Santa Cruz County Regional Transportation Commission

Track Maintenance Planning / Cost Evaluation for the Santa Cruz Branch

Watsonville Junction, CA to Davenport, CA

Prepared for Egan Consulting Group
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EXECUTIVE SUMMARY

INTRODUCTION

The Santa Cruz County Regional Transportation Commission (SCCRTC) is investigating the possible purchase of the Santa Cruz Branch ("Branch") from the Union Pacific Railroad. The Branch extends approximately 31.9 miles from Watsonville Junction, a connection point with Union Pacific's national network, through Santa Cruz, CA to Davenport, CA. Part of SCCRTC's due diligence effort includes (1) understanding of the overall condition of the Branch, then (2) developing an estimated annual cost to maintain the Branch dependant on traffic levels, and (3) developing preliminary capital cost estimates that would reflect upgrading the Branch to support several potential future applications.

The purpose of this study is to identify the likely cost of regular maintenance of track and signal facilities along the Branch based on current track conditions (considered to be FRA Excepted Track) and current freight traffic levels, as well as a look forward to capital costs estimates that might be required to improve the Branch to:

(1) No Action
(2) Class 1 with 268,000 pounds load rating
(3) Class 1 with 286,000 pounds load rating
(4) Class 2 with 286,000 pounds load rating
(5) Class 3 with 286,000 pounds load rating

The analysis that describes maintenance or upgrade costs for structures (including bridges, retaining walls, and culverts) are not included in this report, although potentially significant "state of good repair" issues are known to exist on specific structures, and that maintenance, inspection, and rating of structures represents an ongoing cost as well as identifiable capital cost considerations.

Likewise, in developing this report, we have focused on the requirements for freight operations. We have not considered issues associated with passenger operations and the different evaluation criteria (such as ride quality, travel time, dispatching, and the trade-off between maintenance and capital expenditures) that would be included in a study devoted to passenger rail.

The baseline for track maintenance recommendations in this report is the Federal Railroad Administration's (FRA) Track Safety Standards. This document provides *minimum* standards for track safety, and it effectively establishes several levels of maintenance which have corresponding maximum train speeds. For example, 'Excepted Track" track has the lowest level of maintenance, but also the lowest train speeds (10 MPH maximum for freight trains, with no passenger trains and with significant restrictions on the movement of hazardous materials allowed). This is the current FRA rating for the Santa Cruz Branch. The slightly improved "Class 1" track allows 10 MPH for freight trains, but also allows operation of hazardous materials and passenger trains; however, "Class 1" track has stricter tolerances for track conditions. "Class 2" and "Class 3"track has even stricter maintenance tolerances, but also allows freight train speeds as high as 25 and 40 MPH respectively.

SUMMARY OF CONDITIONS ON THE SANTA CRUZ BRANCH

The Santa Cruz Branch originates in Watsonville and extends approximately 31 miles through Aptos, Capitola, Santa Cruz reaching the end of track in Davenport. The railroad between Watsonville and Santa Cruz was constructed as a 3-foot narrow gauge railroad in 1876-77 by the Santa Cruz Railroad and extended to Davenport in 1905-06 by the Coast Line Railroad. These railroads were subsequently acquired by Parajo & Santa Cruz Railroad and then by Southern Pacific and, in1997, by Union Pacific.

Today, Union Pacific uses the Santa Cruz Branch to provide freight service to rail-served industry located just north of Watsonville, with another railroad within Santa Cruz and occasionally to a small industrial park located two miles west of Santa Cruz. Until early 2009, rail service was provided by Union Pacific Railroad to the Cemex facility located in Davenport. However, that service has been temporarily suspended. Historically, several passenger trains operated daily between Santa Cruz and San Jose via Watsonville. However, no passenger rail service currently uses the Santa Cruz Branch.

Segment #1: Watsonville to Aptos (MP 0.0 to MP 12.5)

This 12.5 mile long segment begins in the Union Pacific yard on the south side of Watsonville, passes over the Parajo River, then proceeds down the middle of Walker Street until curving west to pass by several rail-served industries then passing through several agricultural fields until reaching a small canyon near MP 4.5. The Branch follows this canyon in a northwest direction until breaking out near MP 6.8 at Buena Vista/San Andreas Road, passing through mixed agricultural acreage and scattered residences swinging over San Andreas Road. The Branch then borders the Pacific Ocean for a short stretch adjacent to La Selva beach before swinging away from the ocean passing through increasing residential development until crossing Highway 1 as it approaches Aptos.

The track is in relatively fair shape along this segment including the in-street portion in Watsonville. The track appears to be relatively well-maintained with 90# rail on single-shouldered tie plates with minor to moderate rail wear on curves. Heavier rail sections (112# - 136#) have been installed at locations of sharp curvature. Tie condition appeared fair to good with evidence of a recent tie renewal program. Where ditches have been maintained, the track surface and overall condition of the ballast were adequate for Excepted Track conditions. Issues that will require attention include locations of minor field encroachment just north of Watsonville and isolated locations of slope stability and drainage issues between MP 4.5 and MP 12.5.

Segment #2: Aptos to Santa Cruz (MP 12.5 to MP 22.5)

From Aptos to Santa Cruz, this 10-mile section of the Santa Cruz Branch passes through an increasingly urbanized area passing over several arroyos, through cuts and fills, skirting along canyon edges and the Pacific Ocean near Capitola. As the Branch crosses over the San Lorenzo River at MP 19.4 and into Santa Cruz, the track enters a 3,000 feet section of in-street trackage that begins near the amusement park and extends through the middle of Beach Street until passing through the intersection of Beach and Pacific Streets. MP 22.5 is located near Natural Bridges Road and represents the likely extent of trackage that might be required to interchange with the Santa Cruz Big Trees and Pacific (SCBG) at the Santa Cruz wye and to provide service to the industrial park located near here.

As with the previous section, the track is in relatively fair shape with isolated spots of poorly drained track which has resulted in a deteriorated tie condition. If left unchecked, the track structure at these locations will require greater levels of repair. The rail in this segment is primarily 90# rail on single-shouldered tie plates intermixed with heavier rail sections (112# - 136#) installed over bridges and through sharp curves. Curve wear was evident on several curves. One quarter mile-long section of 75# rail near Fair Avenue (MP 21.5) in poor condition was noted. A mile long section of 136# rail had been recently (1996) installed between the Santa Cruz wye and Seaside Street. This rail appeared to be in good condition. Tie condition appeared fair to good with evidence of a recent tie renewal program. Where ditches have been maintained, the track surface and overall condition of the ballast were adequate for Excepted Track conditions. Issues that will require attention include isolated locations of slope stability and drainage issues, encroachment along the right-of-way at various locations such as observed near Mar Vista Drive. The retaining wall that supports the bridge approach near MP 15.8 in Capitola should be repaired. The use of the Branch right-of-way by dirt bikes between Dufour and Bellevue Streets should be restricted.

Segment #3: Santa Cruz to Davenport (MP 22.5 to End of Track, MP 31.9)
Beyond MP 22.5, the Branch is situated between Highway 1 and the Pacific Ocean until crossing Highway 1 near the Cemex facility at MP 31.19. Much of the trackage in this 9.4-long segment is in good condition and consists of a well-drained track structure and continuous-welded-rail. Because the Cemex facility is currently closed, little if any maintenance would be required for this segment.

Defective railroad tie replacements are generally the most immediate need for most shortline railroads to stay in operation. Based on the field inspection, it appears as if approximately 1/3rd of the 85,000 to 90,000 ties on the railroad have recently been replaced, with the new ties relatively evenly distributed along the length of the line. This was confirmed by information provided by SCCRTC, which indicated that Union Pacific replaced approximately 34,000 railroad ties in 2003. The “average” railroad tie on the line will probably have about 30 to 35 years of useful life. In areas with proper drainage, and where there are no sharp curves, the most recently installed ties, already about 6 years old, likely have 25-30 years of useful life remaining. In areas where there is poor drainage, the useful lifespan of these new ties will be significantly shorter, perhaps as little as 4-7 years, depending upon how often they are saturated and whether or not they are in curved track.

While subgrade and ballast conditions rarely appear to be immediate crises, in the long term, they are perhaps more important than the condition of the railroad ties. Maintenance of ballast, subgrade, and drainage pathways represents an investment activity that must be performed on an ongoing basis, but one which is easily overlooked or deferred. Associated with these conditions, and unique to the Santa Cruz Branch, is the condition of vegetation along the right of way, which overhangs the track in many areas and which has dropped leaf material onto the track, contaminating the ballast and clogging drainage ditches. The overhanging vegetation also creates a condition which can be a violation for State clearance standards and FRA rules. The growing conditions along the line make this issue more severe and critical than normal.

Some sections of the Branch, such as the segment between Santa Cruz and Davenport (between approximately MP (MP) 21 and MP 31) and the segment between the fields north of Watsonville and Trestle Beach Road (between approximately MP 4.5 and MP

9.3), the ballast and subgrade are in relatively good condition, save for isolated sections. A significant amount of work appears to have been done by Union Pacific to restore proper drainage or to add new crushed rock ballast in these areas over the last 10 years. The isolated sections within these longer segments should be addressed in the near future.

However, other sections of the Branch are in uniformly poor condition, such as several segments in and around the City of Santa Cruz (for example, between Bay Street and Rankin Street), and on the northern outskirts of Watsonville where the track runs adjacent to farmers' fields. In these areas, the ballast is completely saturated with mud. While the “poor” sections are generally suitable for the current low train speeds, the drainage conditions in these segments will drastically shorten the life of other track components, especially ties.

We recommend that an aggressive program to improve and then maintain drainage and ballast conditions be established immediately. Such a program, if adhered-to over a period of time, is probably the single best way to maintain the Commission's investment. There are other maintenance items that need to be addressed, but these are relatively minor, or would have isolated impacts to short portions of the railroad (for example, at a specific grade crossing) compared to the impact a good drainage program would produce.

We have characterized sections of the Branch, and the track components within those sections, in three conditions: ”good,” “fair,” and “poor.”

A section characterized as “good” meets or exceeds the parameters for Class 1 track, and perhaps approaches or meets the parameters for Class 2 or Class 3 track.

The areas characterized as “fair” appear to meet the requirements for Class 1 track, with isolated areas which do not meet one or more of the parameters for Class 1 track. These sections would not be appropriate for operation at Class 2 speeds without additional improvements.

The areas characterized as “poor” may be suitable only as Excepted Track, or are in a condition such that they meet the geometric requirements for Class 1 track, but would need more maintenance attention, and need this attention relatively soon, to maintain the Class 1 designation. In many cases, we have characterized a section as “poor” due to drainage conditions which, though they may not present an immediate hazard to operations, if left unaddressed, do present an issue with respect to longevity of the track structure, since the poor drainage will shorten the life of the ties and track surface. Indeed, even in the segments characterized as “good,” there are isolated areas (such as at grade crossings) which also require maintenance attention in the near future.

To generalize, taken as a whole, the Branch is currently suitable for FRA Class 1 operations. The portion of the line between Santa Cruz and the end of track at Davenport is in “good” condition and is, in fact, close to Class 2, although there are isolated areas, particularly at grade crossings, that are in “poor” condition. The section of the Branch through Santa Cruz to Aptos is generally in “fair” condition, with some areas in “poor” condition. The section of the Branch from Aptos to approximately MP 4 near Watsonville is in “fair” to “good” condition. Finally, the section of the Branch between MP 4 and Watsonville Junction (south of the Parajo River) is in “fair” to “poor” condition.

In the remainder of this report, we have provided more detail about conditions along the line, and have characterized individual track components, and done so over much shorter sections of the line.

SUMMARY OF RECOMMENDATIONS AND ASSOCIATED COSTS
The annual cost of track maintenance for the Santa Cruz Branch is a function of level of freight rail service on the Branch plus a reflection of the implementation of a capital improvement program should a long term use of the Santa Cruz Branch ultimately be identified.

- ***Maintenance Costs***
    - "Ongoing" costs for maintenance activities performed on a regular basis - at least annually, but perhaps monthly, weekly, or even daily - by railroad forces. These activities also include inspection cycles of track and signal components as stipulated by the FRA. Maintenance costs have been expressed as an annualized cost.
- ***Capital Improvement Program***, which includes two sub-programs:
    - *Preservation* maintenance costs, which are associated with maintenance items or activities which, by the nature of the work, do not lend themselves to a progressive, continuous approach to maintenance, but rather require that accumulated wear-and-tear be fixed by complete replacement and which appreciably prolong the life of the asset. These are activities that would likely be performed at intervals much greater than one year, for example, replacement of the embedded track at the Santa Cruz Boardwalk.

    - *Modernization* costs necessary to address problematic conditions which, if brought to a certain level of serviceability (or "state of good repair") would eliminate the need for immediate, and perhaps frequent, short-term fixes, and place the section of track into a condition where it could be maintained in a less frequent, more programmatic manner over a long-term basis. These would often fall into the category of capital costs. These have been expressed as unit costs for each element of work. Under this capital expenditure program, class of track and load rating improvements can be funded that would allow potential rail-served shippers to handle heavier rail cars over a track structure that allows higher operating velocities.

Examples of ongoing maintenance costs include track inspection, a baseline track maintenance crew to address minor issues (such as loose track bolts, turnout maintenance, spot surfacing, clearing fallen trees, repair of trespasser damage, etc) monthly inspection of grade crossing signal systems by contract forces, and an annual ditching program to clear drainage pathways.

Capitalized Preservation Maintenance Costs include rehabilitating track at public or private grade crossings, or rehabilitating the track embedded in pavement at the Santa Cruz Beach Boardwalk or at Walker Street in Watsonville. The latter cannot effectively be maintained on a monthly or annual basis; rather, the most cost effective way to maintain embedded track is to let it degrade to some minimum level of serviceability, then repair large sections all-at-once. These activities repair components that eventually degrade over time, and prolong the life of the asset.

Another example of a preservation cost is replacement of railroad ties. While a shortline operator could replace the ties by itself, it may be more cost-effective, and produce a better product, if a contractor were employed to replace ties in larger quantities every 24 to 48 months. The shortline operator would install a smaller number ties on an as-needed basis to correct unusual conditions or at particularly troublesome areas.

An example of a modernization activity might be to replace the bolted rail with Continuous Welded Rail (CWR) thereby eliminating as many rail joints as possible (since the bolts wear and loosen over time) in order to provide the short line operator with a serviceable railroad on which to begin operation. Such repairs are relatively expensive and might create cash-flow issues in the early years of operation if not properly budgeted. After the CWR has been installed, the ongoing cost of rail maintenance, would be relatively minor.

The baseline case for costing assumes a level of service of approximately 4,500 annual carloads of 268,000 pound (268k) gross weight on rail (GWR) capacity per year with a similar number of returning empty cars), and representing approximately 0.7 million gross tons (MGT) total traffic per year, with a 10 MPH maximum operating speed, equating to FRA Class 1 Excepted Track.

While FRA Class 1 Excepted Track and 268,000 pound weight on rail constitute the current case, HDR explored the relative increase in costs required to attain FRA Class 1 with 286,000 pound weight on rail, FRA Class 2 with 286,000 pound weight on rail, and FRA Class 3 with 286,000 pound weight on rail. The increased levels of service and the associated impacts on cost, are summarized in Table 1.0, below. The upgrade to FRA Class 2/3 and/or the increase in weight on rail, are entirely optional, and are not required to provide freight rail service on par with 2008 levels.

Table 1.0: Estimated Maintenance and Capital Costs – Entire Santa Cruz Branch

FRA Track Class	Load Rating	On-Going Maintenance	Capital Expenditure
Excepted	268K	$370,000	None
Class 1	268K	$370,000	$7.8M
Class 1	286K	$410,000	$10.0M
Class 2	286K	$540,000	$23.0M
Class 3	286K	$540,000	$95.7M

Operating the line at Class 2 or Class 3 speeds will require a significantly higher level of capital investment, as well as maintenance. While the trackage between Santa Cruz and Davenport (Segment 3) might be operated at increased speeds with comparatively little investment, the track maintenance costs will increase significantly. Thus, there is likely no incentive for a freight operator to undertake a level of maintenance or investment at speeds higher than Class 1 since the key benefits derived from upgraded track are increased safety, reduced risk of derailments, and the ability to move at a higher rate of speed. The length of the line and track geometry are such that the only operating savings generated from this investment would be minor fuel savings and protection against crew overtime. Whether the line is run at 10 MPH or 25 MPH, each day of operation will require one train crew. Furthermore, current freight service is only operating between Watsonville and Santa Cruz as the operation at the Cemex facility at Davenport is temporarily suspended. Consequently, Table 2.0 below lists the estimated maintenance and capital costs for the two segments between Watsonville and Santa Cruz, a total of 22.5 miles. Maintenance costs could conceivably also be reduced by 1/3; however, this adjustment is not recommended at this time as the costs for on-going maintenance included in Table 2.0 would therefore be considered an upper-limit for a track maintenance budget. Also, under the tax credit allocation formula described below, the total length of the branch line should be included for on-going maintenance cost allocations.

Table 2.0: Estimated Maintenance and Capital Costs for Segments #1 & #2 = 22.5 miles			
FRA Track Class	**Load Rating**	**On-Going Maintenance**	**Capital Expenditure**
Excepted	268K	$370,000	None
Class 1	268K	$370,000	$6.3M
Class 1	286K	$410,000	$7.0M
Class 2	286K	$540,000	$16.0M
Class 3	286K	$540,000	$67.5M

Recommendations

From the perspective of the fourth quarter, 2009, the Santa Cruz Branch is currently seeing limited freight service due to the closure of the Cemex facility. Rail shipments are being originated and delivered to the Santa Cruz, Big Trees and Pacific Railroad in Santa Cruz, and at various industries along the corridor primarily at Watsonville. No rail service is currently warranted beyond Milepost 22.5. For that reason, Table 3.0 displays the maintenance and a proposed capital program for branch-line rehabilitation should only the first 22.5 miles of the Branch be rehabilitated. In addition, because there is no identified use of the Branch, no capital expenditure program is recommended at this time. Accordingly, as the cost estimates were not derived with any proposed purpose in mind, the estimated costs included in Table 1.0 and 3.0 should only be used as "placeholders" and not used to developed projects that might be pursued in the future.

Table 3.0 Recommendations				
FRA Track Class	**Load rating**	**On-Going Maintenance**	**Capital Expenditure**	**Comments**
Excepted Track	268K	$370K	None	As-Is
1	268K	$370K	$6.3M	Not Recommended
1	286K	$410K	$7.0M	Not Recommended
2	286K	$540K	$16.0M	Not Recommended
3	286K	$540K	$67.5M	Not Recommended

For instance, if the Branch Line were used for the current limited freight service, then the Excepted Track designation would be adequate. If some remedial repairs are desired should the Cemex facility resume operations, then applying for a grant or loan (see Other Funding Sources below), would allow SCCRTC or the freight operator to perform repairs to the track and bridges. If higher speeds are desired, adopting a program to improve track conditions to allow for a Class 2 or Class 3 operation may be established. However, SCCRTC would need to understand why a higher speed operation is warranted.

The freight operation that was in-service when Cemex was in full operation was considered adequate under the existing Excepted Track regime. Furthermore, at higher speeds, additional work at the at-grade rail/highway crossings would be required so that the active warning devices that protect each crossing are updated to accommodate the higher speeds. If remotely controlled signals and switches are indicated should Centralized Traffic Control be required, then a more reliable signal from the track circuits would be necessary. If so, then rehabilitating the Branch using a P-811 would then be warranted. Rehabilitating trackage using a P-811 results in a completely new track section being install in one pass by this locomotive-powered track laying machine. This is a large-scale operation where the new rail is distributed ahead of the P-811 operation, then the ties are pulled on the existing track and as the P-811 proceeds over this track, the old rails are picked up and shoved to the side of the track, the old ties and ballast scooped up and recycled, then new ties are placed on a smoothed subgrade and the new rails pulled in from the side of the track onto the new ties. In this sense, the front of the P-811 rides on the old track and the rear of the machine rides on the new track, all in one motion forward.

As a comparison, comparable costs for the P-811 upgrade of a 14.7 mile section of a secondary branch main in Oregon for a proposed commuter rail service cost $2.8M/mile. Site work associated with bridge replacement and repair, grading costs associated with the proposed commuter service cost $2.5M/mile and systems cost $1.4M/mile. Total physical plant costs are therefore in the $6.7M/mile range. To upgrade the segment of the Santa Cruz Branch from Watsonville through Santa Cruz to Natural Bridges Drive would cost an estimated $150 million.

P-811 in operation. One pass of this machine results in completely new track section.

As a result, HDR cannot recommend that a program to procure capital expenditure funds be initiated until such time as a purpose for the use of the Branch is identified. This Branch Track Maintenance Study conducted by HDR plus the Bridge Rehabilitation Study performed by HNTB, can both be used as reliable data sources to develop a purpose-built rehabilitation program once the use of the Santa Cruz Branch as been determined.

Other Funding Sources:

Several alternative sources for fund to rehabilitate the track and bridges along the Branch should be investigated. These include the Railroad Rehabilitation & Improvement and Financing (RRIF) Program. Administrated by the FRA, the RRIF program can be used to:

(1) Acquire, improve and/or rehabilitate rail facilities or intermodal yards including track, components of track, bridges, yards, and shops,
(2) Refinance debt incurred for the purposes listed above,
(3) Develop or establish new rail facilities or intermodal yards.

Further information can be obtained by using the following link to FRA's website:

http://www.fra.dot.gov/us/content/177

In addition, the American Short Line & Regional Railroad Association (ASLRRA) has established, through Congress, a tax credit program that allows tax credits to be apportioned to rail-related projects. This program was recently re-authorized and should be examined for applicability as a funding source for Santa Cruz Branch rail improvements. The tax credit is for maintenance expense on shortline rail right of way and can be applied at the rate of $3,500.00 per mile, which for this Branch would equate to $108,500.00 of tax credit per year for the 31-mile long Branch. Should a catastrophic incident occur, such as a flood or earthquake, the Santa Cruz Branch would become eligible for FEMA relief should the Santa Cruz area qualify for this type of aid.

Based on our understanding of the current and projected traffic (i.e., freight traffic consisting of non-hazardous commodities, only), we see little benefit to designating the line as a Class 1 railroad, and we recommend that the line continue to be designated as Excepted Track (which provides the same operating speeds as Class 1 track, but a wider latitude for maintenance) and maintained to *at least* Class 1 criteria. If the railroad were operated at Class 1 speeds, the railroad should be maintained at Class 2 criteria.

UNDERLYING ASSUMPTIONS

The assumptions upon which this, or any other cost estimate, are based are key to understanding the meaning of the cost estimate. Different assumptions about the balance between capital investment and maintenance expense, or about the standard to which the line will be maintained, will result in differing maintenance cost estimates.

HDR's assessment of this line is based on an assumption that the line will be required to move approximately 4,500 carloads of bulk freight a year. Secondly, we have assumed that SCCRTC will want to apply all Best Practices to the maintenance plan. Thirdly, this maintenance plan is not constrained by balancing maintenance needs with a related revenue stream. As such, this maintenance plan may be at odds with the maintenance plan a particular railroad might elect to apply to this line.

Class 1 railroads (such as Union Pacific or BNSF) historically have retained properties where the revenues exceeded their cost of operation, deferred maintenance when possible on less profitable lines, and ultimately either sold under-performing lines to shortline railroads or abandoned the line segment.

Shortline railroads, working on a different business model than Class 1 railroads, are quite successful in operating properties that were not profitable as Class 1 railroad branch lines (not to be confused with FRA Class of Track 1, 2, 3 and so forth, a Class 1 railroad is a designation as derived by the Surface Transportation Board as a railroad whose revenue exceeds $250M annually).

All railroads make maintenance and capital decisions based on the business case for a particular line segment or market. Often business realities will result in a minimalist approach to maintenance. In such cases, the money allocated to maintenance is not driven by Best Practices, but is driven by traffic levels and revenues generated by the line. Please note that HDR was not asked to develop a revenue-constrained model for maintenance.

HDR's recommendations above assume that the railroad will be maintained in its current condition, or better, regardless of the freight service on the railroad or income generated by the freight business. One of the outcomes of this expectation is that the level of maintenance performed exceeds minimum requirements, with the intent of pro-actively avoiding infrastructure degradation in the out years.

HDR recognizes that it might be possible to defer major maintenance for a period of time. For example, it might be possible to do minimal maintenance beyond basic "on-going maintenance" for one, two, or three years, depending upon traffic levels. However, within a limited time frame, it is probable that conditions would then require some level of capitalized maintenance program to preserve or to modernize the facility. Until such time as a purpose for the Branch is identified, other than its current usage, then only a limited program of on-going maintenance and no capital expenditure program is hereby recommended

The details of our maintenance findings are included in the following sections.

SANTA CRUZ BRANCH MAINTENANCE STUDY

1. INTRODUCTION

The Santa Cruz County Regional Transportation Commission is investigating the possible purchase of the Santa Cruz Branch from Union Pacific Railroad. The Branch extends approximately 31 miles from Watsonville Junction, a connection point with Union Pacific's national network, through Santa Cruz, CA to Davenport, CA. Part of SCCRTC's due diligence effort includes developing an understanding of the overall condition of the Branch, and the estimated cost to maintain the Branch on an ongoing basis.

This report is divided into several sections, beginning with an overview of the categories of track maintenance (ongoing, capital programs for preservation or modernization) of the facility; continuing with an general overview of the components of railroad track and their conditions on the Branch, and general recommendations for each type of track component; an overview of track geometry; an overview of each section of the Branch; and concluding with recommendations and cost estimates for the various categories of maintenance and capital expenditure.

Note that directions along the railroad are established by the operating timetable and do not always correspond to directions on a compass. However, for the purposes of this report, Watsonville will be considered the South end of the line, while Davenport will be considered the North end of the line. Points along the track, regardless of their relationship to each other with respect to compass directions, will be referred to as "North" or "South" of various other landmarks along the railroad. And, using this scheme of north and south as a reference, the respective sides of the right of way will be described as "East" or "West." Thus, the "West" rail is the rail closest to the ocean.

1.1 Description of Types of Maintenance

The purpose of this report is to identify the likely cost of maintenance of track and signal facilities along the line, as well as the capital cost of any initial expenditures required to bring the line into a "state of good repair." In developing the costs, it was assumed that a short line operator would perform the majority of the regular, ongoing maintenance. It was assumed that a contractor would perform major maintenance projects which are required on a less frequent, but nonetheless recurring basis, the results of which have a longer lifespan and prolong the life of the track structure. These larger, but less frequent projects which are intended to prolong the life of the asset are described herein as "preservation" maintenance costs which are listed under a capital expenditure budget.

"Modernization or State of Good Repair" projects refer to those activities that are necessary to address deferred maintenance issues, or major, one-time investments that have an indefinite lifespan (as opposed to regularly recurring activities). An example of a state of good repair activity might be to purchase and install new or second-hand CWR over a large segment of the Branch, or to rehabilitate the track at grade crossings where large sections of ballast and roadbed have become fouled with mud. After the capital expenditure repairs are complete, only minor maintenance to the track would then be necessary.

The maintenance cost for structures (including bridges, retaining walls, and culverts) is not included in this report, although potentially significant “state of good repair” issues are known to exist on specific structures, and that maintenance of structures represents an ongoing cost.

1.2 Maintenance Criteria and Classes of Track

The baseline for track maintenance recommendations in this report is the Federal Railroad Administration’s Track Safety Standards (Table 1.2). The Track Safety Standards provide *minimum* standards for track safety, which effectively establishes several levels (or “Classes”) of track maintenance with corresponding maximum train speeds. For example, “Class 1” track requires the lowest level of maintenance, but also allows only the lowest train speeds (10 MPH maximum for freight trains), while “Class 2” track allows higher train speeds (25 MPH for freight trains) but also has stricter tolerances for maintenance. Thus, Class 2 track is more maintenance intensive than Class 1 track. Also, note that freight and passenger train speed limits differ for the same Class of Track.

Table 1.2 FRA Track Safety Standards

Track Class	Freight	Passenger
Excepted	10	N/A
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90

Again, please note that the maintenance criteria set forth by the FRA are *minimum* criteria for each class of track and associated operating speed. Maintaining track only to the minimum criteria implies that, as soon as one of the many maintenance parameters falls below the FRA criteria, the track must be immediately repaired, or operated as the next lowest class of track. For example, if track were both operated and maintained at Class 1 levels, any defect that did not meet the criteria for Class 1 track would essentially render the track unfit for service.

In order to provide some margin of safety, it is common practice in the railroad industry to maintain track to the next class *higher* than that at which the track is actually operated. For example, if operations occur at Class 1 speeds, it would be common practice to maintain the track to Class 2 standards. In this way, minor defects that arise do not unintentionally reduce the class, or quality, of track to a level below that at which it is being operated. For example, if the track were operated at Class 1 levels, but maintained to Class 2 levels, defects in the track that rendered it unsuitable for Class 2 speeds (despite the fact that the track was not being operated at Class 2 speeds) would likely still be within the tolerances for the Class 1 operating speeds. By maintaining the track to the next highest class, a margin of safety is introduced to the track maintenance process.

This study assumes that the level of track maintenance (and thus the cost of track maintenance) will be commensurate with a railroad that has an indefinite longevity. In other words, the levels of maintenance identified in this report assume that the service levels on the line remain at historic levels, that the current condition of the line will be maintained to current conditions, and that the line will need to be maintained at the current level indefinitely - over, say a 30 to 50 year time span.

Currently, most of the track between Watsonville and Davenport is considered “Excepted Track,” a designation which reduces the maintenance and inspection burden. This designation is generally used for track that does not meet the minimum maintenance requirements for even Class 1 track, but is still operated at Class 1 speeds. With this designation come certain restrictions on what commodities are carried over the railroad. Specifically, passengers cannot be transported over excepted track, and hazardous materials can only be transported under specific circumstances.

Since, to our knowledge, the current types of traffic (i.e., no hazardous materials or passengers) will remain on the line, we believe that the line should continue to be operated as Excepted Track, but maintained to at least Class 1 criteria, and preferably to Class 2 criteria, wherever possible. Note that if passenger trains are operated over the section between the Santa Cruz wye and the Boardwalk, this short section would need to be maintained to Class 1 standards.

2.0 COMPONENTS OF RAILROAD TRACK

At the most basic level, railroad track is comprised of 5 major components, each of which is an engineered material serving a structural function:

1. Rail and track fittings
2. Ties
3. Ballast
4. Subballast
5. Subgrade

Following forces downward through the track, we see that the full weight of a train bears on the rails which, through their “bridging” or “girder” action, distribute the load of each wheel across several ties which, in turn, distribute that load downward to the crushed rock ballast which, in turn, distributes that load downward to the subballast, which, in turn, distributes that load downward to the subgrade (or natural ground). As loads are distributed downward through the track structure, they are dispersed, so that components at the bottom of the track structure (like subgrade and subballast) see the lowest stresses, while components higher up in the track structure (like rail and ties) see much higher stresses. Thus, to understand the condition of the railroad, it is important to understand the condition of each of these major components.

Discussion of each of these components will begin with the rail, and continue working “downward” through the track to the ties. The ballast, subballast (of which there is little or none on the Santa Cruz Branch), subgrade, and drainage conditions will be discussed as a group, since their conditions are closely inter-related. Finally, the track geometry, which describes the surface (vertical) and alignment (horizontal) conditions of the track will be discussed.

2.1 Rail and Rail Fittings

2.1.1 Types of Rail

Under traffic conditions experienced on this rail line, rail is one of the longest-lived track components, but also represents a significant investment at the time of replacement. In general, larger, heavier rails, though more expensive, provide better support for the trains, have a longer life, and also promote longer life for the ties that support the rails, than do lighter, more flexible rails.

Approximately 40% of the track on the Branch is comprised of a relatively small, light rail section known as “90 pound” rail, so-called because the rail weighs 90 pounds per yard (the standard unit of measurement for railroad rail). 90 pound rail is suitable for low speeds, but the relatively flexible nature of track constructed with this rail (and its ancillary components) make it generally unsatisfactory for combinations of higher speeds and/or heavier equipment. The specific style or “section” of 90 pound rail on the Branch is known as “90RA,” where the letters “RA” designate a particular cross sectional shape (know as the “section”) of the rail.

Of the 20 miles of track between Watsonville and Santa Cruz, 13 miles is laid with 90RA rail. Most of the straight (“tangent”) sections have 90RA rail, while many of the curved sections, and particularly the sharper curves, are laid with heavier rail, which has higher girder strength, is less flexible in both the vertical and horizontal directions, and is generally considered superior to 90RA rail. Examples of these heavier rail sections found on the Branch include 110RE, large quantities of 112RE, 113HF, 132HF, and 136RE. As with 90 pound rail, the number designates the weight per yard, while the letters designate the specific cross sectional shape. Notably, many areas between Watsonville and Santa Cruz identified on track charts as 113HF rail appear to be combinations of rail sizes ranging between 110RE and 113HF, but primarily 112RE, a rail section which, by virtue of its geometry, was slightly more prone to failure than other, similar weight sections. Please note that we have not attempted to inventory each specific size of rail on the Branch, nor verify the accuracy of the rail sizes listed in the track charts.

North of Santa Cruz, all the rail – about 10 miles – or about 1/3rd of the total length of the 31-mile long railroad, is 110RE or heavier. There are short sections (less than 0.1 miles) of 75CS rail (even lighter and less strong than 90RA rail) in service between Rankin Street and Fair Avenue in Santa Cruz.

Most of the rail on the Branch (about 20 miles of the 31 mile total length) is “jointed rail,” which has a splice, held fast by bolts, connecting every rail to the adjacent rail. The disadvantage of jointed rail is that the joints need regular maintenance – the bolts become loose and require tightening, and over time the joint bars wear to the point that they can no longer be tightened effectively (this is particularly true if the joints have been allowed to remain loose for long periods). The remainder of the Branch, mostly north of Santa Cruz, has heavier rail known as “continuously welded rail” (CWR), a type of rail which has no bolted joints between rails, but rather each rail is welded to the adjacent rail, thus forming continuous strings of rail extending for several miles.

It is necessary, especially in CWR, to place anchors on the rail to restrain the rail from longitudinal movement, since rail, like all steel, expands and contracts with variations in temperature. Anchors applied to the rail base next to the ties use the ties, which are embedded in the ballast section, to restrain the movement of the rails. If rails are not properly restrained by anchors, the longitudinal movement accompanying cold weather may cause the rail at joints to pull apart, literally shearing-off the bolts, while the expansion of unrestrained rails in hot weather may cause compression forces to accumulate in the track and possibly causing the track to shift laterally, sometimes violently. Both of these situations have the potential to cause a derailment.

While rail anchoring on jointed rail is less critical with respect to the compression forces that occur during hot weather, it could be a problem if higher train speeds were implemented, since the traction and braking forces transmitted from the trains to the rail would be significantly higher. The anchor pattern on the jointed 90RA rail is inconsistent, and, while no pull-aparts were noted during the field inspection, the generally insufficient number of rail anchors on the 90RA rail (particularly on or near steep grades) should be addressed if Class 2 speeds are contemplated.

All of the 90RA rail and much, if not most, of the heavier rail on the Branch was produced by the open-hearth steelmaking process, and is subject to a higher incidence of internal defects than rail produced after 1931, when a technique known as “control cooling” improved the metallurgy of steel rails. The defects in open-hearth rail do tend to increase the incidence of broken rails, particularly when the rails are poorly supported, either due to defective ties or inadequate surface, both of which are often associated with poor subgrade conditions. Like the 90 pound rail, much of the heavier rail is also “open-hearth.” This should be a consideration if significantly higher train speeds are contemplated.

2.1.2 Rail Condition

Because the Branch is laid with so many different types of rail, including many stretches of second-hand rail which has already been well-worn before it was installed in the Branch, it is difficult to make blanket characterizations regarding the rail conditions over long segments of the line. To understand more specific details of the rail condition the reader is directed to the appendices at the end of this report, which characterize conditions within shorter sections of the Branch.

Due to the ballast and subgrade conditions, joint bar conditions, as well as maintenance levels appropriate to a Branch line (but not to a higher-speed line), sections of the existing track laid with 90RA rail appear to have been “surface bent.” This means that there is a permanent downward bend in the rail at the joints. The factors that tend to increase the vertical loads at rail joints – factors which fundamentally *cause* low joints - are exacerbated when joints become low or bent downward. As joints become lower, these forces further increase in a self-reinforcing cycle which results in increasingly rapid deterioration of the joint infrastructure. At Class 1 speeds (10 MPH maximum), the surface bent rails on the Branch do not appear to pose a problem, nor do they generally appear to exceed the minimum geometric parameters for Class 1 track. However, the surface bent rail does not appear to meet the minimum criteria for Class 2 track.

Based on the field inspection, approximately 50% of the 90RA rail on the Branch, or about 7.5 track miles of rail, appears to be surface bent to the point where speeds above 10 MPH could be problematic from a maintenance standpoint. The condition appears to be worst near Watsonville, where some sections might, in fact, not meet the geometric parameters for Class 1 track, but rather be suitable for operation only as Excepted track. There is no economical way to repair this condition, other than to replace the rail. The situation can be mitigated, somewhat, by tightening the joints, adding ballast, and surfacing (leveling and/or raising) the track with a modern tamping machine that is equipped with rail clamps between its front and rear axles.

While the remaining 50% of the 90RA rail has less surface bending (though some surface bending is still present), the inherent flexibility of this small rail implies that a great deal of maintenance effort would have to be expended in order to operate at Class 2 or Class 3 speeds.

One of the effects of surface bent rails is that, as a train operates over such track, the combination of low joints on alternating rails imparts an undesirable rocking as a train progresses which can become exacerbated at specific speeds due to a harmonic established between the low rail joints (which occur at regular intervals, based on the length of each rail and the consequent location of each rail joint) and the wheels and suspension of a railcar. Indeed, this rocking can become so severe that it can become a hazard. This rocking motion is known to be a particular problem for certain types of railcars, since the natural frequency of their rocking motion reaches a harmonic with the low joints at certain critical speeds, typically between 12 and 18 MPH.

The “critical speed” of covered hoppers on jointed rail should be considered as SCCRTC considers increasing the speeds of freight trains on the Branch above 10 MPH. The issue of critical speeds results from a specific length of rail car responding to the location of joints in specific lengths of rail, and is most commonly associated with grain hoppers on 39’ rail. Generally, operating rules on most railroads dictate that, if a train with certain types of covered hoppers cannot maintain a speed above approximately 18 MPH, it must reduce its operating speed below 12 MPH. The many steep grades along the southern sections of the line may prevent trains from achieving the maximum speed for Class 2 operations, 25 MPH. In these sections, if trains cannot operate at least faster than the critical speed range for covered hoppers, trains may be forced to operate at speeds below the critical range. Since the issue of harmonic speeds is related to speed, the length rail car and length of each rail, and the covered hoppers used for cement service are shorter than grain hoppers (and not generally known for the problem of harmonic rocking on 39’ rails) if there are stretches of shorter rail on the branch (36’ rails were one early standard length), this phenomena should be considered in conjunction with the shorter cars. Observation of train operations would likely identify if this is an issue. Severe harmonic rocking is unlikely to be an issue at Class 1 speeds.

Restrictions of this nature tend to be car-type and rail-length specific, based on the natural harmonic period of a specific type of car with a specific center of gravity when on specific lengths of jointed rail; thus, these restrictions may or may not apply to the specific design of covered hoppers commonly routed over the Branch. However, by virtue of the narrow window of acceptable speeds between 18 and 25 MPH, if such restrictions were applicable, they could effectively reduce operating speeds over the jointed rail sections of the Branch to little more than allowed by FRA Class 1 track.

Surface bent rails near MP 2.5, between Ohlone Dr and the State Highway 1 overpass in Watsonville. This section is one of the worst for surface bent rails.

Also of note is the fact that a significant amount of rail in the curves south of Santa Cruz is worn-down to the point that the flanges of the train wheels are riding on the joint bars. This is an undesirable condition, not only because of the amount of accumulated wear that is required to reach this point, but also because of the unusual impacts created when wheel flanges suddenly strike the joint bars, making it difficult to keep the bolts at each joint tight. This condition is generally frowned upon by the FRA, and, if allowed to continue, cold pose a threat of derailment. There is no economical way to repair this condition, other than to replace the rail. The rail joints could be welded in the field, eliminating the joint bars, but this expensive process would not eliminate the fundamental problem of worn rail.

This joint bar shows evidence of wheel flanges striking the top of the bar. While wheel flanges are normally maintained at a relatively constant geometry, if the top of the rail is worn-down sufficiently, the flanges can contact the joint bars. This condition places unusual stresses on the joint bars and bolts, and the pounding makes it difficult to keep the bolts tight.

The tie plate in the foreground is of a style suitable for larger rail, but has been modified with an extra spike hole, closer to the rail, to fit this size rail. This is considered poor practice, as it reduces the number of spike holes available. Since the plate is too large to fit the rail, the shoulder on the inside of the plate is not serving any function.

The portions of the rail on the Branch comprised of heavier rail sections, ranges in condition from “good” to “poor.” Much of the heavier rail is severely curve worn, meaning that the gauge side of the rail (the vertical surface oriented toward the inside of the track) has been worn to a slanted surface, matching the “average” shape of a wheel flange, or that the top surface of the rail has been worn down. There are two main concerns associated with heavy curve wear: 1) the reduction in cross sectional area of the rail increases the stress in the rail when trains pass over it, and 2) a heavily worn gauge face, which nearly matches the angle of the wheel flanges, presents a “slope” up which a wheel flange can climb and subsequently cause a derailment.

North of Santa Cruz, there is a mixture of jointed rail and continuously welded rail (“CWR”), with all rail being 110RE or heavier. The rail in this portion of the line, comprising approximately 1/3rd of the railroad (or about 10 miles) appears to be in consistently good condition, no doubt due in part to the much broader and smaller number of curves. There appears to be little problem with thermal expansion in the CWR, though it is not known if the rail has been thermally adjusted to a specific neutral temperature (i.e., a temperature at which there is zero thermal stress).

The tie plates, upon which the rail sits, are, in some cases, a “hybrid” tie plate, designed for a larger sized rail (e.g., 132HF or 136RE), but modified to suit smaller rails (e.g., 110RE through 113HF). Though they will provide adequate bearing area over the tie, there are some disadvantages to using these tie plates, chiefly that high-production gauging work done by a full tie gang, with specialized equipment, is difficult with these plates. Though these plates appear to be confined mostly to the 110RE to 113HF rail on the portion of the line between MP 4.5 and Aptos, they are intermixed with other styles of tie plates along the line, and thus the total number of this type of plate is uncertain.

2.1.3 Rail Joint Condition

The railroad is constructed primarily with jointed rail between Watsonville and Santa Cruz, with short segments of welded rail in Walker Street in Watsonville. Many of the 90RA joint bars are of the “continuous” or “wrap-around” style, are worn, or feature one or more loose bolts. These joint conditions promote surface bent rails, tie damage, and “batter” to the rail ends. As noted previously, each of these conditions added together can cause more rapid deterioration in the overall condition of the track.

North of Santa Cruz, track charts indicate that most or all of the rail is CWR which, by definition, has few or no joints. Consequently, one of the major maintenance items (rail joint maintenance) has been eliminated for the track north of Santa Cruz. The same is true for the rail embedded in pavement in Walker Street in Watsonville, and also in Beach Street, between Pacific Avenue and Cliff Street, in Santa Cruz. Rail joints embedded in pavement in front of the Santa Cruz amusement park are in fair to poor condition, though, in their current condition, they would meet the minimum requirements for Class 1 track.

2.1.4 Recommendations for Rail and Joint Maintenance

While the 90RA rail on the Branch is in “fair” to “poor” condition, it appears generally suitable for the current level of service at 10 MPH, with 268,000 pound gross weight on rail (GWR) cars. With proper maintenance, including a tie and joint maintenance and surfacing program, it could be made suitable for 286,000 pound GWR cars. Note, however, that a larger state of good repair investment would be required for 286,000 pound operations (particularly if Class 2 or higher operating speeds were desired), chiefly to address subgrade issues. Much of this investment would also be focused on eliminating the worst stretches of 90RA rail. While there are examples of railroads with 90 pound rail in service for speeds above 10 MPH, in general, these are situations that require very intense levels of maintenance, and involve track (rails, ties, ballast, subgrade) that is in relatively good condition.

Overall, given that the 90RA rail on the line is approaching 100 years of age, and for the last 40-50 years it has been supporting loads far in excess of what it was originally intended to carry, this rail has yielded an exceptional return on the original investment. However, the fatigue life of the rail, both the 90RA and heavier sections, is a consideration (though perhaps more so for the 90RA rail). Fatigue life is related to metallurgy as well as the amount of traffic (tonnage) that has been accumulated on a given piece of rail, and to the geometric deflections the rail has undergone while accumulating that tonnage. The consequence of rail reaching or exceeding its fatigue life is a significantly higher incidence of broken rails and increased risk of derailment. However, since most of the rail on the Branch is second-hand material released from other locations, it is impossible to know how much traffic has passed over it before it was installed in the Branch.

Due to the uncertainty in remaining fatigue life, for the base case scenario, (268,000 pound loads operating at Class 1 speeds), we have assumed that, over the next 24 years, approximately 14 track miles of rail, or nearly 50% of the rail on the Branch, will need to be replaced to address fatigue issues, as well as to address rail head wear in curves. In addition, as part of the capital expenditure program under the modernization category, approximately 1.5 miles of rail would be replaced within the next one to two years in order to address the most severely worn curves and areas of surface bending. We would recommend that the short sections of 75CS rail be replaced within the first 1 to 2 years of operation under 268,000 pound loads, or immediately if 286,000 pound loads are introduced. Once the future purpose of the Branch is fully understood, the existing 90RA should be completely replaced with 115# CWR or heavier rail.

Although special “high clearance” joint bars have been used in the railroad industry as an attempt to extend the life of severely curve worn rail by reducing the incidence of wheel flanges contacting the joint bars, we do not believe they are an appropriate repair, since they do not address two of the fundamental problems related to severely worn rail (increased stresses and higher probability of flange-climb derailments).

A detailed inventory and assessment of the rail condition, including an update of track charts, should be an early priority. This assessment, in turn, would provide a reasonable basis for establishing a rail maintenance program. For example, while much of the 90RA rail is surface bent, the 90RA rail between MP 9.7 and MP 12.0 is in generally good condition and the track in this area is generally well-supported by a clean ballast section. A detailed assessment for the base case scenario may reveal the surface bent rail to be some of the last rail to be replaced, with higher priority being given to replacing curve worn rail.

For the cost estimates, we have assumed that such an assessment would be done visually, and be performed by the shortline operator as part of the regular ongoing maintenance activities, rather than being performed by an specialty rail inspection contractor. However, a highly detailed inventory could be performed with the assistance of a rail inspection contractor, which includes identification of rail types, rail wear parameters, and even a search for internal defects in rail and joint bars. The Commission should consider such an inspection and inventory, especially in light of the rail wear conditions on the Branch. If performed at regular intervals, such inspections can be used as a predictive tool to anticipate rail wear and schedule rail replacement.

The cost of railroad rail and associated fittings, being comprised entirely of steel, is highly responsive to domestic and international market conditions for steel products and scrap, which must be kept in mind when evaluating railroad maintenance costing and the specific scheduling of rail purchases. To economize on material costs for rail replacement work, our estimate assumes that rail replacement would be performed with second hand rail, which is consistent with industry practice for a freight line with this level of traffic.

In an effort to extend the life of the rail, it is possible to change the orientation of the rails in curves, known as “transposing” the rail. This practice moves the inside rail on a curve to the position occupied by the outside rail, and vice versa. In so doing, the wheels and wheel flanges wear against surfaces that were formerly on the “outside” or “field side” of the track. However, this practice would likely only be worthwhile on rail heavier than 90RA, and would further only be worthwhile in curves where the outside of the rail was in good condition – there is only minimal value in transposing rails when the condition of the “field side” is nearly as bad as the condition of the running or “gauge” side. Since all the heavy rail on the Branch is second hand (implying that the “outside” surface of the rail is already worn), transposing the rail would be cost effective in only a very few locations.

In order to preserve the rail in curves and to retard the rate of wear, we recommend immediate installation of curve lubricators at selected locations, but especially at curves over 4 degrees. These are wayside devices that dispense a lubricating solution from an internal reservoir which would be periodically refilled by maintenance forces. Various types of lubricants are commercially available, with some being bio-degradable. Based on track charts, there are approximately 43 locations where curves exceed 4 degrees; however, it is likely that many curves are close enough together that one curve lubricator could be installed in a location such that the lubricants it dispenses would be distributed over several curves. Another advantage of lubricators is that they will tend to decrease the tendency for flange climb derailments in areas of high curve wear. Lubricators have an added benefit in that they could be placed near populated locations to reduce the “wheel squeal” caused by the interaction of a rail car wheel as it passes around a sharp curve.

Determining the actual quantity of lubricant dispensed, type of lubricant, and location for the lubricator device is, to an extent, a trial and error process to obtain the proper amount and location of lubrication based on site-specific and device-specific experience. Variables include train speeds, ambient temperatures, precipitation amounts, train weights, track geometry, and the need for gauge face lubrication versus top-of-rail lubrication on the outside and inside rails, respectively. The downside to the trial and error process is waste of lubricant or, in the most extreme cases, difficulty for trains to climb steep grades.

For the capital expenditure estimate under the preservation category, we have assumed that 15 curve lubricators be installed. It is important to note that the locations of these lubricators be planned carefully so that the lubrication patterns conform to those identified in the American Railway Engineering and Maintenance of Way Association (AREMA) Manual, since it is possible to unexpectedly increase curving forces by installing lubricators in the wrong locations. These devices are comparatively small and can be relocated relatively easily, should it be desired to try new locations in attempt to maximize their benefit; indeed, though the AREMA Manual provides guidelines for the placement of lubricators, it also identifies the fact that the site-specific conditions play a large role in determining lubricator placement and lubricant application rates.

Although curve lubricators are a permanent option, another option would be to apply friction modifiers from a hirail truck during track inspections. This is likely the most effective, short-term method to obtain curve lubrication at start-up of operations. However, if the track is inspected by hirail truck only once per week, it is possible that rainy conditions could decrease the effectiveness of lubrication applied, if there is a sufficient lag between the inspection and train operations. Thus, this option should be evaluated in concert with the operating plan for the Branch.

In order to preserve the condition of the rail joints, ties under the joints, and retard their deterioration, we recommend that a program of rail joint lubrication, bolt tightening and bolt replacement be instituted on the jointed rail sections of the Branch as part of the state of good repair work. We estimate that as many as 50% of the bolts would need replacement in the first one to two years. We have assumed that subsequent bolt replacement and tightening would be performed by maintenance forces. Since this will produce benefits not only for the longevity of rail joints, but also the rail and ties, this should be a high priority activity.

Establishing proper rail anchoring wherever possible and particularly on the hill between MP 4.5 and the Buena Vista Road crossing and on the “crests” at vertical curves is recommended, though not the top priority for rail maintenance. Our cost estimates assume maintenance forces would perform this work as part of the ongoing maintenance task, since applying anchors is relatively fast, inexpensive, and can be accomplished with hand tools, and even a small investment of time – perhaps a day or two – can result in substantial progress.

Addition of rail anchors (which rely on the elasticity of the steel from which they are made to clamp them to the base of the rail) on the 90RA rail, while helpful to maintaining the track and reducing pull-aparts (and also the potential for track buckling in hot weather), could be difficult to accomplish. Since 90RA rail is an obsolete section, no rail anchors are being produced that will fit this rail, meaning that the only anchors available for purchase are previously used. Through experience, we know that many of these second-hand anchors are worn and have limited or no effective holding power. Furthermore, since the base of the rail is likely worn (from sliding in the tie plates – as a result of not being anchored), it could be difficult to get a new rail anchor (if available) to clamp and restrain the rail firmly.

We assume that the CWR track north of Santa Cruz is adequately anchored, though no information was available regarding the thermal adjustment of this CWR track. Based on track charts, which indicate that this rail has been in place since at least 1978, it is reasonable to assume that this rail has become, over time, adequately thermally adjusted. Note, however, that any track maintenance north of Santa Cruz should take the CWR into account and ensure that, if rail is replaced, the new rail is exactly the same length as the rail being removed.

If Class 2 or Class 3 operating speeds are pursued, a program of periodic rail inspections should be instituted pursuant to FRA regulations, since the consequences of a derailment due to a broken rail at higher speeds can be quite dramatic. At Class 1 speeds, a decision should be made about the advisability of performing rail inspections, weighing the costs against the benefits.

2.2 Ties

The condition of the railroad's ties is one of the most critical issues for a branch line railroad because their function is so vital to the overall track structure, because they deteriorate relatively quickly if not well-cared for, and because there are so many of them to maintain. Railroad ties are generally the most immediate and potentially the most expensive maintenance item for shortline railroads.

The purpose of railroad ties is to provide vertical support for the track (known as "surface"), to restrain the track laterally (known as "alignment"), and to maintain the proper distance between the rails (that is, to hold the rails in "gauge"). Over time, railroad ties deteriorate and eventually lose their ability to perform these functions. While tie lifespans vary widely depending upon species of timber (e.g., Eastern hardwood species or Western softwood species), climate, condition of the ballast, and whether the tie is installed in straight or curved track (among other factors), as an overall estimate, ties in the Santa Cruz Branch should have a 30-35 year lifespan, if they are provided with proper drainage.

2.2.1 Tie Condition

Overall, tie condition on the Branch is fair. The field inspections employed random sets of 100 consecutive ties as samples to form the basis for the evaluation of tie condition. Based on the field inspection, it appears as if approximately 1/3rd of the roughly 90,000 ties on the railroad have recently been replaced, with the new ties relatively evenly distributed along the length of the line. This was confirmed by information provided to HDR by SCCRTC, which indicated that Union Pacific replaced approximately 34,000 railroad ties in 2003.

In general, the distribution of new ties (the 34,000 ties replaced in 2003) was fairly uniform along the line. For any given sample of 100 consecutive ties, approximately 33% of those ties appear to have been replaced in 2003, leaving them with about 24-29 years of useful life at the current service level (again, assuming proper drainage). Likewise, in the same sample, approximately 33% of the ties appear to have approximately 5 to 15 years useful life. The remaining 33% were defective meaning that they do not adequately hold gauge, surface and/or alignment, or appear to have less than 5 years of useful life remaining.

As a note, this distribution is important, and is, in fact, advantageous. If long stretches of ties were replaced with 100% new ties, those stretches would tend to fail all at the same time, assuming the ties deteriorated at approximately the same rate. Likewise, if long stretches of ties are all consistently in poor condition, with no good ties interspersed, those stretches would tend to require immediate replacement of at sufficient number of defective ties to maintain reliable operations and to meet FRA criteria.

Wood railroad ties tend to deteriorate as a result of multiple causes, some visible, some invisible. Deterioration which manifests itself visibly includes abrasion from tie plates (called “plate cutting”), center-binding, and splitting of the wood. Deterioration which is not readily visible is chiefly caused by rotting, which begins with the wood at the center of the tie and progresses towards the outside layers of wood. As a result of the good wood on the outside of the tie and the rotting center, the rot is often effectively concealed. During the field inspection, the appearance of a tie and its sound when struck with a solid object were used as the bases of judgment for whether a tie in the sample was defective.

Concrete ties are being used increasingly on many railroads throughout the USA as well as the world. These ties have a working life as long if not longer than wood ties. However, concrete ties cannot be interspersed among the wood ties that are in use on the Santa Cruz Branch. Also, concrete ties each weigh over 600- to 700 pounds and cannot be easily handled by a small maintenance crew. Concrete ties are mentioned in this report as they could be used should long sections of track need to be replaced under the modernization program as a capital expense. These ties would be installed using a P-811 track laying machine. Other features of concrete ties include: (1) concrete ties are typically installed on 24 inch centers and accordingly not as many are needed per mile as compared to wood ties, (2) if the fewer number of concrete ties per mile is factored in, the cost difference between wood and concrete ties is negligible, and (3) a railroad completely constructed with concrete ties requires a subballast layer as well as a thicker layer of ballast under each tie. Because each concrete tie is designed to accommodate only a specified rail section, the decision of the choice of rail to be used on the Branch should be made in conjunction if a decision of whether or not to use concrete ties.

As noted, in areas with proper drainage, and where there are no sharp curves, the new ties likely have 20-25 years of useful life remaining. In areas where there is poor drainage or where curves are sharp, the lifespan of these new ties will be significantly shorter, perhaps as little as 3-5 years. The species of timber, or mix of species, which has an impact on tie longevity (particularly in curves) for the new ties, is unknown.

The distance between ties (“tie spacing”) is generally about 23 inches, though it is inconsistent in many locations, with intermittent areas where two adjacent ties might be as far as 26” to 30” apart. There are typically two primary causes of this: 1) ties being pulled along with the rail as the rail slides longitudinally, usually due to inadequate anchoring, or 2) when tie replacements were performed, for example, replacing four adjacent defective ties with only three new ties. Note that wide tie spacing is little different from having defective ties (i.e., defective ties being those ties that do little or nothing to hold gauge, surface, or alignment) interspersed with good ties. As such, this is not a major concern. However, where tie counts have been taken, we have assumed that tie replacement would also address areas where there are occasional wide tie spacing.

The track gauge (distance between the rails, designed to be 56.5”), was 56.5” to 57” in nearly all locations. Widening of the gauge is one early sign of having too many defective ties in an area – which is usually first noticed in curves – and can lead to derailments if the rails spread too far apart. Nearly all the curves on the Branch had gauge measurements of 57" or less, with little evidence of additional gauge widening due to "plate push," or movement in the tie plates. The relatively good gauge conditions on the railroad suggest a solid basis for an ongoing maintenance program.

The Federal Railroad Administration has established *minimum* criteria for the number of non-defective ties in a 39 foot length of track for the various classes of track. As mentioned previously, a non-defective tie is one that holds the rails in gauge, provides adequate support to the rails, and also acts (in concert with the ballast and other ties) to restrain the track laterally. For wood tie track, there is a certain amount of subjectivity to these determinations, since wood is an inherently elastic, flexible material. The FRA's criteria for track Classes 1, 2, and 3 are summarized in the table, below:

Class of track	Minimum quantity of ties per 39 foot length of tangent track and curves <2 degrees	Minimum quantity of ties per 39 foot length of turnouts and in curves >2 degrees	Maximum freight train operating speed
1	5 ties	6 ties	10 MPH
2	8 ties	9 ties	25 MPH
3	8 ties	10 ties	40 MPH

In addition, the FRA has requirements pertaining to the maximum distance a non-defective tie can be located from a rail joint; fundamentally, this particular criteria is in response to the increased maintenance requirements of a rail joint, and the increased forces that tend to accumulate there.

Also note that the FRA has identified that curved track needs a higher proportion of non-defective ties than tangent (straight) track. Simply put, in curved track, a train *attempts* to continue in a straight line. But, with the wheel flanges bearing against the rail, the wheels are forced sideways, around the curve. The force to restrain the rails is resolved through the ties and the ballast, down into the subgrade (this is also the cause of curve wear on rails, discussed in Section 2.1). In resolving these forces, the ties in a curve accumulate much more wear than ties in straight track.

In a typical 39 foot length of track on the Branch, there are approximately 20 ties. The FRA minimum standards for Class 1 track require that only 5 of these ties, or 25%, need to be non-defective in tangent track, while only 6 of these ties, or about 30% need to be non-defective in curves sharper than 2 degrees. Likewise, the minimum standards for Class 2 track require 8 non-defective ties, or 40% of the total ties, per 39 foot length for tangent track, and 9 non-defective ties for curves sharper than 2 degrees.

In practice the FRA minimums are truly *minimum* requirements for safety. Indeed, it is possible to have the minimum number of non-defective ties required by the FRA, but still not be able to provide adequate gauge restraint, adequate support, and/or adequate alignment restraint, particularly on sharp curves, or in areas where the rail, joint, ballast, or subgrade conditions are poor. The consequence of inadequacies in any of these areas is, at best, rapid deterioration of the few good ties and, at worst, derailments.

2.2.2 Recommendations for Tie Maintenance

Based on field examination, and considering the rail, joint, ballast, and subgrade conditions, as well as the track geometry, we believe that the roughly 60% to 70% quantity of non-defective ties present in the Branch is adequate for operation at Class 1 speeds with 268,000 pound GWR cars. Note that it appears as if 33% of these ties may fail within the next 5-15 years, meaning that relatively soon, if a maintenance program is not developed and implemented, only 33% of the ties will be adequate. This number is probably inadequate for many of the sharp curves on the line, given the level of service, which puts a premium on implementing a tie maintenance program.

To maintain the current quality of ties in the Branch, we recommend an average annual replacement of 3% of the total ties per year. We believe that this level of replacement will be suitable to maintain minimum Class 1 standards for 268,000 GWR cars. At this replacement level, and assuming an average 30-35 year tie life, with approximately 3% of the ties failing each year, and a similar number being replaced each year, some of the ties will always be defective, or nearly so. Likewise, This plan assumes the current level of service stays at approximately 0.7 million gross tons (MGT). With less than a 3% annual replacement rate, a relatively larger proportion of the ties might always be defective, which may not be a desirable plan (particularly if more traffic is expected), since it leaves little margin for error.

The 3% annual tie replacement level accounts for the inconsistent drainage (which will not likely be fixed all-at-once and which has been problematic for some time already), for the sharp curves which require better tie quality to provide additional restraint, and for sometimes inconsistent tie life. To reap economies of scale in the replacement process, rather than an annual program conducted under the on-going maintenance budget, larger quantities of ties could be replaced at somewhat longer increments - perhaps 20% to 25% of the ties every five years under a capitalized preservation program. As drainage and ballast conditions are improved over the first few years of operations, it is possible that tie conditions may warrant a re-evaluation of the tie replacement increments, perhaps allowing for a modest reduction of the overall number of defective ties replaced under the preservation program..

Some comparatively short stretches of ties show evidence of a center-bound condition, a situation where there is insufficient support under the rail seat (tie plate area) of the tie, but where there is support is present in the center of the tie. This manifests itself as splintering in the center of ties. If left unchecked, the ties may break in the center. To correct this condition, the ties need to be tamped (ballast compacted under the rail seat area of the tie to restore the proper support), perhaps with the addition of ballast in that section of track. While there are a few areas of center-bound ties evident (less than 0.5 miles, total), there are many more locations where center-bound conditions are incipient due to insufficient ballast. These will be addressed in section 2.3 of this report. We recommend the existing and incipient center-bound conditions be addressed as part of the state of good repair effort. The tie conditions in these areas appear not to have degraded sufficiently enough to warrant complete tie replacement. However, if all the ties become center-bound as the condition progresses from “bad” to “worse,” they will all need replacement.

Higher levels of tie replacement are recommended for increased levels of service. Our recommendations for tie replacement, based on different operating speeds and maximum Gross Weight on Rail (GWR) operated, are summarized in the table below:

	268,000 GWR	**286,000 GWR**
10 MPH	3%	4.5%
25 MPH	6.5%	7.5%

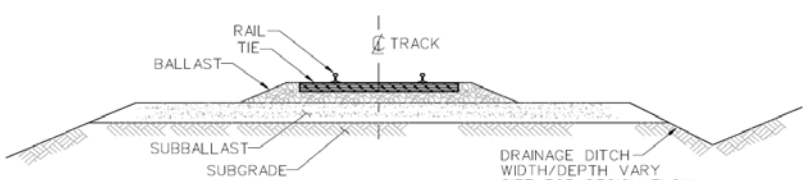
The higher level of tie replacement for the higher speeds is a reflection of the fact that much more attention will have to be paid to tie condition in the many curves on the line, since the outward force generated in a curve is proportional to the *square* of the speed. Thus, small increases in speed can produce dramatic decrease in tie life in a curve.

2.3 Ballast, Subballast, Subgrade, and Drainage

Due to the interrelated nature of railroad ballast, subballast, subgrade, and drainage, these components of railroad track will be discussed in concert.

2.3.1 Description of Railroad Ballast, Subgrade, and Drainage
Railroad ballast is a crushed rock product, commonly ranging in size from 0.75” to 2.5”. The surfaces or facets of the rock are intended to be flat, with angular corners. This helps ballast particles interlock into a relatively rigid structure that can support and distribute the loads imposed by train wheels as those wheel forces are directed downward through the rail and ties. Ballast also helps restrain the track laterally, both by virtue of its sheer weight, piled-up at the ends of the ties, and also by the friction of the angular rock against the sides of the ties. Finally, the relatively large particle size for ballast ensures that water will drain readily out from the ballast.

For a line such as the Santa Cruz Branch, ideally, the railroad ties would be elevated approximately 8”-12” above the subballast or subgrade on a layer of ballast; in addition, the ties would be fully surrounded by ballast, with the top of the ballast matching the top of the ties. Again, ideally, the top layer of ballast would horizontally extend outward from the ends of the ties about 9” to 12” before sloping down toward the subballast. This shape of ballast is known as the “ballast section,” and is employed by railroads because it promotes efficient use of ballast (which is generally expensive), promotes good drainage for ties, provides sufficient ballast to distribute the loads from ties to the subballast or subgrade, and provides adequate ballast material to restrain the track from lateral movement. Please refer to the sample drawing below, which illustrates the various roadbed components and their relationship to each other.



SAMPLE ROADBED COMPONENTS

By providing a 9” to 12” layer of ballast below the tie, but above the subballast or subgrade, there is sufficient place for water to drain away from the ties into adjacent drainage ditches. If this layer of ballast is surrounded on all sides by subgrade material or mud, then there is no place for the water to drain, and eventually the ballast will become contaminated with this material (known as “becoming fouled”), thus reducing the ballast’s ability to provide drainage and support.

If ballast becomes clogged, or fouled, with debris or soil from the subgrade, it loses its ability to perform one or more of its basic functions. For example, mud (consisting of fine soil particles, fine sands, silts, and clays), through pumping action of the track during passage of trains, or simply through poor drainage, can work its way up into the ballast. Mud acts as a lubricant between the ballast particles, reducing their bearing capacity. Mud also effectively traps water around the railroad ties, keeping them damp and promoting much faster deterioration of the wood through rotting. If the ballast (and underlying subgrade) is completely saturated with mud, the ballast (along with the subgrade) can actually lose its ability to support the loads imposed bypassing trains.

Furthermore, fouled ballast retains moisture which, in turn, lowers the resistance of the track section to transmit electrical current. Track circuits that depend on high resistance values to perform reliably such as at the various at-grade crossings and if a wayside signaling system is ever installed will require a relatively clean ballast section.

Note that the drawing of sample roadbed components indicates a layer of subballast. As noted previously, there is little or no subballast on the Santa Cruz Branch. Subballast is an engineered material with specific gradation designed for the prevailing geotechnical conditions, depth of ballast, type of ties, and anticipated traffic demands (particularly gross weight on rail and annual gross tonnage). Subballast is generally used in modern track construction for lines carrying any significant tonnage because it provides a layer in addition to the ballast which can distribute loads over the subgrade, and because when compacted, subballast acts to “cap” the subgrade, preventing fines (small soil particles) from migrating up through the subgrade and fouling the ballast.

Historically, however, subballast was rarely used in railroad construction – this was particularly true at the time of construction of the Santa Cruz Branch in the late 1800s, since trains in those times were very, very light compared to modern trains, and because at that early date, ballast consisted of dirt from the surrounding ground heaped on the track. There was simply no need for subballast, especially where the native soils were generally sandy and had some ability to drain on their own.

We have included a discussion of subballast here because considerations for new construction, or reconstruction of existing tracks, should include thought of incorporating a subballast layer. This is particularly true in areas of trackage embedded in streets, since it will promote a rigid track structure, which will help the longevity not only of the track, but also of the surrounding pavement.

The following discussion of ballast conditions will, of necessity, overlap with discussion of subgrade and drainage conditions, since these soil and rock materials work in concert to support the track, and they have an interdependent relationship; thus these elements of the track structure are being treated together.

2.3.2 Ballast, Subgrade, and Drainage Conditions and Recommendations.
Ballast conditions on the Branch are highly variable, but can generally be described in broad sections which have relatively consistent characteristics. Characterizations of each of these segments follow in Section 4.0, and in the appendices. A description of the

terminology used to characterize the ballast condition as “good,” “fair,” “poor.” and “very poor,” and the recommended remedial actions for each characterization, follows.

Where the ballast is in “good” condition, little action is required, other than regular maintenance of the track (surfacing). In general, the ballast is usually in good condition where the track is on an embankment, or where drainage has been consistently maintained. There are many locations where the quality of the ballast is good, but where pedestrian traffic has eroded the ballast away from the ends of ties. In these areas, additional ballast should be added to provide adequate support for the ties and prevent a center-bound tie condition from developing. It would be common railroad practice to take actions to prevent such pedestrian activity, since it does represent an increased maintenance cost, as well as a potential liability.

Where the ballast is in “fair” condition, there is generally indication that it is becoming fouled with fines, silt, or mud, or organic debris from overhanging trees. However, the amount of fouling has not reached a severe condition, yet. It may be possible to mitigate the conditions causing the fouling, and arrest the contamination to the ballast. Since the fouling has not reached a severe state, it may also be possible to reverse some of the fouling conditions. Generally, fair ballast can be found in areas along side-hill cuts or cuts where drainage ditches are present, but perhaps not of sufficient depth, or at grade crossings where, because of inadequate roadway drainage, contaminants from the roadway are washing onto the track.

Ballast that is in fair condition could be addressed in several manners. First, it is important to identify and mitigate the condition causing the ballast to be fouled. For example, if the track is pumping, a condition which causes fine soil particles (“fines”) to migrate upward from the subgrade, a typical solution would be to raise the track several inches on new ballast. This would stiffen the track structure, and mitigate the pumping condition.

Another typical cause of fouled are foreign contaminants. In this case, the source of these contaminants should be identified and mitigated. One possible method to address surface contaminants, such as pine needles, could be with the broom tool on a ballast regulator. The success of this method would be highly dependent upon the nature of the contaminants. However, if successful, it would be a relatively inexpensive method of remediating these issues – though it would not address the root cause of the problem.

Likewise, if the surrounding soil is the source of the fouling due to inadequate or clogged drainage ditches, a ballast regulator may be able to clear the ditches. Essentially, this is a strategy of “pushing away” surface contaminants before they accumulate and the situation worsens. As noted, the root cause of the contamination must also be addressed.

If prompt action is taken in areas of “fair” ballast, these areas can be prevented from becoming areas of “poor” ballast. This is the sort of investment activity which we recommend be done not only as part of the state of good repair work, but also on an ongoing basis. Unfortunately, this is also the sort of activity that is easily forgone in lieu of addressing apparent crises. However, by maintaining proper drainage around the track, the lifespan of the ballast and ties will be preserved.

In areas of “poor” ballast conditions, contaminants are not confined to the surface of the track, but rather extend downward into the ballast section and into the subgrade. These are much more difficult to mitigate, since the contaminants cannot simply be pushed away. And, in general, the root cause of the fouled ballast may be more difficult to address. Often, these conditions are found in areas where there are cuts on one or both sides of the tracks, but the cuts are of inadequate width to allow for a proper drainage ditch. The site geometry that encouraged construction of a cut of substandard width also tends to be associated with over-steepened walls of the cut. As a result, material erodes or sloughs off the walls of the cut and, with no drainage ditch to intercept debris, the material accumulates on the track, perhaps flowing for long distances between the rails. A prime example of this situation can be found near Capitola, between MP 15.3 and MP 15.7, in the cut between Monterey Avenue and the Grove Road private crossing.

The cut between Monterey Ave and the Grove Road private crossing has over-steepened walls. Material is sloughing off the cut walls and has completely filled the drainage ditches. Contaminants are washing off the adjacent roadways, at the top of the cut, onto the track. Debris from trees has accumulated to the point where it has contaminated the ballast. Ties conditions in this area are worse than average, since the ties are continuously wet. Track surface, alignment, and rail joint conditions have also suffered as a result of the fouled ballast and tie conditions. There are other segments similar to this along the line, chiefly between Buena Vista Road and Santa Cruz.

The simplest way to address the ballast conditions in such situations is to raise the track and add more ballast, with the idea that the track can be raised high enough to get it above the material that is fouling the ballast and, by lifting the track higher, create a *de facto* drainage ditch. In some situations, this will be effective, but in other situations, particularly where the ballast has been fouled by fines or mud, this is a temporary fix, at best. Unless the track is raised significantly – say 9" to 12" - the fouled material will generally work its way upward through the new ballast due to the pumping action of the trains. This pumping action will be amplified by the poor subgrade (really, the old, fouled ballast), which provides a fundamentally weak foundation for the track.

One option in areas of poor ballast conditions is to "skeletonize" the track, or to remove the ballast from around the ends of the ties and from the cribs between the ties. This is a very labor intensive activity, and requires a method of disposing of the material without piling it back on the tracks. A standard rubber-tire loader-backhoe can readily clean material away from the ends of the ties, though such a machine will have a difficult time disposing of the waste material, particularly in narrow cuts. A hirail Gradall™ machine, with associated railcars cars for waste material, is the ideal piece of equipment for removing the fouled ballast from the shoulders and for reestablishing the drainage ditch. A vacuum truck can clean the fouled ballast from between the ties after the ballast shoulders have been removed by the backhoe, Gradall™, or other equipment. After removing the fouled ballast, new ballast would have to be imported, placed, and the track resurfaced. Depending upon the nature, depth, and degree of fouling, it may be possible to remove only a few inches of ballast, and address the remaining issues with a track raise of several inches on new ballast.

Equipment such as Gradalls and vacuum trucks are somewhat rare and expensive to rent and, as such, a relatively large amount of skeletonizing has been included in our state of good repair cost estimate in order to reap economies of scale when addressing the most difficult areas. It is likely that such equipment will have to make return trips every few years, and so an annual cost for ditching, performed by an outside contractor, has also been included.

Completely new track could be installed using a P-811 track laying machine. This apparatus is a self-contained train that removes the old track and installs new track in one motion as the P-811 equipment moves down the track. All rail, ties and ballast are replaced in this process. Concrete ties could be specified during the P-811 operation. The 34,000 new ties recently installed by Union Pacific as well as all other sound ties could be gathered and reused for the construction of siding track or in a yard.

Even if the poor ballast condition can be remediated, in order to properly address some of these situations and prevent recurrence, the fundamental subgrade and geotechnical conditions must be addressed. Possible solutions include a more sophisticated drainage system, perhaps including perforated underdrain pipes at the track level and interceptor structures at the top of the cuts may be needed to address the problem. In some cases, the only suitable long-term repair may be to further lay-back the slopes and widen cuts, or construct retaining walls to allow widening of the cuts. Our cost projections do not include design or construction of such measures, which are highly dependent upon site geometry, right-of-way width, soil conditions, surrounding land uses, and drainage conditions. Rather, it has been assumed that these areas, if not fixed by simply raising the track, would be areas of permanently poor ballast conditions, with concomitant ongoing operations and maintenance costs.

Ballast categorized in "very poor" condition generally has been completely fouled by mud, to the point that mud may be over the tops of the ties. When conditions are this bad, there are few options. Attempts to raise the track and simply add ballast in an effort to get the track above the fouled ballast will almost certainly meet with defeat and rapid recurrence of the conditions. As before, the root cause of the problem must be addressed. But, in these cases, there may be few if any incremental improvements available, short of completely skeletonizing the track to a substantial depth below the ties, or even completely replacing the track in order to allow improvement of the subgrade conditions or installation of a layer of subballast to restore bearing capacity.

Note, however, that the previous assumptions about incremental or complete track repair imply that continued sloughing or movement of the cut walls is acceptable condition. Depending upon right-of-way conditions and adjacent land uses (e.g., roadways or structures), this may not be the case. We recommend that these specific areas be reviewed in conjunction with geotechnical engineers.

The drainage conditions along the Branch speak to the larger issue of rain-related damage to drainage courses and catastrophic flooding or slope movement. While we do not have sufficient data to comment on specific locations, it is evident that, between the time the railroad and early drainage conveyances (such as drainage ditches and culverts) were constructed and the present day, there have been significant changes in the region’s hydrology. In particular, urbanization has increased the amount of impervious area, as compared to the amount of impervious area at the time when the railroad was constructed. The increase in impervious area results in a change in the rate of runoff and flow regime after a rain event. Examples of this situation have manifested themselves in the form of silt flowing off farmers’ fields, water sheet-flowing off roadways into the railroad’s drainage courses, and even in a large number of new culvert pipes originating on adjacent properties and draining onto the right-of-way. The priority and remediation approach given to specific areas would best be determined by both the shortline operator and the SCCRTC, working in concert, since other stakeholders (either upstream or downstream) will be involved in many cases.

2.4 Effects of Rail Car Weight

Rail car weight has a significant impact on the longevity of all track components, though the effect of railcar weight on the longevity of railroad rails is perhaps the easiest to understand. If a rail is considered as a girder, serving as a bridge for the train wheels between the ties which support the rail, it is evident that the rail must have a certain minimum strength in order to support the weight of the wheels. As with any girder, the heavier the load, the more the girder deflects. The same is true for rail under the weight of a railroad car. The stresses (unit loads, normalized for area of application) within the rail are related to the deflections and loads placed on the rail. As these stresses reach some limiting amount, the rail will fail, literally breaking.

Though sometimes difficult to imagine, the phenomena of a rail breaking is fundamentally the same as with a piece of lumber spanning a gap. The more weight placed on the piece of lumber, the more the wood deflects, and the higher the stresses in the fibers of the wood become, until eventually the wood breaks. While wood is not nearly as strong as the steel in a railroad rail, the same principals are at work.

A related phenomenon is that of fatigue life of a component. If enough cycles of loading and unloading, and the associated deflections, are accumulated on a component, that component can break just as if its maximum strength were exceeded, even though the individual applications of a load were always well within the component's strength limits. This phenomenon can readily be observed by bending a steel paper clip back and forth; if bent enough times, the accumulation of loads will cause the paper clip to break.

Fatigue is an important consideration since, in the early days of the Branch, when most of the 90RA rail was installed, rail cars weighed on the order of 140,000 pounds, significantly less than modern rail cars. The rail and rail cars were a system, each matched to the other. As rail car weights increased, they put increasing stresses on the rail. Modern cars place a significant stress on rails, particularly the smaller rail. It has been found that, under most conditions, 263K cars approach the practical maximum strength of smaller rails, particularly for fatigue life. And, as stresses get even closer to the absolute maximum allowable, each additional increment of stress becomes more and more significant in the overall fatigue life of the component. Thus, while 286k GWR cars are only about 9% heavier than 263K cars, the heavier cars do much more "damage" to the track components when compared to 263K cars. This additional damage is reflected in a disproportionately higher maintenance cost (especially for sections of track constructed with smaller rail) associated with 286K cars. Studies show that the additional damage done by 286K cars requires on the order of 20% more maintenance expenditure when compared to 263K cars. Note that the above discussion, which focuses on railcars uses the 263k and 286k designations. These, along with 315k, are normal designations for railcars. The limit of 268k allowed on the line is an operating construct, not strictly related to the railcar weight on rail designations. The intermediate weight allowance is accomplished by utilizing a railcar rated for loading to 286,000 pounds and "light-loading" the car to the intermediate weight of 268,000 pounds.

Please note that, while rail has been cited as an example of the effect of heavier rail cars, every track component (including joint bars, ties, and even ballast) is affected in a similar manner. If the total system of track components is fundamentally operating near the limit of its strength (such as a system comprised of small rail, small ties plates, moderately defective ties, and fouled ballast), it will have a much shorter service life under heavier rail cars than a track system which has sufficient strength in reserve (such as a system of larger rail, larger tie plates, solid ties, and clean ballast). Similar principals apply to railroad structures.

While the track structure is somewhat affected by increased axle loadings, the bridges along the Branch most acutely feel the impacts of the high load ratings. Bridges were evaluated in another study recently commissioned by SCCRTC. Pleased refer to this document for recommendations on bridge load ratings for the Santa Cruz Branch.

This is not to say that operation of 286K GWR cars is inherently unsafe. Rather, when compared with operation of 268K cars, 286K GWR operation requires a higher level of maintenance, and problems will manifest themselves (and require attention) much sooner than under 268K GWR operation. The higher expenditures are reflected in the maintenance recommendations in Section 6.0.

3.0 TRACK GEOMETRY

3.1 Description of Track Geometry

Track geometry describes the geometric relationship of the actual track components to an ideal condition. This is usually done with respect to an idealized horizontal frame of reference, known as alignment (which may be straight or curved), and an idealized vertical frame of reference, known as surface. These are crucial metrics, since increasing variations from the ideal situation will cause increasing levels of stress to be imposed on the track by passing trains. At some point, the level of stress can become so high that the track can no longer adequately guide the train, resulting in a derailment. These metrics are especially critical on curved track, since the natural tendency is for a train to attempt to travel in a straight line, while the track (the rails, ties, and ballast) is what exerts the necessary force to guide the train in a curved path, literally "pushing" the train sideways around the curve.

Note that this Section of the report considers track geometry in two broad categories: the "micro-level" elements of track geometry, such as the banking or "superelevation" of track in curves, or the elevation of a specific rail joint with respect to the surrounding track (such as the surface bent rails described in Section 2.1.2); and the "macro-level" issues of track geometry, which address the manner in which the track was originally located and designed – or has evolved – around curves and over hills. In general, maintenance activities address the "micro-level" issues, which are the same issues upon which the Federal Railroad Administration has focused most of the safety standards.

3.2 Track Geometry at the "Micro-Level"

Between Santa Cruz and Davenport (Segment #3), in the area of continuously welded rail, surface and alignment appear to generally meet the requirements for Class 2 track (except at private grade crossings). South of Santa Cruz (Segments #1 & #2) , the condition is more variable, though, in general, the condition appears to be between Class 1 and Class 2, with limited areas that may not meet the requirements for Class 1 track.

Curves, in general, appear to have a significant amount of banking, or "superelevation." Despite the fact that there is moderate to heavy curve rail wear on almost all the curves, we recommend that some of this superelevation be removed, in conjunction with a curve lubrication program, in order to prevent or arrest plate cutting or rail head crushing on the low rail due to forces exerted by trains. In combination with the lubrication program, curve superelevation should be limited to 1" or less, even on the sharpest curves on this freight-only Branch. Determining how much superelevation to leave in each curve should be done in conjunction with anticipated train speeds (considering the actual operating speeds of trains in both southbound and northbound directions – which essentially correspond to loaded and empty trains) and in conjunction with a careful assessment of the current amount of superelevation and wear pattern on the rails.

For example, despite the fact that maximum authorized speed might be 10 MPH on a specific curve, due to steep grades adverse to the prevailing direction of loads, the actual speed of loaded trains might be lower. On this same curve, empty trains traveling downhill might easily achieve the maximum speed. The actual amount of superelevation should balance these considerations, as well as the amount of existing curve wear, location and application rate of curve lubricators, and other operating considerations that would affect train speed. Thus, the actual superelevation will be specific to each curve.

For the preservation capital expenditure program, we have made the assumption that 2- to 4 miles of track would need to be resurfaced annually or bi-annually if traffic levels remain low; this quantity includes resurfacing the worst of the curves to modify the amount of superelevation.

3.3 Track Geometry at the "Macro-Level"

Considered at the "macro-level" (often known as the "location" of the line), most of the alignment was originally designed and located for a narrow gauge railroad, one which contemplated much smaller and lighter railroad equipment and shorter trains. As a result, the tracks tend to go over and around obstacles (such as hills), rather than employing expensive earthwork to cut through them. The result is a relatively steeply graded railroad with many sharp, abrupt curves.

Generally, from MP ("MP") 0.4 to MP 4.5, the railroad is laid across flat terrain, bridging comparatively shallow sloughs and rivers as necessary. From MP 4.5 to approximately MP 6.0, the railroad follows a side-hill alignment up a river valley, cresting the hill near MP 6.0. From MP 6.0 to MP 21.0, the railroad climbs in and out of major drainages that lead from the coastal mountains down to the ocean; the result in this area is a curving, hilly alignment which works its way over the top of each wide ridge, then descends into the drainage, often crossing the bottom of the drainage on a bridge. From MP 21 to MP 31, the railroad is on a plateau of varying width at the edge of the shoreline. This section has much wider curves, is less steeply graded than the southern sections of the line, and to our knowledge, was constructed later and to different standards than the section between Santa Cruz and Watsonville.

In the section between MP 4.5 to MP 20, there are many sharp horizontal curves and reverse curves, many with little or no tangent between them. It is industry standard practice to provide a tangent section between reverse curves in order to minimize undesirable forces generated in trains and in the track when a train is going around two different curves at once, since this configuration tends to exacerbate the "weak link" in the system, be it the track, the railcars, or the train handling practices. To increase speeds on the reverse curves to Class 2 levels, additional field survey and design work would be necessary to determine if a tangent could be provided between the curves given the right of way and grading constraints, to determine the appropriate amount of superelevation, and to determine the appropriate superelevation runoff rates and distances.

Throughout the entire length of the railroad, there are also many abrupt vertical curves. These are a train-handling consideration, as they can generate significant forces within the length of a train as slack in the couplings between railcars redistributes itself. In combination with horizontal curves these can present a significant train handling challenge if operated at high speeds and long trains. To operate over these sections at Class 2 speeds would require a high level of track maintenance to ensure the in-train forces could be resolved through the track structure to the subgrade. In addition, several vertical curves appear to be so abrupt that they may not meet the typical length requirements for Class 2 track (though these requirements are generally railroad-specific, established to address the particular mix of traffic, they tend to be longer than what is currently in place on the Branch).

Given the current geometry and the difficulty in managing the forces in long, heavy freight trains, Class 2 speeds are not currently recommended for most of the stretches between MP 4.5 and MP 20, particularly on the back-to-back reverse curves.
Our cost projections do not include upgrades to the track geometry at the “macro-level” to meet Class 2 operating speeds. To understand if these areas are suitable for Class 2 speeds, additional field investigation and preliminary design (using either field survey or scale-accurate aerial imagery) would be necessary. Too, a thorough understanding of the traffic and assumed operating speeds would be necessary, including the number of “uphill” loaded and empty trains versus the same types of trains operating “downhill.”

3.4 Equipment and Operating Recommendations Following from Track Geometry
Track geometry has the potential to affect operation of trains and the type of equipment used on the Branch, since the forces created by trains not only must be resolved through the track, but also are the result of the track geometry. Like the relationship between ballast and subgrade, the relationship between train and track geometry is a kind of feedback loop, with each one influencing the other.

Due to the many curves, we recommend that locomotives with six axles not be used on the Branch. Such locomotives have a longer rigid wheelbase than the four-axle locomotives currently used on the Branch, and would impart higher forces to the track on curves – and thus impose a higher maintenance burden than contemplated in this report. In addition, on curve-worn rail, such locomotives have a somewhat higher risk of derailment.

We recommend maintaining current operating restrictions regarding train length until the shortline operator’s train operating and track maintenance crews come to understand the peculiarities of this specific railroad and develop a plan for managing in-train forces. Longer trains place greater stresses on the track, particularly on curves, and may increase the maintenance burden (or even the chance of derailment). In addition, “slack action,” resulting from free play in the couplings between cars, especially in longer trains, compounds the forces imposed on the track structure. While it is possible that longer trains could be operated, we recommend that such operations be instituted only after either an empirical (by experienced operating and maintenance personnel) or analytical (by computer simulation) understanding of the proposed conditions is reached.

We understand that, historically, trains on Branch exceeded the current maximum number of cars, and also exceeded the current 10 MPH speed limits. These situations likely existed during a time when operating conditions were different, and when more maintenance staff was available to tend to the regular inspection and maintenance issues along the Branch and to do so on a more frequent basis. Current practice in the shortline industry is generally to forgo higher train speeds and the associated maintenance burden in an effort to reduce manpower requirements.

For example, historically, rail cars weighed much less, meaning that the forces generated in possibly longer, but lighter trains were lower than the forces that would be generated in trains with the heavier rail cars currently used by cement and lumber shippers. It is likely that most loaded rail cars traversing the Branch under Southern Pacific’s ownership weighed 220,000 pounds or less, a situation which probably existed until the mid-1980s. As such, we believe that historic operating patterns with older, lighter cars do not form a reasonable basis for evaluation of operations with modern equipment.

4.0 SPECIFIC CONDITIONS ALONG THE SANTA CRUZ BRANCH

As discussed in earlier sections, conditions along the Santa Cruz Branch are highly variable. To help understand these, we have broken the Branch into three geographic segments which have relatively consistent conditions. The descriptions of these segments and recommendations for on-going maintenance and capital expenditures for the higher cost preservation and modernization elements on the Branch have been broken down into smaller sections as described below. The three segments divide the Branch into thirds: Segment 1 is the segment from Watsonville to Aptos, Segment 2 from Aptos to Natural Bridges Crossing (MP 22.5) just west of Santa Cruz and Segment 3 from the Natural Bridges Crossing (MP 22.5) to end of Track at Davenport. Please refer to the respective estimates for the costs of the proposed maintenance work. Our evaluation of the conditions of each section was based on sampling and inspecting smaller portions within each section, chosen because the samples are likely representative of the section as a whole. These samples also formed the basis for the quantities and cost estimate.

MP 0.4 to MP 1.1 (Segment 1)
Between MP 0.4, at the Salinas Road grade crossing in Watsonville (and also the proposed beginning of SCCTRC ownership) to MP 1.1, Front Street, the track is in fair condition. Much of the track in this area is on a low embankment and has fair to good ballast. There is some plate cutting on the low rail of curves in this segment. Curve lubrication is recommended, as well as surfacing, reducing superelevation to help mitigate the plate cutting on the low rail, which could be addressed during regular maintenance of the line.

MP 1.1 to MP 1.7 (Segment 1)
Between MP 1.1 and MP 1.7 (the intersection of Beach and Walker Streets), the track is embedded in the asphalt pavement, with short sections of concrete crossing panel at Riverside Avenue and Beach Street. It was not possible to inspect the track in this area, but the welded rail, in combination with good condition pavement suggests that the track is in relatively good condition. The condition of the subgrade is unknown, but, based on the current condition of this track, it likely has 15 years of service remaining before it needs rehabilitation. It is likely that the curved track in Walker Street near the Beach Street intersection will need some tie rehabilitation. This could likely be performed as part of the regular maintenance activities. There is a turnout near Beach Street which is in good condition, although the turnout was installed in a curve, a situation which requires an increased level of maintenance. The industry track which diverges from that turnout has roughly 70% defective ties and has apparently been excluded from recent tie maintenance programs.

Track maintenance options in this segment are limited, since the track structure is inaccessible, buried in the pavement. However, since it has been recently reconstructed, track maintenance requirements should be limited. We have included maintenance for this track as part of the capital expenditure preservation program, since maintenance would likely be performed all at once, as a complete rebuild of the track, rather than incrementally, as an ongoing process.

Since the track runs down a street, there is almost certainly some kind of agreement between the railroad and the City which identifies maintenance responsibility for the track and pavement, and establishes the right and obligations of both parties. This should be investigated so that SCCRTC can understand what portion of the track and pavement maintenance cost it must bear.

Given the street operation, there is no practical way to upgrade this trackage to Class 2 or Class 3 speeds without redesign of the grade crossing warning devices, revised roadway channelization, and possibly installation of additional grade crossing warning devices, traffic signals and design of traffic signal advance pre-emption.

MP 1.7 to MP 2.8 (Segment 1)
The curve beginning at MP 1.7 (near the intersection of Walker and Beach Streets) has some wide gauge, which should be addressed as part of the on-going maintenance effort.

The turnouts in this segment are generally in good condition, each having recently received significant numbers of new ties. However, the turnout nearest Ohlone Road is sitting in mud and puddles of water, which should be addressed immediately in order to preserve the ties and surface. This repair has been included in the preservation capital expenditure program recommendations.

Between approximately MP 2 and MP 2.7 (the State Highway 1 overpass), the ballast is completely fouled with mud from adjacent farming operations. This is one of the fundamental causes of the surface bent rails in this section, and will also be a root cause of severely shortened tie life, even for the relatively new ties recently installed by Union Pacific. The turnout near Ohlone Road crossing is sitting in puddles of water, and needs surfacing, despite the fact that it has nearly new ties and has probably been surfaced in the last 6 years. The mud in this area is the result of silt from the adjacent farming operations being plowed toward the roadbed by the farmers. Working with the adjacent farmers, this practice could be stopped immediately.

Though the damage has essentially been done, to mitigate this condition, the fouled shoulder ballast should be plowed away from the track, and the track skeletonized and raised on new ballast. Care must be taken to meet track surface runoff criteria for the Ohlone grade crossing. Once the work to improve track drainage has been completed, the surface-bent rail should be replaced with 115# or better CWR. We have included this work in the both the preservation and modernization program recommendations. In order to preserve the ties and prevent the rail condition from deteriorating further, we recommend that work in this area be carried out within the first one to two years of operation.

Due to the mud fouling the ballast and also the subgrade, it is unlikely that this segment can be brought and maintained in Class 2 or 3 standards without complete replacement of the track, beginning at the subgrade layer. Without a more detailed investigation, and without knowing what standards the SCCRTC would want the new track designed to, a rough estimate for complete replacement with modern materials (such as with second-hand CWR and fittings) would be on the order of $1 to $1.5 million.

MP 2.8 to MP 4.5 (Segment 1)
North of MP 2.8, the track is elevated on a somewhat higher embankment, and there is progressively less mud fouling the ballast in the northern portion of this segment. When the beginning of the grade, near MP 4.5, is reached, the ballast is in generally good condition and the track is on a relatively high embankment surrounded by sloughs. The low rail in the curves is experiencing some plate cutting. The rails in this segment exhibit some surface bending, but not so severe that it jeopardizes operations at Class 1 speeds. There are isolated locations, particularly several private grade crossings, with poor ballast conditions. In addition to tightening joints, we recommend that some of the superelevation be removed from the curves in order to reduce the plate cutting as part of the base-case ongoing maintenance. Note that the private crossings in this segment also need attention, though their condition does not appear to be critical for operations at Class 1 speeds.

To achieve Class 2 or 3 speeds, complete replacement of all the rail (all 90RA on the Branch) with 115# or better CWR is recommended; while the existing track and rail could be rehabilitated to meet Class 2 or 3 standards, it could not be maintained at these standards at a cost effective manner due to the worn joints and surface bent rails. Additional ballasting, surfacing, and limited tie replacement would need to be performed in conjunction with the rail replacement.

MP 4.5 to MP 6.9 (Segment 1)
From MP 4.5, at the beginning of the grade, to MP 6.8, Buena Vista Road, the track is in generally good condition, though the low rail in several of the curves is leaning outward with evidence of plate cutting. Drainage ditches have been established on the uphill (west) side of the track in most locations.

There is evidence of some ground movement in several specific portions of this segment. Near MP 5.0, the hillside above the track shows some signs of movement. However, this movement is slow enough that trees in that area are still upright. Though we have no geotechnical reports for this area, the movement in this area *appears* to be slow, and does not *appear* to pose an imminent hazard.

Near MP 6.1, there is evidence of significant movement on the downslope side of the track. This has been reinforced with rip-rap and boulders. This repair is characteristic of an area that has seen rapid slippage. The steep slope down to Buena Vista Road may be the cause of the slope instability in this area; the slope repairs were made where Buena Vista Road is closest to the track and the slope down from the track to Buena Vista Rd may be steepest here (Buena Vista Rd appears to have been cut into the toe of the slope and the location of the road may be the root cause of this failure). Again, without any geotechnical information, it *appears* as if this situation has been addressed, since the repair appears to have been effective, while the other portions of the slope downhill towards Buena Vista Rd are likely not as steep as in this area.

Several trestles between MP 5.0 and MP 6.3 have been heavily filled-in with sand and debris washing down from above. Having sand completely surround the trestle bents is detrimental to the timber, as it tends to retain water and promotes rot. One of the trestles, at MP 6.0, has concrete energy dissipaters cast in the hillside above it and a steep slope on the downhill side of the trestle with evidence of erosion of the downhill slope. The bents have also been completely surrounded in concrete. It is unknown who performed the concrete work. Just as being surrounded with sand promotes rot of the timber, the concrete has a similar, and perhaps worse, effect. This situation should be addressed immediately by addressing the fundamental drainage issues. In addition, the conditions of the structures should be reviewed by an engineer with a background in railroad structural evaluation.

Trestle near MP 4.85 completely filled with sand from hillside above.

Trestle near MP 6.01 with concrete energy dissipaters and channelization. Bents cast in concrete.

Near MP 6.8 (immediately south of the Buena Vista Road grade crossing) is a cut where Buena Vista Rd closely parallels the tracks. The wall of the cut on the east side of the tracks, adjacent to the road, is very steep, and is supported by large slabs of concrete piled atop one another. This improvised wall shows some signs that it is moving. Furthermore, drainage off the road is directly down to the tracks.

Closer to the Buena Vista Road grade crossing, roadway drainage from both San Andreas and Buena Vista Roads ponds around the tracks. The tracks are underwater, and the ballast in this area is completely fouled with mud, which affects tie life, but also appear to already be affecting track surface in this area. There is wide gauge in the crossing. This is one location where a combination of on-going maintenance (to fix the wide gauge) and the capital expenditure preservation program (to repair this and other crossings) is recommended. It is possible that the grade crossing warning devices, which relay on electrical currents in the rails, may not operate properly when there is standing water and mud at this crossing.

The ballast in this segment is in generally fair to good condition and should generally promote long tie life. There are some areas where the ballast as become fouled, but the fouling appears to be by sands, rather than silts, so the fouled ballast likely still has some drainage characteristics and is not an immediate concern for Class 1 operations or maintenance. However, there are long stretches where overhanging trees are raining debris on the track, perhaps for as much as 40% of this segment.

Buena Vista Road crossing. There is evidence that the water floods the tracks. The County Road department has been attempting to address drainage here. Sharp curve places a premium on tie condition.

Retaining wall south of Buena Vista Road. Appears to be slow movement of this wall. Road above drains onto track.

For the base case scenario and given that the current use of the Branch is for freight service only, we recommend that the superelevation be reduced (by raising the low rail for a total distance of as much as 1 mile) where the low rail plate cutting problems are most significant. Curve lubricators should also be installed in this segment. Also, the track and crossing surface at Buena Vista Road (an other crossings) should be repaired or replaced as part of the capital expenditure preservation program.

To upgrade this segment to Class 2 or 3 operating speeds would require replacement of most or all the 90RA rail, and approximately 60% - 70% of the remaining curve rail in order to eliminate the rail wear issues in curves with 115# or better CWR under the capex modernization program.

MP 6.9 to MP 9.4 (Segment 1)

This segment extends from Buena Vista Road to the private crossing at Trestle Beach Road. As noted in the description of the previous segment, the Buena Vista Road crossing is a problem area. Two other crossings, Peaceful Valley Road and Spring Valley Road, and the track immediately surrounding them, are in poor condition. Otherwise, the track surface and ballast conditions in this segment are fair to good, with “fair” areas being generally limited in extent.

There are two areas where the ballast is fouled with debris from overhanging trees, between approximately MP 8.4 to MP 8.6, and between MP 9.2 to MP 9.4. Addressing these areas, while important, is not an immediate priority. However, drainage in this area is fair, and the ballast section and drainage pathways should be improved to arrest the decay of what appear to be ties in relatively good condition.

At approximately MP 8.3 to MP 8.4, there is a turnout and maintenance of way spur. This turnout is located in a curve, which places a premium on the condition of the rail and ties, though the current condition is adequate for Class 1 speeds. There is a significant amount of sand between the rails in this vicinity, and the drainage ditches are full of sand. If the ditches are cleared and the source of the sand is addressed, the tie life should be preserved relatively well. The source of sand appears to be a small trestle just uphill of this location. The drainage under the trestle has become filled-in with sand, filling-up to the level that water (carrying sand) flows along the track drainage ditches rather than under the trestle.

Looking north at sand on track near turnout at MP 8.4. Sand appears to be originating at short trestle which has filled-in. Rather than flowing under the trestle, sand flows along the track.

Looking north at ballast and drainage ditches fouled by leaves near MP 8.5. A similar condition exists near MP 9.3

Retaining wall near MP 8.8. This wall is constructed of rails pounded into the embankment and railroad ties used for lagging. As the ties decay, the track will lose support. Nearby, there is a small hole developing in the ballast near a culvert location. This indicates that the culvert under the tracks is failing.

Between approximately MP 8.6 and MP 8.9, the track is supported by several short retaining walls. The walls do not appear to be of an engineered design, possibly with inadequate passive resistance in the soil to secure the rail which is serving as soldier piles. In addition, as the ties that form the lagging decay, the track will lose support. This situation was addressed in the Supplemental Structures Report. There is a culvert in this section that appears to be failing, with a small hole opening up in the ballast between the ties near MP 8.8. The track in his area has relatively few defective ties, but the rail has heavy curve wear. Pedestrian traffic in this area has eroded the subgrade near the La Selva Beach trestle approaches.

For the base case scenario, the erosion of the ballast at the trestle approaches should be addressed, and the culvert repaired under the on-going maintenance program. Also, the track and crossing surface at Spring Valley Road should be repaired or upgraded within the first one to two years of operation. Similarly, the track and crossing surface at Peaceful Valley Road should also be upgraded, though as a private crossing, this is a lower priority; if nothing else, track drainage at the Peaceful Valley Road crossing should be addressed in the first one to two years. Debris from overhanging trees, particularly near MP 8.5 and in the area south of Trestle Beach Road, should be cleared from the track.

To upgrade this segment to Class 2 or 3 , conditions at the grade crossings (public and private) should be addressed. Generally, the 90RA rail in this segment is in generally good condition, and in conjunction with a regular surfacing program, might be able to serve at Class 2 or 3 speeds, so long as the joints can be fully tightened and maintained and the areas of poor drainage and fouled ballast addressed. Some selected rails in the tangents might need to be replaced in order to eliminate isolated surface bent conditions, though these are generally confined to the areas around the grade crossings. It would be imprudent to operate at Class 2 or 3 speeds between the San Andreas Road underpass and the north side of La Selva Beach trestle unless the heavily curve worn rail in this area were replaced.

MP 9.4 to MP 9.7 (Segment 1)
Between MP 9.4, and MP 9.7, the private crossing to the Celesians' camp at the end of Sumner Ave, the ballast is completely fouled with mud and/or leaves from adjacent fields, erosion of over-steepened walls of cuts, and overhanging trees. We recommend that this be one of the first areas to be addressed in the state of good repair program. Although new ties were reportedly installed in the track with the most recent tie program, the track is nearly completely covered in mud; these new ties will not last long. The walls of the cut at Trestle Beach Road appear to have been over-steepened, and are sloughing into the cut. There is evidence that the walls of the cut are moving. However, Union Pacific has established drainage ditches in both these areas in an effort to keep the problem from getting even worse.

Looking south from private crossing at MP 9.4 towards Trestle Beach Road, showing sloughing walls of cut and fouled ballast.

Looking south from private crossing at MP 9.7 towards area of fouled ballast. This view looks toward Trestle Beach Road, which is not quite visible in the background, beyond the vertical curve.

Recommendations for the base case preservation program are similar to those for the track between MP 2 and MP 2.8 in Watsonville. The track should be skeletonized (i.e., the fouled ballast should be excavated from the ends of the ties and disposed of off site) and subsequently, new ballast added. Ideally, the tie cribs should either be cleaned with a vacuum truck, and/or the track lifted several inches on fresh ballast to promote long tie life. The drainage patterns that create the mud – the fields above and to either side of the track – should be addressed in conjunction with the adjacent landowners.

To operate this segment at Class 2 or 3 speeds, in addition to the work noted above, the 90RA rail should be replaced with 115# or better CWR. At Class 2 or 3 speeds, the poor subgrade conditions would place a premium on establishing as stiff a track structure as possible, which implies rail larger than 90RA.

MP 9.7 to MP 12.5 (Segment 1)
Between MP 9.7 and MP 12.5, Trout Gulch Road, the ballast is generally good to fair, with the fair conditions existing as a result of overhanging trees and a few areas of limited length at cuts or grade crossings where the ballast is badly fouled with mud. The ballast between Rio Del Mar overpass and State Highway 1 underpass (where the elevation of the railroad track is used as a reference for the naming of the structure) is particularly heavily fouled with tree leaves, though the drainage ditches are adequate. Overall, the ballast section in this area is generally well defined, track surface is good, and drainage should be adequate to provide nearly full tie life, particularly if the leaves are cleared from the track between Rio Del Mar and State Highway 1 and at other isolated locations.

Little work is needed in this area, aside from addressing the debris from trees, since drainage is generally good. Near MP 11.3 there is a wood box culvert with short wood retaining walls that appear to be failing, though this appears to impact mostly the drainage, rather than present an immediate hazard to the track. However, the conditions of this culvert should continue to be monitored.

MP 12.5 to MP 12.6 (Segment 2)
Between MP 12.5 and MP 12.6, at Aptos, the ballast is badly fouled with mud, to the point where the ties are covered in mud. This will greatly reduce the lifespan of the ties. The adjacent parking areas appear to encroach on the right-of-way, and the debris from the parking lots and pedestrian activity is one of the root causes of this ballast fouling. The heavy rail in this area helps mitigate the poor ballast conditions, though this rail is badly curve worn.

As this is a higher cost item, addressing the fouled ballast by skeletonizing the track (and likely relaying the rail with a larger section) in this area has been included as a capital expense in the modernization estimate. However, to prevent this problem from recurring, the encroaching properties, landscaping, and pedestrian activity should be addressed.

Private crossings at Aptos. Drainage ditches are obstructed, ballast is completely fouled with mud. Appear to be encroachments from adjacent parking areas.

MP 12.6 to MP 14.3 (Segment 2)
In this segment, ballast, surface, and drainage are generally good. Tie conditions appear to be better than average in this segment. Like other segments, ballast conditions are worse where there is tree debris on the track. Many of the curves in this area have heavy rail, which, in combination with the good ballast and drainage, promotes a low level of maintenance at Class 1 speeds. There is limited fouling of the ballast at the few private crossings in this segment. The several back-to-back reverse curves in this segment would have to be evaluated for geometry before increasing speeds to Class 2 or Class 3 levels.

Near Estates Drive, there is a retaining wall approximately 200’ long that is in early stages of failure. Further investigation of this structure is required.

In general, little immediate work is required in this segment for the base case scenario. It is evident that the drainage ditches convey water in this segment (flowing water was present during the field investigation), and the source and ultimate destination of this water should be determined, since the railroad drainage ditches appear to be connected to the roadway drainage system

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MP 14.3 to MP 15.7 (Segment 2)
This segment includes the cut at Grove Lane, discussed in Section 2.3.1 of this report. In combination with the badly fouled ballast, and the surface in this segment is poor. These conditions extend to Monterey Avenue, at the north end of the segment. While not an immediate crisis, this is a section which should receive drainage attention (skeletonizing) and a track raise in the next one to two years, which has been included as part of the capex preservation work effort.

Particular attention should be paid to establishing drainage near Monterey Avenue, to prevent the condition of the crossing from deteriorating. Currently, mud from the cut flows downhill to the crossing, fouling the ballast there, and also potentially causing difficulty for the crossing gate circuitry

The retaining wall at the left side of this photon near Estates Drive private crossing (near MP 13.7) is leaning outward, with some of the timbers exhibiting signs of deterioration. Further investigation of this structure is required.

An unusually large number of ties, at the location of a former turnout near Monterey Avenue, need replacement. The original turnout ties, which are still in the track, may have impeded establishing drainage pathways, and are in poor condition. Though this particular area should receive extra attention, it is only about 100' long, and does not significantly affect the evaluation of the condition of the segment. This relatively small quantity of tie replacement work is assumed to be performed as part of the ongoing maintenance, but should be a relatively high priority and, depending upon scheduling of the work, should likely be accomplished before the track is skeletonized.

If Class 2 or 3 speeds were implemented without significant rehabilitation of the ballast section and drainage, this segment, particularly the area around Grove Lane, would rapidly deteriorate. As with the previous segment, the track geometry includes several back-to-back reverse curves which would have to be evaluated for track geometry before increasing speeds to Class 2 or 3 levels.

MP 15.7 to MP 16.4 (Segment 2)

This segment extends from Monterey Avenue to 47th Avenue. The railroad is generally on a fill, or has good drainage and good tie condition though this segment. While the ballast is generally clean, there is an inadequate ballast shoulder between Monterey Avenue and the Capitola bridge, largely due to pedestrian traffic. In addition, the retaining walls at the south approach to the Capitola bridge are being badly undermined by pedestrian traffic. This situation – including the trespassing that has caused it - should be addressed in near future as part of the ongoing maintenance activities. Only minor preservation-related capital expenditure program work is recommended for this segment.

Achieving Class 2 or 3 speeds in this area would require re-establishing an adequate ballast shoulder and relaying the 90RA rail in curves.

Retaining wall at south approach to the Capitola bridge, near MP 15.8. Pedestrian traffic has badly undermined this wall, a situation which should be addressed immediately.

MP 16.4 to MP 17.8 (Segment 2)

This segment extends from the 47th Avenue crossing to the 17th Avenue crossing. The ballast and drainage conditions in this segment range from fair to poor, depending upon the exact location, though tie conditions are consistent with the rest of the railroad, (i.e., with approximately 1/3rd having been recently replaced, 1/3rd in fair condition, and 1/3 in poor condition). Rail in this segment is mostly 90RA. There are some isolated areas, such as near 30th Avenue, which merit early tie replacement as part of the periodic tie program. Since access in this segment is relatively good, ditching, to address poor drainage, and other maintenance activities, could likely be accomplished by railroad forces as part of the ongoing maintenance program, rather than with contract forces.

There are few curves in this segment, which would make it comparatively easy to upgrade to Class 2 or 3 speeds from a train operations perspective, though heavier rail would be necessary.

MP 17.8 to MP 19.5 (Segment 2)

This segment extends from 17th Avenue to the south end of the amusement park (where the embedded track begins). Between 17th Avenue and the Seabright Avenue, ballast and drainage are fair to poor. The ballast section is not well defined, and is becoming fouled with fines, in part due to pedestrian traffic. The condition deteriorates further on the north side of Seabright Avenue (between Seabright Avenue and the San Lorenzo bridge), where heavy pedestrian traffic, erosion from adjacent landscaping, over-steepened cut walls, overhanging trees, and lack of drainage ditches all contribute to the generally poor surface and what will be shortened tie life in this segment. Tie condition in this area appears to be somewhat better than average, but that is a reflection of the recently replaced ties and does not reflect an inherently stronger track structure.

Re-establishing drainage ditches would be the first step in this segment. For areas of heavily fouled ballast, an approach similar to that discussed in Section 2.3.1 of this report (a combination of cleaning the ballast shoulders, attempting to clean the worst of the fouled ballast from the tie cribs, and a track raise, may be appropriate. If a track raise is considered, the vertical profile at the several grade crossings, and at the vertical obstructions near MP 19.4, must be considered.

Looking northward from approx. MP 19.4. Erosion from steep cut walls, tight clearances, and pedestrian traffic have clogged drainage ditches and fouled ballast, a problem made worse by debris from overhanging trees.

This type of fairly major work effort is proposed under the preservation program and would be funded for repair along with other track sections rated as poor under a capital expenditure program yet to be defined. All remediations defined in the recommendation section of this report include skeletonizing the most serious portions of fouled ballast in this segment. In addition, there are areas of center-bound ties in this segment which would be remedied if these repairs are implemented.

To operate at Class 2 or 3 speeds, the track between approximately 7th Avenue and the San Lorenzo River bridge should be lifted with fresh ballast and new CWR rail installed to replace the existing surface bent rail.

MP 19.5 to MP 20.05 (Segment 2)
This segment includes the track embedded in asphalt in front of the amusement park and in Beach Street. The track conditions here are highly variable.

In front of the amusement park, there are sections of track that have recently been renewed, with good gauge and surface, as well as sections that are in need of renewal in the near future, with gauge approaching 57.5” and low joints. The heavy pedestrian traffic in this area suggests that the condition of the asphalt walking surface is likely to be a concern for SCCRTC, though we do not know the division of responsibility for the asphalt maintenance in this area. Approximately 20 joints need to be addressed in the near future to maintain a suitable walking surface. Repairing these would, at minimum, entail removing a patch of asphalt 10’ wide by 12’ long, removing all the ties, excavating approximately 12” below the rail, and installing new ties. With joints on roughly 19’ centers, it is evident that this method is only slightly less expensive – and produces a poorer final product - than a complete rehabilitation of the entire segment. As part of the preservation program, we recommend rehabilitation of at least 200 feet of embedded track (the worst 200 feet) within the next two years.

Between Cliff Street and Pacific Avenue, the track is in better condition, with welded rail (CWR). At the curves near Cliff Street and again near Pacific Avenue, there are isolated areas of wide gauge which need to be addressed in the near future as part of the state of good repair program. Even though a “spot” maintenance program might adequately address the issues in this area, for the benefit of the “other” users and for the sake of consistent appearances, as part of the preservation or modernization repair work, we recommend removing the asphalt and rehabilitating the track, and repaving. A better, albeit more expensive project would be to extend the existing concrete crossing panels further, for the full length of the curves (this additional work effort has not been included in the repair estimate).

Ideally, this segment would be completely reconstructed with concrete crossing panels from the San Lorenzo River to Pacific Avenue. That, however, could be quite expensive (depending upon the division of responsibility for the pavement surface). And, since the track between Cliff Streets and Pacific Avenue is in relatively good condition, there is little need for a major rehabilitation in this area. Funding for these repairs have been included under the preservation program for which a capital expenditure outlay would be necessary.

We understand that there may be a cost sharing agreement between various parties (e.g., the amusement park and the City) for track maintenance in this area. As part of SCCRTC's due diligence, the terms of that cost sharing agreement should be investigated to identify responsibility for payment for any improvements. This could reduce SCCRTC's cost burden for maintenance of this track.

Due to the all-or-nothing nature of embedded track rehabilitation, any rehabilitated areas would result in a track structure suitable for Class 2 or 3 speeds. Note, however, that the surrounding uses of the area, particularly at the Boardwalk, do not lend themselves to a 20MPH operation. With proper signaling and advance preemption of traffic signals, 20MPH could be achieved along Beach Street. However, developing the parameters of such improvements requires consultation with the roadway authority and additional design to fully understand the scope of the necessary improvements.

Example of recent spot asphalt repair in front of the Boardwalk (near MP 19.8).

Track in Beach Street, near Pacific Avenue intersection (MP 20.0). We recommend installing concrete crossing panels in this part of the curve.

MP 20.05 to MP 20.8 (Segment 2)
This segment includes the track from Pacific Avenue to California Avenue. With the exception of the area at the Pacific Avenue grade crossing, the ballast and drainage in this area are in generally good condition. Near Pacific Avenue, the ballast and drainage are in fair condition, but with a little work by regular maintenance forces, could probably be improved. In the wye area, and north of the wye, pedestrian traffic has eroded the ballast shoulders. Ties in this area have been derailed upon, leaving a higher proportion than average in poor condition. In combination with the scant ballast, this could create conditions for center-binding of the ties. There is evidence of plate cutting on the low rail of the curve. The two 90RA turnouts in the main track are in adequate condition, with relatively good ties.

The track towards Felton is in generally good condition for the limited service it sees, though there is a much higher proportion of defective ties on these two legs of the wye. No additional work, beyond regular maintenance, is recommended on the Felton line. We do not have information on the division of responsibility for maintenance on the portions of the track (the wye and the small interchange yard) used for the Big Trees and Pacific's operation.

Recommendations for the capex preservation program along the main track include addition of ballast and surfacing to mitigate the scant ballast and prevent center-binding of ties. This area should receive attention as part of the regular tie replacement program.

To operate at Class 2 or 3 speeds, we recommend upgrading the turnouts to eliminate the self-guarded frogs and to provide a larger rail size. In addition, the northernmost of the turnouts would have to be upgraded to a larger size turnout, or the track geometry reconfigured, since the main line is currently on the diverging leg of the turnout, and 20MPH speeds are not possible with the current turnout angle.

MP 20.8 to MP 21.3 (Segment 2)
This segment includes the many grade crossings between California Avenue and Rankin Street. Only a few of these crossings are equipped with active warning devices. Ballast and drainage conditions in this segment range from fair to very poor, and the track generally has a poorly defined or non-existent ballast section in most areas. This is particularly true between Lennox Street and Younglove Street, where, in spots, the track is sitting in mud. The heavy rail in this segment (113HF to 136RE) and probable low train speeds are what have preserved it in useable condition. Tie conditions in this segment are fair to poor as a result of a recent derailment that has damaged many of the ties. Most of the roadway drainage appears to be directed to culverts which, we believe, may drain to the ocean.

The track at the grade crossings themselves, as well as the grade crossing approaches is in generally fair condition. The notable exception is Lennox Street, where there is wide gauge developing in the crossing; this should be addressed in the near future as part of the base case state of good repair work. A short-term repair performed under the on-going maintenance program might be to replace ties and asphalt as needed to address the gauge problems, but the longer-term repair would be to rehabilitate the track through the entire crossing. This major effort would need to be funded under a capital expenditure program related to upgrading or modernizing the facility once a long-term purpose of the Branch is identified.

The track between Dufor Street and Bellevue Street is the worst of this segment, since a series of off-road bike jumps have been built next to the track. Dirt from this activity has completely fouled the ballast, and will result in the need for, at minimum, skeletonizing this track, in addition to re-establishing drainage, in this area. This work has been included under the capex preservation program recommendations. A better solution would be to replace this track completely, to allow repair of the subgrade, though this would be much more costly than skeletonizing the track.

If operations are contemplated at Class 2 or 3 speeds in this area, it is nearly certain that all grade crossings would need to be upgraded with active warning devices. This cost would likely be several million dollars and, due to the amount of signal design and required consultations with the California Public Utilities Commission, has not been included in any of our estimates.

Indeed, we understand that current train speeds tend to be quite slow (likely less than 10 MPH) in this area, and that new active warning devices might be warranted at several of these crossings if 10 MPH operations are desired. Such upgrades might also include wayside horns or quiet zones in an effort to reduce the noise from train horns in this residential area.

MP 21.3 to MP 22.2 (Segment 2)
This section begins at Rankin Street, where the rail size changes from heavy, 136RE rail, to lighter 90RA rail. The north end of the section is at Natural Bridges Drive. Ballast conditions are generally fair, with some moderate to heavy fouling with sand. However, the drainage pathways are in generally fair to good condition, with some definition to the ballast section, and it is likely that water is able to drain from the ballast to provide adequate tie life. There is evidence of significant recent work to improve drainage through this segment; most of the drainage appears to eventually flow to culverts which direct the water towards the ocean.

The surface and alignment in this segment are poor, with plate cutting in the curve north of Rankin Street, and a very abrupt vertical curve at Fair Avenue. North of Almar Avenue, there are short sections of 75CS rail, even lighter than 90RA.

We recommend that the 75CS rail be replaced as part of the capex modernization program. Rather than upgrading only the short segments of 75CS rail, we recommend upgrading the entire section where 75CS rail is present, between Almar Avenue and Swift Street, to heavier rail, 115RE CWR or larger. This portion is approximately 0.2 miles in length. Approximately 10% of the ties should be replaced at the same time, since the existing ties have been marked or broken in a derailment and approximately 50% are defective in this section of track. During this process, the excess superelevation could be removed from the curves.

Track in this section was obviously former yard trackage, and the main line follows the diverging route of former turnouts (long since removed). This makes the alignment unsuitable for Class 2 or 3 speeds without significant reconstruction (possibly including re-profiling the roadways) near grade crossings and re-grading for new track embankment. In addition, the vertical curves are unsuitable for Class 2 or 3 speeds. Design effort would be required to identify the impacts of realigning the track (if necessary) and re-profiling the track, and the impacts of those activities on grade crossings and roadway surface profiles. Thus, we have not evaluated the feasibility of upgrading the track in this segment for operation at Class 2 or 3 speeds.

MP 22.2 to MP 27.2 (Segment 3)
This segment begins at Natural Bridges Drive, and ends at the Scaroni Road private crossing at MP 27.2. The Natural Bridges Drive crossing marks the beginning of the "northern" section of the railroad, which is generally characterized by larger rail, long sections of continuously welded rail, better ballast, and better drainage. Tie condition is generally good, with an inspection of this section showing the average of approximately 35% (or more) of the ties having been renewed recently. Surface and alignment are generally good. There are isolated problem areas, such as sections of poor drainage at the fifteen private crossings in this segment, and a section in the vicinity of MP 24.1 to MP 24.3, where drainage is poor and the ballast is fouled. An alignment issue was noted at the trestle north of Natural Bridges Drive, possibly indicating settlement of the structure.

One of the poorest locations is near MP 25.5, at one of the Walker Ranch State Park private crossings, where the track is completely buried in silt and sand. At this location, due to the extent of fouling of the ballast and subgrade, two repair scenarios may be possible.

The first, a more temporary fix, would be to completely skeletonize the track with a vacuum truck to a depth several inches below the ties, and replace that material with new ballast, using larger ballast - for example, meeting American Railway Engineering and Maintenance of Way Association (AREMA) number 24 ballast specifications- at the lower layers to provide a stronger foundation, and smaller material (such as AREMA number 4A ballast) around the ties. If the fundamental drainage problem were addressed, this repair would likely last 5-15 years, depending upon traffic level, and the condition of the subgrade. We believe this approach is suitable for the base case scenario with relatively slow speeds; thus, this is the scenario upon which we have included in the capex preservation program estimate.

The second approach, a long term repair for the track at MP 25.5, is to remove the existing track completely and replace it with new track, beginning with a compacted subgrade, and a layer of subballast before laying track and ballasting it. This work could only proceed after the fundamental drainage problems have been addressed and the area allowed to dry. The decision as to whether track replacement, or skeletonizing the track is pursued should be based on some additional field investigations and a decision on how to address the drainage. This second approach is appropriate if Class 2 or 3 speeds were desired in this segment.

At MP 25.5, it may be possible to convey some of the water ponding around the track to what appears to be a lagoon or pond, closer to the ocean. This possibility (and its regulatory ramifications) should be investigated further in the immediate future, since it would address the fundamental cause of the fouled ballast. In addition, drainage coming down from the roadway (which slopes downward to the track) should be diverted before it reaches the track. Leaving this section "as-is," buried in mud, will greatly reduce the life of the ties recently installed here.

As noted, we have included these extensive repairs under the capex preservation program. Costs have been based on using a vacuum truck to skeletonize the track at

MP25.5. Other than regular maintenance, we believe that this section could be made suitable for operation at Class 2 or 3 speeds by repairing the many private crossings and permanently addressing the unique drainage conditions at each crossing. While Class 2 or 3 speeds may be possible, we recommend that they not be instituted unless there is a proven operational demand, since higher speeds will lead to much more rapid deterioration of the existing track in this segment. Time may prove that tie life is fairly long (perhaps even longer than as 30 years in tangents with historically good drainage) in this section, and that would be lengthened even further if operations occur at lower speeds. However, because operations at the Cemex facility in Davenport have been temporarily suspended, we further recommend that no remedial action under the various proposed capital expenditure programs be taken on this and the other sections that composed Segment 3. Continued on-going maintenance is recommended along the various Segment 3 sections to make sure that the Branch can remain in service. These maintenance activities are likely to be minor in scope and limited to inspection, removal of tree limbs and sand-build-up on the track and so forth.

Fouled ballast and poor drainage at the private crossing near MP 25.5.

Track at Scaroni Road private crossing, near MP 27.2.

MP 27.2 to MP 31.2 (Segment 3)

This section begins at the Scaroni Road private crossing, and ends at the State Highway 1 grade crossing at Davenport. Conditions are generally similar to those of the previous segment, with rail, ties, ballast and drainage generally good, except at private crossings. There are 5 private crossings in this section and, like the crossing at MP 25.5, they drain water and roadway debris and silt down toward the track. The worst, at MP 28.5, is in comparable condition to the location at MP 25.5. Near MP 29.5, there is an area where pedestrians have eroded the ballast beneath the track; in this area, there is also a great deal of sand that has blown onto the tracks. Controlled vegetation planting might help mitigate the blowing sand, but the primary issue here is the scant ballast and control of pedestrian traffic.

We have included work at the crossing at MP 28.5 as part of the state of good repair work. Outside the relatively short section of additional ballast needed at MP 29.5, there are few immediate needs in this segment.

At MP 29.5, working with the State Parks Department (which appears to have established a parking area and de-facto beach access across the right of way) and the California Public Utilities Commission, a new private crossing should be established to better control pedestrian activity in this area.

Other than regular maintenance, we believe that this segment could be made suitable for operation at Class 2 or 3 speeds by repairing the private crossings and permanently addressing the unique drainage conditions at each crossing. There are 5 private crossings in this section. We have based the preservation program estimate on upgrading several private crossings on an out-of-face (all at once) basis. While Class 2 or 3 speeds may be possible, they should not be instituted unless there is a proven operational demand, since higher speeds will lead to much more rapid deterioration of the existing track in this section. Time may prove that tie life is fairly long (perhaps even longer than 30 years in tangents with historically good drainage) in this segment, and that would be lengthened even further if operations occur at lower speeds.

MP 31.2 to MP 31.9 End of Track (Segment 3)
This is the section between the State Highway 1 grade crossing and the end of track. Cemex maintains the track from just north of the private crossing at the Cemex main gate, approximately MP 31.3 to the end of track at MP 31.9.

Between MP 31.2 and MP 31.3, the drainage is poor and the track is sitting in mud, though the ties are in relatively good condition. To preserve the ties, drainage should be re-established and the ballast shoulders should be cleaned. It will be difficult to raise the track due to the adjacent grade crossings. However, since this track is near the “end of track”, there is little justification for speeds above 10 MPH. Indeed, given the likely operating conditions, along with a derail protecting the yard immediately north of this location, 5 MPH would be an acceptable speed here. As with other areas, overhanging vegetation is leaving debris on the tracks, exacerbating the drainage issues.

We understand that the yard track north of MP 31.3 is maintained by Cemex. It was rebuilt by a contractor and most of it is in very good condition. However, the two spurs that cross Cement Plant Road are in poor condition, with bad drainage and, in one case, a broken frog in a turnout immediately adjacent to the grade crossing. Since much of the yard was completely rebuilt at once, the track condition will also tend to deteriorate all at once, but this date is likely 20 years in the future, and SCCRTC should negotiate any further agreements with Cemex so maintenance of this track remains Cemex’s responsibility. Please note that, while Cemex may be responsible for maintaining this track, in the opinion of the Federal Railroad Administration and California Public Utilities Commission, SCCRTC, as the track owner, may still have some responsibility for the condition of this track and the associated grade crossings.

Our recommendations for this yard track are to replace the broken frog and address drainage and tie conditions on the two spur tracks crossing Cement Plant Road. However, estimated costs for this work are assumed to be borne by Cemex and are not reflected in our maintenance planning costs.

5.0 SUMMARY OF GRADE CROSSING CONDITIONS

Most of the public grade crossing surfaces along the Branch are in good condition, and have been rebuilt with concrete panels and/or rehabilitated with heavy rail and new asphalt paving around the track. The main exceptions are at Buena Vista Road, Spring Valley Road, Mar Vista Drive, the track embedded in asphalt in Santa Cruz, and at Lennox Street.

At Buena Vista Road, heavy traffic and poor drainage has impacted the condition of the asphalt and wide gauge is developing in the crossing.

At Spring Valley Road, the timber plank and asphalt roadway surface is simply worn out, and the track surface is poor as a result of bad drainage in the immediate vicinity of the crossing.

At Mar Vista Drive, the timber plank crossing is in fair condition, but is showing signs of wear and may deteriorate rapidly, though the track appears to be in good condition.

The embedded track and the Lennox Street crossing have been addressed in the previous Sections of this report.

Note that the Seabright Avenue crossing, while equipped with concrete panels, is equipped with panels designed for smaller rail than is currently in the crossing. Although not a major railroad maintenance concern, it could pose an issue for bicyclists; signage indicating a rough grade crossing may be warranted at this location.

Most of the remaining crossings are in fair to good condition, with the exception of the private crossings. The recommendations for base case preservation at-grade crossing replacement program would include replacement of several at-grade crossing surfaces on an out-of-face basis. With 40 total crossings, the program would be designed to rehabilitate all crossings within a two-to three year period with an expected 20 year life for each crossing.

In actuality, after performing state of good repair work at Buena Vista Drive, Lennox Street, and at the embedded track in Santa Cruz, there are few public crossings that require immediate attention to the track conditions for the base case, since the most heavily used crossings appear to have been reconstructed within the last 5-10 years. It may be possible to “save” the equivalent annualized cost of crossing replacement over several years until such time as material acquisition costs are most favorable – though the current market (in year 2009) is depressed, making the present time a good time to stockpile track material. In the future, a contractor could be engaged to repair several crossings at once, hopefully realizing an economy of scale in the process. We also recommend rehabilitating 2 private crossings (of the 37 total private crossings on the Branch, counted per the track charts) per year as part of the maintenance program.

For the base case, we recommend that the active warning devices at two crossings, Buena Vista Road and Seabright Avenue, be upgraded to more modern equipment as part of the capex modernization activities. These crossings were identified based on a review of information provided by Union Pacific and using judgment regarding assumed traffic levels at various roadways.

Buena Vista Road has only bells and flashers, though the crossing’s location on a main access to a landfill implies heavy traffic. The addition of crossing gates and upgraded bells and flashers would improve the warning to motorists at this location. Likewise, upgrading the controls to a more modern system would result in constant warning times and more reliable operation, particularly in an area where ongoing drainage issues may affect electrical circuitry for the crossing (grade crossing circuitry relies, in part, upon using the rails as conductors and the ties and ballast as insulators).

Seabright Avenue is equipped with a single wig-wag signal and traffic signal pre-emption. Wig-wags are no longer common (there may be only a handful remaining in operation on the west coast), and obtaining replacement parts is difficult or impossible. We recommend that this crossing be upgraded with modern active warning devices, such as bells, flashers, and gates, and equipped with a modern control system. There is a higher potential for faults at a wig-wag crossing to present themselves in a non-failsafe manner. In other words, if there is an equipment failure at the wig-wag, rather than failing in a manner that warns motorists, there is a higher likelihood (when compared with other types of warning devices) that no warning will be presented to motorists. As at Buena Vista Road, upgraded controls would result in constant warning times and more reliable operation, particularly in an area where ongoing drainage issues may affect electrical circuitry for the crossing.

To ensure reliable warning to motorists, other crossings that would benefit from an upgrade include Spring Valley Road, which has older equipment, as well as 30th Street, which has very restricted sight lines and no crossing gates. Upgrading these crossings with new equipment would also provide an inventory of "spare parts" with which other crossings with similar, older equipment could be maintained.

We have not looked at the incident history at any of the crossings on the Branch, but it is logical that many crossings with restricted sight lines – particularly in the residential area north of Bay Street – would benefit from installation active warning devices. Investment in such equipment is up to the Commission, and we have not included costs for such improvements in our estimates. However, it may be possible to obtain funding for such improvements at the state level.

For operation at Class 2 (25 MPH) or Class 3 (40 MPH) speeds, we have assumed that many more active warning devices would need to be upgraded to provide either more forms of warning (for example, where there are only flashers and bells at 30th Avenue, the crossing would benefit by the addition of automatic gates, as well), or more sophisticated control systems (Constant Warning Time Device, CWTD) which can predict the actual speed of a train, and adjust the warning time provided to motorists, accordingly. The assumptions for warning device upgrades for higher speed operations also assume that the areas with embedded track (such as Walker Drive, or the Santa Cruz Boardwalk) would remain at 10 MPH; in addition, due to the complexity of the circuits required for closely adjacent crossings, we have assumed that the track between MP 19.5 and MP 21.4 would also remain at 10 MPH.

However, due to the complexity of the electrical circuitry, we have considered each crossing independently, and without interconnections to highway signals. In actuality, FRA has mandated that, depending on the crossing configuration, may require some of the crossings to be "interconnected," which adds cost. In addition, it may be necessary to revise the roadway channelization in order to discourage motorists from evading lowered crossing gates. Many of these improvements should be designed with the ultimate installation of FRA-approved Quiet Zone in mind. Once these zones have been installed and approved, the locomotive engineer would be alleviated of the responsibility of sounding the train whistle/horn at each crossing. A specific study, accompanied by access to the existing control units, discussions with regulatory agencies, and perhaps preliminary design work, would be necessary to determine the actual cost for higher speed and quiet zone operation.

We have assumed that rehabilitation of the crossing surfaces would be performed at the railroad's expense, and that no other agreements exist to mitigate that cost to the railroad. This should be investigated, since many private crossings require that the crossing owner (ie, the party which has the right to the crossing) bear the cost of maintenance.

6.0 SUMMARY OF RECOMMENDATIONS AND ASSOCIATED COSTS

The Santa Cruz Branch has been divided into three roughly equal segments as described above. Local rail service is currently active within the first two segments and temporarily suspended in the third or last segment.

Accordingly, recommendations for an on-going maintenance plan and a capital plan for improving the physical plant are described herein and quantified in Table 4.0 & 5.0 below.

On-Going Maintenance

The HDR report summarizes on-going maintenance efforts to include:
(1) Minor track inspection
(2) Minor track repairs
(3) Vegetation Control/Brush Cutting
(4) Minor drainage and slope stability repairs
(5) Emergency calls (such as tree across track)
(6) At-grade crossing inspection, signal & battery maintenance
(7) Miscellaneous

Capital Expenditure: Preservation & Modernization Cost Estimates
The following cost estimates for proposed capital expenditure funding requests are based on the HDR inspection herein (HDR Santa Cruz Branch Maintenance Study) and then broken into two funding phases of 10 years each. Improving the Branch to accommodate Class 3 track performance was estimated from an assumption of total track replacement costs of $3M/mile.

No Action
Under this program, little if any capital expenditures would be required to maintain service on the Santa Cruz Branch. The budget included for the On-Going Maintenance Program would be sufficient to effect repairs should small washouts or slides impair or compromise track safety. The service level would remain at Excepted Track which would limit train movement to a maximum speed of 10 MPH. No passenger trains could be operated and no hazardous materials could be transported.

Class 1 – 268K Rating
Under this program, seven miles of 75# and 90# rail are replaced and ties renewed in accordance with FRA requirements as listed in Table 2.0. Also, this program will undertake the repair of chronic drainage locations, with some repair of a portion of the in-street track section. Several at-grade crossings are upgraded. Should these repairs be implemented, the Class of Track would be upgraded to Class 1 which would allow the

maximum speed to remain at 10 MPH but with the railroad now having the ability to transport passengers and hazardous material commodities if requested by a rail customer.

Class 1 – 286K Rating
Under this program's budget, more rail and ties are replaced and track surfaced. Expanded portions of the in-street track are repaired and several additional at-grade crossings are upgraded. However, the rehabilitation of the track is less important than upgrading the bridge ratings to accommodate the heavier loads. Track improvements are included as the stresses in the track are slightly higher than the lower 268K car loadings. Should these repairs be implemented, the Class of Track could be upgraded to Class 1 which would allow the maximum speed to remain at 10 MPH. However, the Branch could now accommodate passenger trains plus shipments that weigh 286K as well as commodities that could be considered a hazardous material if requested by a rail customer.

Class 2 – 286K Rating
Operating at the current maximum speed of 10 MPH, it would require approximately eight- to nine hours for a switch engine to pick up rail cars at Watsonville, move these cars to Davenport, perform the necessary switching, then return to Watsonville. As noted above, by improving the track structure slightly, 286K car loadings could be accommodated; however, the ability of the Branch to handle the heavier cars is more a function of the bridge ratings along the Branch. Bridge ratings were not analyzed as a part of this work effort. Improving track conditions to Class 2 (see Table 1.0 above) would allow freight trains to operate at 25 MPH wherever possible. In-street sections would remain at the current 10 MPH. With this improvement, the train crew could reduce their cycle time to roughly half. Track improvements under this program include the replacement of all rail sections smaller than 113#, and the implementation of a rigorous tie and surfacing program. Bank stabilization and in-street track replacement programs would also be initiated.

Class 3 – 286K Rating
Upgrading to Class 3 track would only be necessary if a passenger rail program was initiated. This Class of Track would allow freights to operate at a maximum of 40 MPH and passengers, at a maximum of 60 MPH. Track improvements under this program would be similar to those envisioned under Class 2 – 286K program described above and would include the replacement of all rail sections smaller than 113#, and the implementation of a rigorous tie and surfacing program. Bank stabilization and in-street track replacement programs would also be initiated. Depending on the ultimate use of the Branch, a total track replacement program using a P-811 track replacement machine would be warranted. Using the P-811 would also allow the use of sustainable concrete ties as concrete ties cannot be intermixed with the wood ties now being used.

Table 4.0 Track Costs as a Function of Class of Track - Total Branch (31.9 miles)				
FRA Track Class	**Load rating**	**On-Going Maintenance**	**Capital Expenditure**	**Comments**
Excepted Track	268K	$370K	None	Recommended
1	268K	$370K	$7.8M	Not Recommended
1	286K	$410K	$10.0M	Not Recommended
2	286K	$540K	$23.0M	Not Recommended

3	286K	$540K	$95.7M	Not Recommended

- The Capital Expenditures were based on this HDR Santa Cruz Branch Maintenance Study, prorated for a 20 year life-cycle, then broken into two funding phases of 10 years each. The Class 3 summary was estimated from an assumption of total track replacement costs of $3M/mile.

Table 5.0 Track Costs as a Function of Class of Track - Two Segments (22.5 miles)				
FRA Track Class	**Load rating**	**On-Going Maintenance**	**Capital Expenditure**	**Comments**
Excepted Track	268K	$370K	None	As-Is
1	268K	$370K	$6.3M	Not Recommended
1	286K	$410K	$7.0M	Not Recommended
2	286K	$540K	$16.0M	Not Recommended
3	286K	$540K	$67.5M	Not Recommended

Summary

From the perspective of the fourth quarter, 2009, the Santa Cruz Branch is currently seeing limited freight service due to the closure of the Cemex facility. Rail shipments are being originated and delivered to the Santa Cruz, Big Trees and Pacific Railroad in Santa Cruz, and at various industries along the corridor primarily at Watsonville. No rail service is currently warranted beyond Milepost 22.5. For that reason, Table 5.0 displays the rehabilitation costs should only the first 22.5 miles of the Branch be rehabilitated. In addition, because there is no identified use of the Branch, no capital expenditure program is recommended at this time. Accordingly, as the cost estimates were not derived with any proposed purpose in mind, the estimated costs included in Table 4.0 and 5.0 should only be used as “placeholders” and not used to develop projects that might be pursued in the future.

For instance, if SCCRTC would use the Branch for the current limited freight service, then the Excepted Track designation would appear to be adequate. If some remedial repairs are desired should the Cemex facility resume operations, then applying for a grant (see Other Funding Sources below), for up to $7.8 million would allow SCCRTC or the operator to perform additional repairs to the track and bridges. If higher speeds are desired, adopting a program to improve track conditions to allow for a Class 2 or 3 operation may be established. However, SCCRTC would need to understand why a higher speed operation is even required. The current freight operation or the former freight operation that was used when Cemex was in full operation was handled adequately under the existing Excepted Track regime. Furthermore, at the higher speeds, additional work at the at-grade rail/highway crossings would be required so that the active warning devices that protect each crossing are updated to handle the higher speeds. If remotely controlled signals and switches are indicated should Centralized Traffic Control be required, then a more reliable signal from the track circuits would be necessary. If so, then rehabilitating the Branch using a P-811 would then be warranted.

As a comparison, comparable costs for the P-811 upgrade of a 14.7 mile section of a secondary branch main in Oregon for a proposed commuter rail service cost $2.8M/mile. Site work associated with bridge replacement and repair, grading costs associated with the proposed commuter service cost $2.5M/mile and systems cost $1.4M/mile. Total physical plant costs therefore in the $6.7M/mile range. To upgrade the segment of the

Santa Cruz Branch from Watsonville through Santa Cruz to Natural Bridges Drive would cost and estimated $150 million.

As a result, HDR cannot recommend that a program to procure capital expenditure funds be initiated until such time as a purpose for the use of the Branch is identified. This Branch Track Maintenance Study conducted by HDR plus the Bridge Rehabilitation Study performed by HNTB, should both be used as reliable data sources to develop a purpose-built rehabilitation program once the use of the Santa Cruz Branch as been determined.

Other Funding Sources:

Several alternative sources for fund to rehabilitate the track and bridges along the Branch should be investigated. These include the Railroad Rehabilitation & Improvement and Financing (RRIF) Program. Administrated by the FRA, the RRIF program can be used to:

(4) Acquire, improve and/or rehabilitate rail facilities or intermodal yards including track, components of track, bridges, yards, and shops,
(5) Refinance debt incurred for the purposes listed above,
(6) Develop or establish new rail facilities or intermodal yards.

Further information can be obtained by using the following link to FRA's website:

http://www.fra.dot.gov/us/content/177

In addition, the American Short Line & Regional Railroad Association (ASLRRA) has established, through Congress, a tax credit program that allows tax credits to be apportioned to rail-related projects. This program was recently re-authorized and should be examined for applicability as a funding source for Santa Cruz Branch rail improvements. The tax credit is for maintenance expense on shortline rail right of way and can be applied at the rate of $3,500.00 per mile, which for this Branch would equate to $108,500.00 of tax credit per year. Should a catastrophic incident occur, such as a flood or earthquake, the Santa Cruz Branch would become eligible for FEMA relief should the Santa Cruz area qualify for this type of aid.

Appendices:

Estimated costs for on-going maintenance are included below in Table A1. HDR recommends that these tasks should be concentrated on the first two segments (Table A2) with only occasional inspection/maintenance required for the third segment between Santa Cruz and Davenport. The variation in the annual maintenance costs are primarily due to the number of people assigned to the track maintenance crew. The Capital Expenditures were based on the HDR Santa Cruz Branch Maintenance Study as commissioned by Egan Consulting group on behalf of the SCCRTC, prorated for a 20 year life-cycle, then broken into two funding phases of 10 years each. The Class 3 summary was estimated from an assumption of total track replacement costs of $3M/mile.

Table A1: Estimated Maintenance and Capital Costs – Entire Santa Cruz Branch

FRA Track Class	Load Rating	On-Going Maintenance	Capital Expenditure
Excepted	268K	$370,000	None
Class 1	268K	$370,000	$7.80M
Class 1	286K	$410,000	$10.0M
Class 2	286K	$540,000	$23.0M
Class 2	286K	$540,000	$95.7M

Table A2: Track Costs as a Function of Class of Track - Two Segments (22.5 miles)

FRA Track Class	Load rating	On-Going Maintenance	Capital Expenditure	Comments
Excepted Track	268K	$370K	None	Recommended
1	268K	$370K	$6.3M	Not Recommended
1	286K	$410K	$7.0M	Not Recommended
2	286K	$540K	$16.0M	Not Recommended
3	286K	$540K	$67.5M	Not Recommended

The report further identifies recommended actions and associated costs for ongoing maintenance work, and the capital expenditure programs that focus on either preservation or modernization of the facility on a cyclical basis. These activities have been described more fully in this document, where the “base case” describes the operation of 268,000 pound gross weight on rail (268K) equipment at Class 1 speeds.

Note that an increase of speed dictates a significant increase of capex funding levels. This is primarily due to the need to relay essentially all the 90RA rail if a speed increase is contemplated. At a fundamental level, the total energy available in the system is a function of the *square* of the speed of the train. Thus, an increase in speed dramatically increases the forces on the track and, thus, a much more robust track structure is required.

Likewise, an increase in car weight results in an increase in maintenance cost. This increase is significant, since 90RA rail approaches its limit under 268,000 pound GWR.

under higher loads, e.g., 286,000 pound GWR, excellent track maintenance would be necessary to prevent failures. Track surfacing and tie replacement, in particular, would be of prime importance.

Assumptions Associated with the Cost Estimates
The assumptions upon which this, or any other cost estimate, is based are key to understanding the meaning of the estimate. Different assumptions about the balance between capital investment and maintenance expense, or about the standard to which the line will be maintained, will result in differing maintenance cost estimates.

These cost estimates reflect the basic assumption that the condition of the line will be maintained at its current level; that good conditions, where they exist, will not be allowed to deteriorate; where small "islands" of poor condition track exist within much larger stretches of generally good track (for example, the private crossings on the north end of the line), the poor sections will have at least some upgrades performed if capital funds can be obtained; and that where larger sections of track are in generally poor condition, some improvements will be made in order to ensure reliable operation and to prolong the life of the infrastructure, again if funding can be procured. Our recommendations are premised on the idea that the railroad will be maintained as a going concern and investments made on a regular basis to address accumulated wear and tear on major track components well before the components are completely worn-out.

We believe this approach is typical of the level of maintenance desired by many public agencies in a best case scenario in order to minimize potential risk and liability to the fullest extent possible, particularly where the railroad and the public interface. One example of such an interface is at grade crossings, where the crossing surface is often a high-maintenance item. Our cost estimates assume that the heavily trafficked public crossings would receive attention on a more regular basis, prior to reaching such a poor condition.

These assumptions may not be consistent with the business plan a rail operator might adopt when considering the level of freight business and revenues on a particular railroad asset. In light of revenue constraints, due to insufficient freight rail volume, the operator may defer long-term maintenance items, such as rail replacement, or a tie replacement program, based on the expectation that either: 1) the traffic base will grow and justify additional maintenance expenditures in the future, or, 2) the railroad or agency will apply for and be deemed eligible for a state or federal grant or low-interest loan to pay for the additional maintenance.

In a revenue-constrained case, the operator might choose a maintenance strategy and budget that resembles in general the "On-Going Maintenance Costs" presented, below, while forgoing much or all of the heavy maintenance items. Alternatively, the operator may seek to remove a portion of the line from active service (in the current case, with CEMEX not operating, the segment from Santa Cruz to Davenport), thereby reducing on-going maintenance costs.

Also, please note that the cost estimates are predicated on freight train operations presuming 4,500 carloads per year, and do not reflect the current standards widely applied where there is regular passenger service should this service be implemented in the future.

In general, where rail passenger service is provided by a public agency, the standard of care has been to obtain capital funds in order to perform complete (or near-complete) rehabilitation of most of the railroad in an effort to minimize both risk and on-going maintenance costs, since, for public agencies, capital funding has historically been easier to obtain.

The cost of each category of work, on-going; “capitalized” preservation and modernization upgrade repairs, has been identified in the accompanying spreadsheets, based upon our experience with the cost of similar work over the last few years. The descriptions that follow identify the general nature of each category of work for the base case scenario. In some cases, an exact location for work has not been identified. For example, it is not necessary to identify individual tie replacements in order to understand the overall cost of tie replacement. In other cases, specific projects have been identified by milepost (MP).

Costs are expressed as “annualized” costs, which represent the equivalent annual cost of specific items of maintenance. Some items, such as herbicide application, would be performed on an annual basis, and thus are easily understood as annualized costs. However, items of capitalized maintenance repairs that focus on preservation of the Branch’s or perhaps to upgrade the Branch’s physical plant through modernization improvements, such as contract tie replacement (under preservation), may occur on a three to four year cycle (or longer) or relaying long sections of rail with a heavier section of CWR to take advantage of economies of scale.

The cost of capitalized maintenance activities has been normalized by the assumed length of cycle over which they are performed. For example, if a major tie program were established at 4-year intervals, replacing about 10,600 ties every 4 years at a cost of about $1.6 million, the equivalent annual cost would be $400,000 (or $1.6 million / 4 years). In the estimates included in Tables A1 and A2, these annualized cost estimates have been totaled for a 20-year life cycle period, then halved to represent two funding cycles for the next 20 years.

Union Pacific and its predecessor, Southern Pacific, appear to have taken an approach which leverages their maintenance equipment and staff capabilities by making very large investments on infrequent intervals. Based on tie and rail condition, it appears as if a significant investment in rehabilitation has been made in line at roughly 10 to 15 year intervals. For example, significant lengths of rail (1 track mile or more) were installed around 1952, 1969, 1978, and 1996. Based of the condition of the ties, with about 1/3 of the overall total in good condition, 1/3 in fair condition, and 1/3 in poor condition, it appears as if major tie programs have been undertaken at regular intervals (roughly at the "third" points in the life of the ties). Such major rehabilitation programs are predicated on economies of scale, but they also imply that, just before a major rehabilitation program is undertaken, the infrastructure may be in poor condition, having seen little or no significant maintenance or investment in many years. As mentioned, this approach leverages economies of scale, and performs the preservation of the Branch under a "capitalized" maintenance program at infrequent intervals.

On-Going Maintenance

On-Going maintenance activities include weekly inspections of the track and monthly inspections of the grade crossing signals as required by the Federal Railroad Administration, as well as the regular types of activities that a small maintenance crew ("section gang") would be expected to handle over the course of a year. The following items are included in the ongoing maintenance cost for the base case scenario, with operations conducted at Class 1 speeds with 268,000 pound GWR equipment:

- Weekly track inspection, requiring 2 person-days.
- Four person-days of a track crew to perform minor maintenance tasks, such as:
    - isolated ("spot") tie replacements in trouble areas,
    - spot track surfacing,
    - replacing damaged or missing signage and access control (fences, etc),
    - tightening bolts at joints,
    - re-filling flange lubricators,
    - adjusting turnouts,
    - performing minor ditching
    - performing minor vegetation control at trouble spots and at grade crossings, and
    - repairing track maintenance equipment.
- Monthly crossing signal inspection by a contract signal maintainer for each crossing with an active warning device.
- Signal maintainers responding to up to 500 hours annually of "trouble" calls for grade crossing signals.
- Replacing back-up power supply batteries at several crossings each year.
- Managing vegetation along the right of way, including:
    - 31 miles of pre-emergent herbicide application, in a pattern approximately 20 feet wide, with spot post-emergent treatment as necessary, and
    - Contract brush cutting and tree pruning, with an allowance of $50,000 per year for this work.
- Re-establishing and cleaning existing drainage ditches by an outside contractor with a Gradall ™ or similar machine, with an allowance of $35,000 per year for this work.

We have assumed that the fully-burdened rate for each person on the section gang is $39/hour, based on a $14/hour salary, $12/hour of overhead and benefits, and including the equivalent of $12.53/hour of equipment costs. Equipment would include a backhoe, dump truck and trailer and a hirail pickup truck. A tie tamper and ballast regulator would also be desirable, but would likely see less frequent service than the other equipment. Any established shortline operator would likely have a tamper and regulator that they can truck to the site on an as-needed basis, and thus none has been included in the fully burdened labor cost. Some shortline operators may already have equipment available to dedicate to the line, which could represent a significant savings in the burdened hourly rate.

We have not included a cost for right-of-way fencing maintenance or replacement. The obligation to maintain R/W fencing sometimes falls upon the railroad. If the railroad must maintain R/W fencing, this could represent a significant additional cost, depending upon the locations, total quantity, and type of fencing that is to be maintained.

Capital Expenditures

The following work efforts are considered to be "over and above" work that is typically considered as normal maintenance. Accordingly, these two programs (preservation and modernization) would be capitalized. This approach is very similar to the methodology employed by the Class 1 railroads wherein they support a small localized group of maintenance personnel to perform the tasks outlined above in the On-going Maintenance section but then allocate funds under their annual Capital Expenditures budget for the more extensive program work such as rail relay, tie replacement, track surfacing, out-of-face at-grade crossing replacements and so forth.

Preservation Maintenance
Preservation maintenance activities include those which would produce results lasting longer than one year. This type of work is sometimes referred to as "capitalized maintenance. This work includes activities where economies of scale could be realized if small increments of work were done together, as a group, by an outside contractor. For example, tie replacement, rather than occurring in small increments every year, might be most economical if performed in a somewhat larger increment every two or three years. Rail replacement is another example of such an activity. Prioritizing the work would need to be done on a location-by-location basis. Note that there are often outside funding sources for this work, including low-interest loans from the Federal Railroad Administration (FRA), or grants from state agencies or the FRA. In particular, our experience indicates that if a reasonable cost-benefit analysis can be demonstrated (for example, reducing truck trips and thus wear and congestion on roadways), even roadway agencies are wiling to fund railroad infrastructure improvements.

The following items are included within the capital expenditure cost for the base case scenario, with operations conducted at Class 1 speeds with 268,000 pound GWR equipment:

- Tie replacement by a contractor, with an average of 33% of the ties replaced in two installments. This program work would be integrated with Union Pacific's the 2003 tie replacement program wherein 1/3 of the ties were replaced. Once the remaining 2/3 of the ties (if necessary) have been replaced, then the Branch should be free from a major tie replacement program for at least the next 20 years.
- Maintenance of embedded track (e.g., along Walker Street in Watsonville or along the Boardwalk in Santa Cruz, together totaling approximately 1 mile of track), which is essentially replacement of that track. Little maintenance is currently required in Watsonville, for example, but, over time, this track will deteriorate and fail, likely all at once. We recommend setting aside money every year to account for the replacement cost of this track, almost as if this cost were a "balloon payment." We assume that the life of embedded track is 20 years, and we assume that its rail and fittings will be second-hand material. Paving would be performed with asphalt, and all work would be performed by a contractor. Note that research into franchise or license agreements covering this embedded track may identify that the roadway authority is obligated to pay a share of the costs. If this were the case, a substantial savings could result to this relatively significant cost factor. Accumulated costs for replacement of the embedded track sections on the Santa Cruz Branch have been pro-rated for the 20-year life cycle cost then lumped into two funding cycles (roughly every 10 years) for capital expenditure budgeting purposes.
- Track surfacing by a contractor, up to one mile per year. This would most economically be accomplished if performed in conjunction with the contract tie replacement program. Though most of the railroad has relatively good surface, some of the superelevation should be removed from curves, and long sections (particularly near Watsonville) need attention. Removing superelevation should be accomplished in conjunction with the establishment of the curve lubrication

program, rail replacement program, and an understanding of the operating speeds (themselves a function of the train crews and types of locomotives) on each curve, since it is possible that some wheel climb derailments on the sharpest cures with the most heavily worn rail are being averted by the current amount of super-elevation. Accordingly, costs for a out-of-face track surfacing program have been included as a capital expenditure as described above.

- Grade crossing track replacement by a contractor, with the equivalent of 120 track feet of public crossing and 200 track feet of private crossing being reconstructed each year. Like rail and ties, grade crossings have a finite lifespan. The rail section through the at-grade crossings as well as through the embedded track section should be constructed with 132# or heavier CWR rail. This heavier section provides added stiffness to the overall track section to better withstand loading due to heavy truck traffic. While only a few public crossings appear to need reconstruction in the immediate future, the money not spent on public crossings in any given year should be spent on reconstructing the worst of the private crossings. Private crossing replacement could potentially be accomplished by the railroad's own forces, possibly at a significant savings. Note that the maintenance cost for private crossings may be the responsibility of the party for which the crossing was established, depending upon the individual agreements - which would represent a substantial savings. However, we have considered it to be the railroad's obligation. From an economy of scale point-of-view, the out-of-face replacement of perhaps half of the at-grade crossing surfaces should be included as a lump sum in one half of a capital expenditure budgeting cycle.
- Grade crossing control replacement by a contractor, which accounts for the finite life and eventual obsolescence of the electronic systems that activate the grade crossing warning devices. We have assumed that one set of crossing controls would be upgraded per year. However, as there are roughly 40 crossings, over a 20 year life cycle for a crossing, only half would be replaced. Until such time as the long-term use of the Branch is identified, we will continue to use this estimate. In the mean time, SCCRTC should encourage each local road authority to petition for the installation of quiet zones which are normally funded out of a local budget.
- Culvert replacement performed by the railroad's own forces. As with other components considered in the preservation maintenance program, culverts do not have an infinite lifespan. We have noted at least one location in the field where a culvert is present, but is not reflected on the track chart, so the true number of culverts is unknown. Nonetheless, we believe that a two culvert per year replacement rate is appropriate. While only one culvert appears to be in an incipient state of failure (near La Selva Beach), the budget for culvert replacement may also be used to hire contractors to replace culverts at more difficult locations, such as at the base of fills, which require specialized equipment and design. As before, this replacement cycle has been prorated over a 20 year life and then broken into two funding packages under a capex culvert replacement program

Modernization Projects

Activities that are considered to modernize or upgrade the physical plant of the Branch are categorized as "modernization." These activities will establish a solid baseline for future maintenance of the railroad, and would help reduce the need for any subsequent major investments in future years. Like the preservation maintenance activities, our experience suggests that outside funding may be available for some of these activities. A base case for programs that might be considered as "modernization" projects are described below:

- Rail replacement by a contractor. We believe that 14 track miles of rail, particularly curve-worn rail and surface-bent 90 pound rail will require replacement once a long-term purpose of the Branch has been identified. Our cost estimate assumes the rail replacement to include 115# or heavier second-hand CWR complete with good condition tie plates and fasteners. Turnout components would be new and would match the chosen rail section. We have expressed rail replacement as an annualized cost, assuming second hand welded rail and fittings are installed for the replacement program. Rail replacement would be accomplished on an out of-face (all at once) basis and accordingly, the annualized costs have been included in this cost estimate have been pro-rated into two funding cycles for capex budgeting purposes.
- Maintenance or replacement of up to 400 track feet of embedded track along the Boardwalk in Santa Cruz to address the most pressing locations (both in front of the Casino, as well as a short section near Pacific Avenue, where track gauge is beginning to widen). This work would be performed by an outside contractor.
- Track skeletonizing and surfacing for the most badly fouled areas of ballast, with work performed by a contractor. This work effort is included under the modernization category as the track structure would be completely renewed including using a heavier rail section. Typically, all questionable tries would be replaced with new.
  - MP 2.0 to MP 2.8, north of Watsonville,
  - MP 6.7 to MP 6.8, at Buena Vista Road,
  - MP 9.4 to MP 9.7, between Trestle Beach Road and the south end of Sumner Avenue,
  - MP 12.5 to MP 12.6, at Aptos,
  - MP 15.1 to MP 15.5, between Grove Lane and Monterey Avenue,
  - MP 19.0 to MP 19.3, at Seabright Avenue,
  - MP 21.2, between Dufor and Bellevue Streets,
  - MP 25.3 to MP 25.5, at the worst of the private crossings at Wilder Ranch State Park, and
  - MP 28.3 to MP 28.5, at a private crossing.
- Installation of curve lubricators at 15 locations, to be located such that a single lubricator can cover several curves. This should be planned and executed in conjunction with the removal of superelevation and rail replacement programs to avoid creating conditions that would encourage a wheel climb derailment.

Costs for the base case scenario are included, below. Costs for other maintenance scenarios are included in the Appendices to this report.

Please note that we have not included costs for reducing or eliminating trespassing issues, since these can be addressed in many different manners and the Commission is in the best position to determine how to address the trespassing issues while remaining sensitive to its constituents. However, we do recommend that a program be initiated immediately, since trespassing is causing damage to the infrastructure (particularly at bridge approaches). There are also safety and train operations issues associated with trespassing that should be addressed.

Other Scenarios

The expected maintenance cost of higher levels of service on the railroad, including heavier rail cars and/or faster speeds, are reflected in the appendices to this report.

While it is logical that a higher level of service would require additional maintenance, the dramatic increase costs at Class 2 or Class 3 operating speeds is due to the anticipated need to replace approximately 14 miles of rail immediately. This would represent some combination of the curve worn rail and the 90 pound rail on the Branch. However, even with this initial investment, there would still be a need to perform rail replacement on an intermittent basis, since rail in the many sharp curves on the Branch will still need to be renewed periodically. Too, the existing heavy rail on the Branch is, by and large, not control cooled, and will eventually show fatigue damage and require replacement, and do so at a faster rate than if train operations occurred at slower speeds. Under these circumstances, the renewal period for rail replacement is assumed to be 20 years, if second hand rail were used for the relay projects.

An analysis of operating scenarios predicated on Class 2 or Class 3 speeds only on specific portions of the Branch, selected in a manner intended to maximize rail life while reducing operating costs, would be fairly complex and is not within the scope of this report. Furthermore, it is unlikely that such an analysis would result in a plan that achieved any significant benefits of Class 2 or 3 speeds while avoiding the associated costs.

Another scenario would be one in which none, or nearly none, of the capitalized maintenance would be performed until each category of asset had been worn to the point of becoming completely defective. At that point, a major rehabilitation program could be undertaken. For example, with respect to tie replacement, only the ties which urgently need replacement would be addressed on an annual basis, while the overall condition of the majority of the ties was allowed to degrade. At some point, a major program would be instituted in order to restore the asset to its original condition.

A program such as this, taken to extremes, might be characterized by track which is barely passable in the years just before the major investment programs. We recommend against such a program. In the short term, such a program does appear to reduce the maintenance cost. But, by deferring maintenance in the short term, it only conceals the complete cost of ownership and maintenance, ultimately making budgeting for the large programs difficult and expensive. In the last years of the cycle, when the track is barely passable, it also increases the risk of operations. And, finally, the cost of the infrequent, but large, programs is highly subject to market forces. For example, such programs may, of necessity need to be implemented at a time when materials costs (such as steel rail) are high.

The following cost estimates for On-Going Maintenance plus an estimate for a Capital Program are based on operations at Class 1 speeds, with 268,000 pound GWR equipment. Additional information for other scenarios (Class 2 track, 286K GWR equipment) follows in additional appendices. The quantities of materials are based on the field investigation, which upon representative "sample" sections of the line were as a basis for evaluation of each larger segment. The conditions of each of the larger segments are discussed in Section 4.0 of this report.

APPENDIX A

ON-GOING MAINTENANCE COSTS FOR CLASS 1 TRACK- 268K CARLOADING

ITEM	Unit Cost or Qty.	Extended Cost	Annual Cost per Category
CROSSING SIGNAL INSPECTION & MAINTENANCE			
Monthly Maint. per crossing	$ 220		
Total Crossings	31		
Annual Maint cost		$ 81,840	
Trouble calls $ / hour	$ 85		
Annual Hours trouble	200		
Total trouble cost		$ 17,000	
Annual battery replacement cost		$ 14,000	
Annual emergency material cost		$ 10,000	
Total Annual X-ing Maint.			$ 122,840
TRACK INSPECTION			
Track Inspection (hrs/ week)	16		
Labor cost	$ 672		
Annual Track Inspection			$ 34,944
VEGETATION MANAGEMENT			
Herbicide, acres per Mile	2.6		
Cost per acre	$ 175		
Annual Cost for 31 miles		$ 14,105	
Vegetation Control / brush cutting		$ 50,000	
Annual Vegetation Management cost			$ 64,105
CONTRACT DITCHING			
Contract Ditching			$ 35,000
SECTION GANG			
Covers Incidental Track / ROW Maintenance			

hourly fully burdened $/man:	$ 39		
man-days/week	4		
Weekly$ @ 4 man days/week	$ 1,248		
Annual cost		$ 64,896	
Ballast cost/ton	$ 40		
Tons/year (for spot surfacing)	150		
Annual ballast cost		$ 6,000	
Consumable materials/yr		$ 45,000	
Annual Section Gang Cost			$ 115,896
Raw Total:			$ 372,785
GRAND TOTAL (ROUNDED) ANNUAL ON-GOING TRACK MAINTENANCE COST (Class 1, 268K)			**$ 370,000**

APPENDIX B

ON-GOING MAINTENANCE COSTS FOR CLASS 1 TRACK, 286K CARLOADING

ITEM	Unit Cost or Qty.	Extended Cost	Annual Cost per Category
CROSSING SIGNAL INSPECTION & MAINTENANCE			
Monthly Maint. per crossing	$ 220		
Total Crossings	31		
Annual Maint cost		$ 81,840	
Trouble calls $ / hour	$ 85.00		
Annual Hours trouble	200		
Total trouble cost		$ 17,000	
Annual battery replacement cost		$ 14,000	
Annual emergency material cost		$ 10,000	
Total Annual Xing Maint.			$ 122,840
TRACK INSPECTION			
Track Inspection (hrs/ week)	16		
Labor cost	$ 672		
Annual Track Inspection			$ 34,944
VEGETATION MANAGEMENT			
Herbicide, acres per Mile	2.6		
Cost per acre	$ 175		
Annual Cost for 31 miles		$ 14,105	
Vegetation Control / brush cutting		$ 50,000	
Annual Vegetation Management cost			$ 64,105
CONTRACT DITCHING			
Contract Ditching			$ 35,000
SECTION GANG			
Covers Incidental Track / ROW Maintenance			
hourly fully burdened $/man:	$ 39.00		

man-days/week		5		
Weekly$ @ 4 man days/week	$ 1,560			
Annual cost			$ 81,120	
Ballast cost/tn	$ 40			
Tons/year (for spot surfacing)		500		
Annual ballast cost			$ 20,000	
Consumable materials/yr			$ 50,000	
Annual Section Gang Cost				$ 151,120
Raw Total:				$ 408,009
GRAND TOTAL (ROUNDED) ANNUAL ON-GOING TRACK MAINTENANCE COST (Class 1, 286K)				**$ 410,000**

APPENDIX C

ON-GOING MAINTENANCE COSTS FOR CLASS 2 TRACK, 286K CARLOADING

ITEM	Unit Cost or Qty.	Extended Cost	Annual Cost per Category
CROSSING SIGNAL INSPECTION & MAINTENANCE			
Monthly Maint. per crossing	$ 220		
Total Crossings	31		
Annual Maint cost		$ 81,840	
Trouble calls $ / hour	$ 85		
Annual Hours trouble	200		
Total trouble cost		$ 17,000	
Annual battery replacement cost		$ 14,000	
Annual emergency material cost		$ 10,000	
Total Annual Xing Maint.			$ 122,840
TRACK INSPECTION			
Track Inspection (hrs/ week)	32		
Labor cost	$ 1,344		
Annual Track Inspection			$ 69,888
VEGETATION MANAGEMENT			
Herbicide, acres per Mile	2.6		
Cost per acre	$ 175		
Annual Cost for 31 miles		$ 14,105	
Vegetation Control / brush cutting		$ 50,000	
Annual Vegetation Management cost			$ 64,105
CONTRACT DITCHING			
Contract Ditching			$ 35,000
SECTION GANG			
Covers Incidental Track / ROW Maintenance			
hourly fully burdened $/man:	$ 39		
man-days/week	10		
Weekly$ @ 4 man days/week	$ 3,120		
Annual cost		$ 162,240	
Ballast cost/tn	$ 40		
Tons/year (for spot surfacing)	750		

Annual ballast cost	$ 30,000	
Consumable materials/yr	$ 60,000	
Annual Section Gang Cost		$ 252,240
Raw Total:		$ 544,073
GRAND TOTAL (ROUNDED) ANNUAL ONGOING TRACK MAINTENANCE COST (Class 2, 286K)		**$ 540,000**