may be considered where the cost of providing the aforementioned level of protection is prohibitive with approval of SMART's Engineer. Where possible, local flood control requirements or FEMA regulations shall be considered when more stringent requirements are applicable.
  - Stormwater facilities for SMART shall be designed so that the proposed improvements do not:
    - Create a flood or inundation hazard to adjacent property.
    - Raise the flood level of a drainage way.
    - Decrease the flood storage capacity or impede the movement of floodwater within a drainage way.
    - Increase soil erosion or sedimentation.
    - Increase the magnitude of the peak outflow of drainage water from the subject area.
- Bridge Design:
  - Major bridges (Las Gallinas, Petaluma, Novato Creek and Russian Rivers) shall preferably pass the 100-year, 24-hour storm event with 1 feet of freeboard without considering the sea level rise.
  - Freeboard shall be provided where practicable to protect bridge structures from debris and scour related failure. Sites that present potential of debris impacting the bridge shall be given further consideration and appropriate measures shall be taken to prevent damage to the bridge or impacts to operations.
  - Minor bridges and structures (including culverts) shall pass 100-year event with a maximum water surface elevation at the soffit.
- Culvert Design:
  - Cross culverts under at-grade track shall pass a 10-year event, and provide that the guideway way is protected to the level described in the Design Requirements (see above). For the 10-year event, the maximum allowable headwater is 1' below the bottom of the sub-ballast.
- Track/Trackbed[6]
  - Track roadbed (top of sub-ballast) shall be designed to the 100-year, 24-hour event.

[6] The trackbed elevation is defined as the top of the sub-ballast in this memo and is assumed equivalent to "existing Ground" as shown in project design sheets.

Sea Level Rise Adaptive Design Criteria (ADC)

For the purpose of this assessment, the following sea level rise adaptive design criteria (ADC) for IOS-1 South bridges and culverts were used. These criteria will be used for periodic adaptation assessment to determine decadal priorities for SMART system protection improvements:

- Bridges:
  - The design criteria for major bridges are the 100-year/24-hour storm event or the 100-year tidal elevation (whichever is higher) plus 1 foot of freeboard *based on storm/tidal events with potential to occur within the next 10 years taking into account sea level rise.*
  - The design criteria for minor bridges and structures shall pass the 100-year event with a maximum surface water elevation at the soffit *based on storm/tidal events with potential to occur within the next 10 years taking into account sea level rise.*
- Culverts
  - Accommodate site drainage to reduce and prevent erosion of railway structures and foundations.
- Track/Track bed
  - For the trackbed, the goal is for the top of the sub-ballast to be designed to the 100-year/24-hour event with maximum water surface elevation where feasible and cost-effective. The goal is also to provide protection of the trackbed elevation from repeated substantial damage from the 10-year/24-hour storm event or the 10-year tidal elevation (whichever is higher) *based on storm/tidal event with potential to occur within the next 10 years taking into account sea level rise.*

The purpose of including a forward-looking criteria of 10 years is to allow for sufficient time for capital improvement planning and funding to occur in advance of the incurrence of predicted increased risk levels associated with predicted near-term sea level rise. The application of these criteria is described further in the section below on the Periodic Adaptation Strategy Review.

Vulnerability Assessment

SMART conducted a vulnerability assessment of potential future flooding at several bridges due to projected rises in sea level.

- Bridges:
  - At one location (Basalt Creek), the existing bridge soffit elevation is below the existing MHHW but this location is constrained due to the elevations of upstream and downstream culverts preventing a raised design. Proposed bridge soffit elevations at all other locations are above the existing MHHW. In most cases, the proposed bridge design would place the soffit elevation above the 2065 estimated MHHW.
  - Some bridge crossings have proposed soffit elevations above the current and 2065 100-year tide level while others do not. Table 1 in Appendix B describes constraints affecting some of the bridges with soffit elevations that are below the 100-year tide levels.

  - The vulnerability assessment is based on generic current estimates of MHHW and 100-year tide.
- Culverts:
  - Culverts were assessed relative to their capacity to carry tidal flow compared to existing conditions. This is presented in the next section, "*Water Quality Impact Analysis*."
- Tracks and Trackbed
  - Current track conditions were evaluated to identify where elevations are lower than current 100-year tide levels (9.0' NAVD 88 except for Gallinas Creek). Proposed track conditions were evaluated to identify where elevations will be lower than assumed 100-year tide levels in 2065 (10.8' NAVD 88). The results are depicted graphically in Figure 1, and detailed locations are provided in Table 2 (see Appendices A and B, respectively).
  - The vulnerability assessment was based solely on a comparison of track (top of rail) and trackbed (existing ground) elevation against current or future tide levels. As a comprehensive low-point analysis was not conducted, some of the areas identified as vulnerable in this analysis may not actually be vulnerable if they are in areas where 100-year tide levels cannot be realized due to existing levees or other structural impediments that prevent or mute the tidal range.
  - Flooding above the top of rail would interrupt rail service and would have the potential to damage the trackbed. Flooding below the top of rail but above the trackbed could result in damage to the structural integrity of the rails, ballast, or ties. SMART's current planning includes inspection of the railbed after storm events to check for potential damage prior to conducting trail service following storm events.
  - As identified in Table 2, there are 4 potential locations where the proposed top of rail would be subject to flooding from the current 100-year tide level, with a total vulnerable track length of 4,200 feet (0.8 mile). There are 4 locations where the existing trackbed (existing ground, excluding at culverts, bridges, and underpasses) would be subject to flooding from the current 100-year tide level, with a total vulnerable track bed of 10,100 feet (1.9 miles).
  - As identified in Table 2, there are 9 locations where the proposed top of rail would be subject to flooding from the assumed 2065 100-year tide level, with a total vulnerable track length of 18,200 feet (3.4 miles). There are also 19 potential locations where the existing trackbed would be subject to flooding from the 2065 100-year tide level, with a total vulnerable track bed of 49,100 feet (9.3 miles).

Water Quality Impact Analysis

The potential for water quality impacts due to bridge and culvert design was assessed in terms of whether the proposed improvements would or would not increase potential flooding or would or would not reduce tidal flow compared to the existing bridges and culverts.

- Bridges:
  - As shown in Table 1, in many cases the crossing design will place the bridge soffit elevation higher than existing conditions, thus reducing existing and future flood potential while allowing increased tidal flow.

  - In some cases, tidal flow is constrained by upstream and/or downstream structures, conditions and controls. In these locations, raising bridge elevations will have no effect on flow levels until these upstream and/or downstream constraints are removed or adjusted.
  - At one location (Basalt Creek), the existing bridge soffit elevation is below the existing MHHW but this location is constrained due to the elevations of upstream and downstream culverts preventing a raised design. Proposed bridge soffit elevations at all other locations are above the existing MHHW. In most cases, the proposed bridge design would place the soffit elevation above the 2065 estimated MHHW. In these cases, the bridge would accommodate normal tidal flows without water quality effects.
  - Some bridge crossings have proposed soffit elevations above the current and 2065 100-year tide level while others do not. Table 1 describes constraints affecting some of the bridges with soffit elevations that are below the 100-year tide levels. Where bridge soffits are less than current or future 100-year tide levels there could be effects on tidal flooding and tidal flows.
  - The proposed project is replacing creosote bridge supports/pilings with steel or concrete supports, which will reduce potential water quality runoff issues associated with creosote exposure to rain events, as well as potential flooding episodes now and in the future.
- Culverts:
  - The water quality impact assessment for culverts focused on whether or not proposed culverts may constrain tidal flow compared to the existing conditions.
    - Where no change is proposed by the project, then no change in tidal flow conditions would be expected and thus no change in water quality conditions.
    - Where the project proposes to increase the capacity of existing culverts, this may increase accommodation of current and potential increased tidal flows in the future depending upon location, elevation of the culvert and other pertinent information. An increase of tidal flow would enhance tidal exchange which would be expected to improve flushing and circulation in tidally-influenced creeks, thus improving water quality. In addition, increased culvert sizing would better accommodate storm flows, thus reducing flood potential and associated water quality adverse effects.
    - Where the project proposes to improve existing storm drainage by adding culverts where none presently exist, this would be expected to increase accommodation of current and potential increased tidal flows in the future and/or reduce potential for overland erosion during storm events. An increase of tidal flow would enhance tidal exchange which would be expected to improve flushing and circulation in tidally-influenced creeks, thus improving water quality. In addition, improved site drainage would better accommodate storm flows, thus reducing flood potential, erosion, and adverse water quality effects.
    - Where the project proposes replacing culverts with smaller diameter units that would have less flow capacity than under existing conditions, this could impede existing and future tidal flow and exchange and/or constrain storm flows, potentially resulting in associated water quality effects.
      - The 6 proposed culvert replacements that will result in a reduced flow capacity compared to the existing condition have all been sized based on SMART hydraulic

design criteria using the Hydraflow Express Extension for AutoCAD using standard TR-55 methodology. It is assumed that some or all of the original culverts were installed without hydrologic or hydraulic calculations - for instance the existing wooden box culvert C16 at Station 1062+55.

   - At the calculated Q100 storm event flow volume, the culverts C16, C37, C54 and C55 operate under "pipe full" conditions where the inlet water elevation is at the culvert soffit elevation. At the calculated Q100 flow volume, the culverts C39 and C50 operate under less than "pipe full" conditions.
   - Tidal flow will not be constrained under normal flow conditions through any of the culverts as they will be at less than "pipe full" conditions. During Q100 storm event conditions, tidal flow will not be constrained through culverts C39 and C50 as they will be at less than "pipe full" conditions. During Q100 storm event conditions tidal flow will not be constrained through culverts C16, C37, C54 and C55 because there is no elevation head on the inlet side of the culverts that would result in a constrained flow through the culverts.
   - As such, water quality effects due to constrained tidal flow are not expected due to the proposed design for these 6 culverts compared to existing conditions.

The potential for water quality impacts due to trackbed design relevant to sea level rise was assessed in terms of whether the proposed improvements would result in greater exposure of railway materials to waters compared to existing conditions.

- Trackbed
  - The project is not changing trackbed elevations. Thus, the project is not changing the potential exposure of the trackbed to future sea level rise. If water quality impact occurs due to future sea level rise resulting in periodic storm-related water contact with the trackbed materials, that is not due to the project, but rather due to a combination of the existing conditions plus the rise in water levels over time.
  - The project is increasing top of rail elevations in most locations by approximately 1 foot. This will increase the resiliency of the top of rails relative to future sea level rise, but will not avoid potential inundation as indicated in Table 1.
  - Where track rehabilitation requires encroachment into waters of the state, that has been disclosed in prior permit applications to the Water Board and SMART is compensating for any net loss of waters/wetlands.
  - In the future, any necessary future track modifications may result in additional encroachment into waters/wetlands, but such track modifications are not the subject of the current application to the Water Board. As necessary, SMART will apply for permits from the Water Board when and if future encroachments into state jurisdictional areas are proposed.
  - The project is replacing creosote ties with concrete ties which will reduce potential water quality runoff issues associated with creosote exposure to rain events, as well as potential flooding episodes now and in the future. Exposure of embankment and railroad ballast during flooding events is an existing condition that SMART's current proposed project will neither avoid nor worsen; as such the potential for water quality effects during flooding events is unchanged relative to existing conditions.

Adaptation Strategy

The following adaptation approaches are proposed by SMART:

- Bridges:
  - Where the bridge design will place the soffit above the existing and 2065 MHHW and 100-year tide levels, no adaptation actions are proposed.
  - In some cases, flow elevations are constrained by upstream and/or downstream structures and controls. In these locations, raising bridge elevations will have no effect on flow levels until these upstream and/or downstream constraints are removed or adjusted. Adaptation actions will need to be identified in concert with actions by other parties to address upstream and/or downstream constraints.
  - Where the bridge design will place the soffit below the 2065 MHHW and/or 100-year tide levels and there are no physical constraints upstream or downstream to raising the bridge level, then raising will be considered sometime between the present and 2065. An estimated timeframe for overtopping is noted in Table 1. Per the ADC, advanced planning to raise such bridges will be part of the 10-year review cycle.
- Culverts:
  - Where no change is proposed by the project, SMART may consider future adaptation actions for system protection, but lacking a water quality nexus, this is not an identified concern for the Water Board permit.
  - Where the project proposes to increase the capacity of existing culverts or improve drainage, no adaptation actions are proposed. SMART may consider future adaptation actions for system protection, but lacking a water quality nexus, this is not an identified concern for the Water Board permit.
  - Where the project proposes culverts that would have less flow capacity than under existing conditions, SMART has assessed these culverts and determined that none of them would actually constrain tidal flow compared to existing conditions (see discussion above). SMART may consider future adaptation actions for system protection, but lacking a current water quality nexus, this is not an identified concern for the Water Board permit.
  - As part of the 10-year update of the SLR Adaptation Strategy (see discussion below), SMART will assess the adequacy of drainage for all culverts relative to rail system protection and erosion. Where new or expanded culverts are necessary to prevent erosion, and/or protect the rail system facilities, SMART will replace, expand, or add additional drainage facilities. SMART will obtain permits for any culverts placed in jurisdictional state waters at that time.
- Trackbed
  - Where the trackbed elevation is currently below the current 100-year tide levels, SMART will monitor the performance of the trackbed, ballast and ties to flooding events. Where evidence shows that system integrity will be repeatedly damaged by 10-year flood events, then SMART will raise the trackbed above the 10-year flood/tide levels as and if necessary to maintain system integrity.
  - Where the trackbed elevations are above the current 100-year tide level but below the 2065 100-year tide level, SMART will assess the future vulnerability of the trackbed to substantial

repeated damage by flooding by the 10 year flood/tide levels. Per the ADC, advanced planning to raise trackbed elevations above the 10-year flood/tide levels where necessary to avoid substantial repeated damage from the 10-year flood/tide event will be part of the 10-year review cycle.

- Adaptation Options to protect the SMART trackbed from current and future flooding risks include:
  - *Monitoring, Inspection and Repair*: As noted above, parts of the current track are subject to flooding already. The current approach is to monitor flooding, inspect the system after the event, and repair any damage that has occurred. This is a viable approach to managing flood damage when flooding and flood damage is not extensive or frequent. As flood damage becomes more frequent and more extensive, then this option will become less favorable given the disruption to service and the cost of repeated repairs.
  - *Raising of the tracks*: Track elevations can be raised 1-2 feet through minor augmenting of the track bed and/or increase in the amount of track tie ballast. These minor augmentations would usually not require expansion of the trackbed prism. In order to confirm whether the prism would need to be expanded or not, site-specific evaluations would need to be completed.
  - *Raising of the trackbed*: It may be necessary to raise the trackbed itself. In this case, the bed prism would have to be expanded laterally to achieve the desired top elevation. This option would require more potential encroachment into jurisdictional waters/wetlands where present adjacent to the railway.
  - *Floodwalls*: It may be possible to provide flood protection through the use of floodwalls at some locations along the route. However, floodwalls are difficult to integrate with roadway and other infrastructure crossings while providing flood protection and thus may only be feasible where the entire area to be protected does not contain at-grade roadway or other infrastructure crossings.
  - *Placement of railway on a causeway*: This option would include construction of an elevated causeway over high-water areas to prevent flooding.
  - *Partnering with other agencies in regional flood protection improvements*. In some cases, such as near the Ygnacio Business Park east of Highway 101, the optimal adaptation strategy may be to protect multiple assets through regional flood control improvements instead of case by case improvements. For example, a business park located east of Highway 101 along Bel Marin Keys Boulevard (between Milepost 25 and 26 in Figure 1) is subject to flooding in the 2065 scenario used in this analysis. Current FEMA maps show this area is protected from current flooding by levees. In the future, these levees may need to be upgraded to protect the business park.
  - *Relocation or realignment of the railway*: This option is the last resort for adaptation due to the substantial financial cost and disruption it would pose to establish an alternative alignment. Hypothetically, the rail line could be realigned westward to integrate with parts of Highway 101. However, Highway 101 is highly constrained at many locations and thus such an alignment may or may not be feasible. Even if feasible, other adaptation options may be more financially, environmentally, or publicly preferred. Thus, at this time, realignment of the railway is not considered a viable adaptation option.

Voluntary Adaptation Actions for Wetland Migration

Water Board staff suggested that SMART should consider potential adaptation actions at the following locations along the IOS-1 South project alignment in relation to landward migration of wetlands:

- *Miller Creek crossing at Silveira Ranch (MP 22.09):* There have been various proposals to purchase this privately owned property and restore wetlands; however, SMART is not aware of the current landowner being willing to participate in any such restoration. Thus, there is no current active proposal for wetland restoration at this site. The current railway bridge over Miller Creek appears to cross a reach that is aligned with the historical location of the creek. The prior realignment of Miller Creek is well downstream (east) of the railroad bridge crossing. The proposed design of the Miller Creek bridge would increase the soffit elevation by 2.1 feet and would accommodate current and future normal and extreme tidal elevations and thus should not constrain tidal exchange.
- *Unknown Creek crossings (MPs 31.75, 32.58 and 32.94):* The upstream areas above these crossing are currently used for cattle grazing. Increasing tidal flow today would impede this land use.
  - At the crossing at MP 31.75, SMART is proposing repair of existing conditions, not bridge replacement.
  - At the crossing at MP 32.58, upstream tidal flow is constrained by a tidegate (not owned by SMART) to prevent tidal flow into upland grazing areas. SMART is proposing to replace the existing 42” cmp with a 72” cmp at the crossing at MP 32.58, which will improve potential tidal flow, but will only be effective if the landowner decides to change the upstream tidal gate operations.
  - At the crossing at MP 32.94, the upstream area is constrained by an existing berm that would limit wetland restoration potential. SMART is proposing replacement of the existing 36” culvert and would thus accommodate existing tidal flow. SMART is not aware of any current proposals to restore wetlands at these locations.
- *San Antonio Creek crossing (MP 33.49):* Upstream areas include tidally influenced wetlands as well as upland areas currently used for cattle grazing. Increasing tidal flows today could impede grazing activity by converting upland areas to tidal wetlands. SMART is proposing an increase of the existing soffit of 0.65” and would thus increase tidal flow passage. SMART is not aware of any current proposals to restore wetlands at this location.

As described above, there are no current proposals for wetland restoration at these locations that can be advanced at this time. In addition, SMART’s proposed improvements would not result in any degradation of existing conditions and would not result in impingement of flooding or tidal flows. Thus, SMART is not proposing any wetland migration actions as part of its 401 Certification application or mitigation.

However, SMART is willing to voluntarily consider accommodating future wetland restoration proposals for the three locations described above under the following conditions:

- All underlying landowners concur with the proposed wetland restoration.
- Proposed wetland restoration activities are fully funded by others.

- Proposed wetland restoration activities would not preclude safe railroad operations and maintenance.
- Where the above criteria are met, SMART will consider providing the following on a voluntary basis:
  - Railway drainage improvements that are:
    - Financially acceptable to the current SMART Board or where fully funded by wetland restoration proponents; and
    - Consistent with railway system protection.
  - Such drainage improvements may include:
    - Installation of culverts to allow for site drainage or tidal connection
    - Minor bridge improvements to improve creek flow or tidal connection; and/or
    - Major bridge improvements or railway realignments only where funded by wetland restoration proponents or third party funders.
- All such actions would be the voluntary and sole discretion of SMART and would not be considered a condition of regulatory permits that are issued for IOS-1 South.

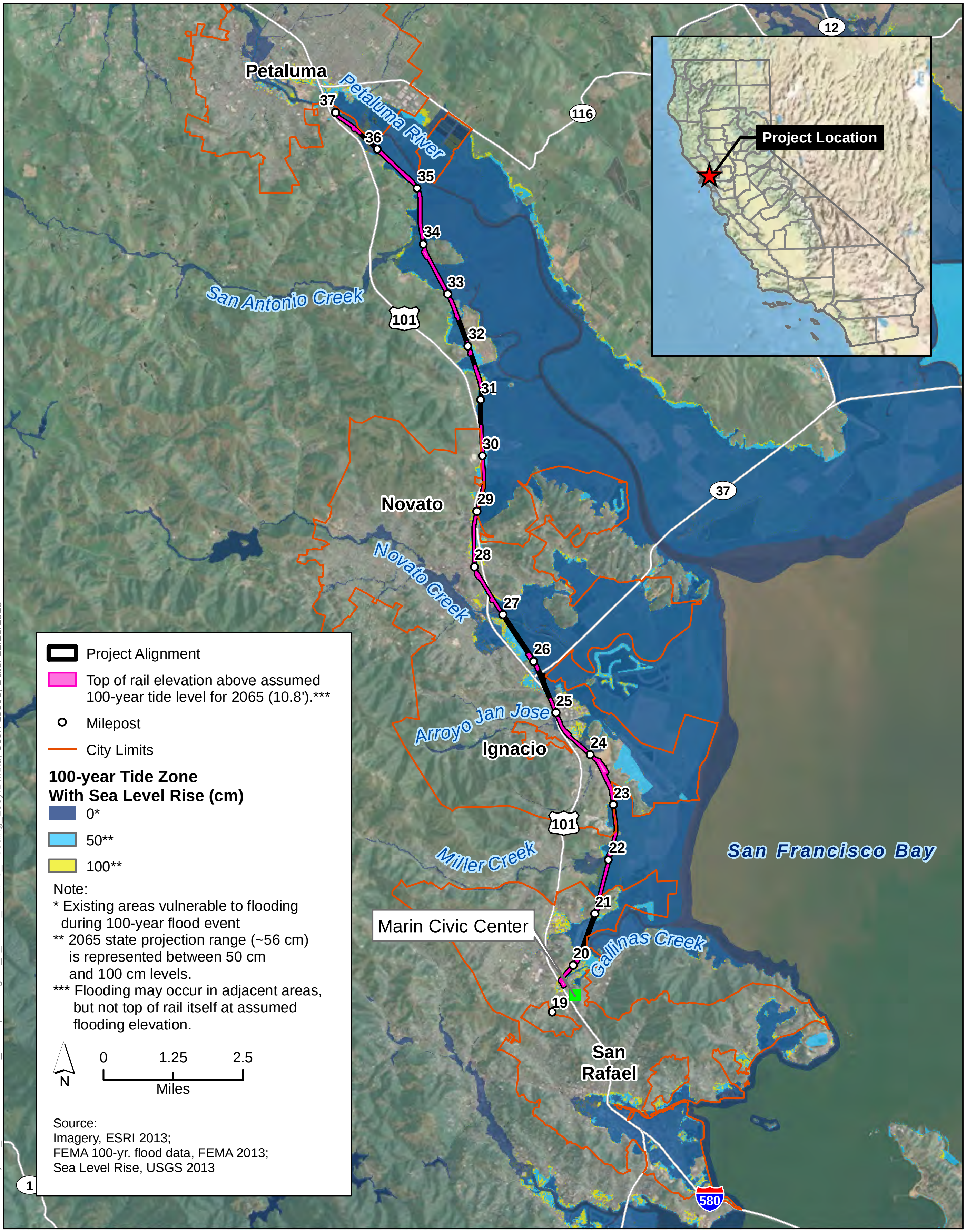
Periodic Adaptation Strategy Review

SMART will conduct a formal review of the adaptation strategy outlined herein at least every 10 years as follows:

- 2013: The first adaptation review consists of the assessment presented in this document.
- 2012 – 2023: SMART will monitor system performance and resiliency to smaller event flooding effects on the trackbed in order to inform capital planning to protect the trackbed and rails from repeated substantial flooding damage.
- 2023 and subsequent reviews: SMART will conduct the following evaluations:
  - Review available scientific information on sea level rise data and projections for the subsequent 50 years. Where data and projections indicate different rates of sea level rise than previously applied, SMART will adjust the ADC to reflect a median-point of then-current projections.
  - Review SMART system vulnerability for the subsequent 50 years in light of available data at that time and the adjusted ADC.
  - Identify a 10-year plan of improvements in the context of its capital improvement program with consideration for ADC, as feasible and unconstrained by surrounding development not owned by SMART. The plan of improvements will be designed to provide system integrity protection predicted for the next ten years in light of the ADC.
  - Identify opportunities for partnership with other local and regional parties for sea level rise adaptation.

- Ongoing:
  - Where SMART's adaptation options are constrained due to adjacent infrastructure (such as adjacent roadways and structures not owned by SMART), SMART will work with adjacent landowners and infrastructure managers to identify opportunities to improve rail system protection in concert with other local or regional parties.
  - SMART will consider requests from wetland restoration proponents for changes in drainage design following the criteria described above under *Voluntary Adaptation Actions for Wetland Migration*.

Appendix A
Figure



Path: K:\Projects_3\SMART\00707_12\mapdoc\Figure_1_Areas_Relative_Flooding_100yrB.mxd; User: 19393; Date: 12/20/2013

Figure 1
Railroad Alignment Relative to Future Flooding from a 100-year Tide (Current and with 2065 Sea Level Rise)
SMART Segment (IOS)-1 South

Appendix B
Tables

Table 1. IOS-1 South Existing and Proposed Bridge Crossings June 2013

Sonoma-Marin Area Rail Tranist

Mile Post Number	Station	Name	Existing MHHW	Existing 100 Year Tide ****	Existing Soffit	2065 MHHW (+22")	2065 100 year Tide (+22")	Min Proposed Soffit	Change in Proposed Soffit	Resulting Freeboard (FT) = Soffit - Existing MHHW	Resulting Freeboard (FT) = Soffit - Existing 100Y tide	Resulting Freeboard (FT) = Soffit - 2065 MHHW	Resulting Freeboard (FT) = Soffit - 100Y Tide	Impact Assessment relative to tidal flow and water quality	SLR Vulnerability Assessment (MHHW)	SLV Vulnerability Assessment (100Y Tide)	Proposed Adaptation Action	Notes	WB comments
20.91	1017+40	**Gallinas Creek - REPLACE ****																	
		℄ BENT 1	6.30	9.50	10.90	8.13	11.33	10.27	-0.63	3.97	1.07	2.14	-1.06		Not overtopped to 2065.	Overtopped after 2050.	Plan for raising by 2050.		
		℄ BENT 12	6.30	9.50	10.90	8.13	11.33	11.14	0.24	4.84	1.94	3.01	-0.19	Tidal flows not constrained	Not overtopped to 2065.	Not overtopped to 2065.	N/A		
		℄ BENT 15	6.30	9.50	10.90	8.13	11.33	11.30	0.40	5.00	2.10	3.17	-0.03	Tidal flows not constrained	Not overtopped to 2065.	Not overtopped to 2065.	N/A		
		℄ BENT 20	6.30	9.50	10.90	8.13	11.33	11.49	0.59	5.19	2.29	3.36	0.16	Tidal flows not constrained	Not overtopped to 2065.	Not overtopped to 2065.	N/A		
22.09	1079+70	**Miller Creek - REPLACE ****																	
		℄ BENT 4	6.30	9.00	10.79	8.13	10.83	12.89	2.10	6.59	3.89	4.76	2.06	Tidal flows not constrained.	Not overtopped to 2065.	Not overtopped to 2065.	If restoration is actually advanced, SMART to voluntarily work with proponents and landowners to facilitate restoration project as feasible with rail system protection and within SMART funding limitations.		Interested in adaptation options.
23.98	1179+50	**Pacheco Creek - REPAIR TO EXISTING CONDITIONS**																	
			6.30	9.00	25.60	8.13	10.83	25.60	0.00	19.30	16.60	17.47	14.77	Tidal flows not constrained.	Not overtopped to 2065.	Not overtopped to 2065.	N/A		If not load bearing repair = okay. Remove abutments?
24.81	1223+32	**San Jose Creek - REPLACE ****																	
		℄ BENT 1	6.30	9.00	21.06	8.13	10.83	20.84	-0.22	14.54	11.84	12.71	10.01	Tidal flows not constrained.	Not overtopped to 2065.	Not overtopped to 2065.	N/A	Constrained by 101 culverts	
		℄ BENT 3	6.30	9.00	21.06	8.13	10.83	20.84	-0.22	14.54	11.84	12.71	10.01	Tidal flows not constrained.	Not overtopped to 2065.	Not overtopped to 2065.	N/A	Constrained by 101 culverts	
26.04	1288+26	**Hanna Slough - REPLACE ****																	
		℄ BENT 4	6.30	9.00	7.16	8.13	10.83	8.81	1.65	2.51	-0.19	0.68	-2.02	Normal tides accommodated. While below extreme tide level, flow likely constrained by flood gates downsteam.	Not overtopped to 2065.	While below extreme tide level, flow likely constrained by flood gates downsteam.	Flow controls upstream and downstream constrain present need/feasibility for adaptation. If flow controls downstream do not contain flood levels in future, bridge elevation may need to be raised.	Flow limited upstream. Downstream = CDFG controlled by pumps. Likely no tidal surge.	
26.93	1335+26	**Novato Creek - REPLACE**																	
			6.30	9.00	10.66	8.13	10.83	11.87	1.21	5.57	2.87	3.74	1.04	Tidal flows not constrained.	Not overtopped to 2065.	Not overtopped to 2065.	N/A		
28.77	1432+41	**Rush Creek - REPAIR TO EXISTING CONDITIONS**																	
			6.30	9.00	8.00	8.13	10.83	8.00	0.00	1.70	-1.00	-0.13	-2.83	Normal tides constrained after 2060. Extreme tides may be constrained today.	Overtopped after 2060.	Overtopped today.	If/when road and tide gates both planned for change allowing increased tidal flow, then adjust bridge to meet ADC, as feasible.	Constrained up and downstream by road culverts and downstream by tide gates.	
29.31	1460+92	**Basalt Creek - REPAIR TO EXISTING CONDITIONS**																	
			6.30	9.00	5.97	8.13	10.83	5.97	0.00	-0.33	-3.03	-2.16	-4.86	Normal tides and extreme tides may be constrained today.	Overtopped today.	Overtopped today.	If/when road raising planned, then plan for raising bridge to meet ADC, as feasible.	Constrained up and downstream with road culverts	
31.75	1589+75	**Unknown Creek - REPAIR TO EXISTING CONDITIONS**																	
			6.30	9.00	7.47	8.13	10.83	7.47	0.00	1.17	-1.53	-0.66	-3.36	Normal tides constrained after 2050. Extreme tides may be constrained today.	Overtopped after 2050.	Overtopped today.	If restoration is actually advanced, SMART to work voluntarily with proponents and landowners to facilitate restoration project as feasible with rail system protection.	Upstream area used by Silveira for grazing. Increasing tidal flow today would impede land use.	If wetland restoration proposed in future, SMART should consider adapting crossing to facilitate.
33.49	1681+62	**San Antonio Creek - REPLACE ****																	
		℄ BENT 1	6.30	9.00	8.56	8.13	10.83	9.21	0.65	2.91	0.21	1.08	-1.62	Normal tides not constrained. Extreme tides may be constrained today.	Not overtopped to 2065.	Overtopped by 2015?	Project represents improvement in terms of raiding the soffitt compared to existing conditions. Future consideration of incremental raising over time.		
34.21	1719+64	**Schultz Slough - REPAIR**																	
		℄ BENT 1	6.30	9.00	9.37	8.13	10.83	9.77	0.40	3.47	0.77	1.64	-1.06	Normal tides not constrained. Extreme tides may be constrained by 2040.	Not overtopped to 2065.	Overtopped by around 2040.	Plan for potential raising by 2040.		
35.56	1790+92	**Unknown Creek - REPAIR TO EXISTING CONDITIONS**																	
			6.30	9.00	8.88	8.13	10.83	8.88	0.00	2.58	-0.12	0.75	-1.95	Normal tides not constrained. Extreme tides may be constrained today.	Not overtopped to 2065.	Overtopped today.	Project is repair of existing conditions only.		
37.20	1877+51	**Petaluma River -Haystack - REPLACE ****																	
		℄ BENT	6.30	9.00	10.13	8.13	10.83	10.13	unknown	3.83	1.13	2.00	-0.70	Normal tides accommodated. Extreme tides may be constrained after 2050.	Not overtopped to 2065.	Overtopped after 2050.	Plan for potential raising by 2050.		

Table 2a. Flood Vulnerability Of Existing Ground, Current 100 Year Tide Level

	Milepost (mi)		Station Number (100 ft.)			
Current Location	South end	North end	South end	North end	Dist (ft)	Comments
S. of Gallinas Creek	20.23	20.74	98100	100800	2,700	Adjacent residential areas subject to flooding.
Between Miller Creek and Pacheco Creek	22.60	22.97	110600	112600	2,000	Adjacent area subject to flooding mostly undeveloped
S and N. of SR37	25.61	25.95	126500	128300	1,800	Undeveloped areas east of 101 subject to flooding
Adjacent to Novato Costco	26.08	26.76	129000	132600	3,600	Undeveloped areas east of 101 subject to flooding
Total					**10,100**	

Excludes existing ground at culverts, under bridges and at underpasses.

Table 2b. Flood Vulnerability of Existing Ground, 2065 100 Year Tide with 22" Sea Level Rise

2065 w/ SLR	Milepost (mi)		Station Number (ft.)			
Location	South end	North end	South end	North end	Dist (ft)	Comments
S. of Gallinas Creek	19.60	20.82	94800	101200	6,400	Residential areas east and west of rail lines also subject to flooding.
S. of Miller Creek	21.59	21.61	105300	105400	100	Limited area of vulnerability. Adjacent open land subject to flooding
Between Miller and Pacheco Creek	22.24	22.46	108700	109900	1,200	Adjacent open land subject to flooding
Between Miller and Pacheco Creek	22.56	23.03	110400	112900	2,500	Adjacent open land subject to flooding with some residential flooding as well.
S. of Hanna Slough	25.38	25.99	125300	128500	3,200	Area east of 101 subject to flooding
S. of Novato Creek	26.02	26.93	128700	133500	4,800	Area east of 101 subject to flooding including Costco/shopping area.
N. of Novato Creek	27.05	27.35	134100	135700	1,600	Areas east of 101 subject to flooding.
S. and N. of Rush Creek	28.37	29.36	141100	146300	5,200	Constrained between roads and freeway.
N. of Basalt Creek	29.57	29.79	147400	148600	1,200	Area east of 101 subject to flooding.
Near Airport	30.42	31.23	151900	156200	4,300	Airport subject to flooding
Near Redwood Landfill	31.44	31.89	157300	159700	2,400	Parts of landfill subject to flooding as well as areas west of rail line.
S. of San Antonio Creek	31.93	33.32	159900	167200	7,300	Area of flooding mostly west and east of rail line except elevated parts of landfill.
S and N of San Antonio Creek	33.39	33.62	167600	168800	1,200	Area of flooding east and west of rail line.
N. of Schultz Slouth	34.81	34.93	175100	175700	600	Area of flooding mostly to east of rail line.
S. and North of Unknown Creek	35.19	35.68	177100	179700	2,600	Area of flooding mostly to east of rail line.
S. of Petaluma River crossing	36.00	36.42	181400	183600	2,200	Area of flooding east and west of rail line.
S. of Petaluma River crossing	36.65	36.93	184800	186300	1,500	Area of flooding east and west of rail line.
N. of Petaluma River Crossing	37.24	37.35	187900	188500	600	Constrained area with 101 and 116 and other development.
N. of Petaluma River Crossing	37.39	37.43	188700	188900	200	Constrained area with 101 and 116 and other development.
Total					**49,100**	

Excludes existing ground at culverts, under bridges and at underpasses.