0105109004-11030

ARCATA RAILS WITH TRAILS CONNECTIVITY PROJECT DRAINAGE ANALYSIS

January 2011

Prepared for:

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Project No. 0105109004-11030

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1.0 INTRODUCTION

The proposed Arcata Rail-with-Trail Connectivity Project involves construction and operation of an approximately 4.3 mile long Class I, Americans with Disabilities Act (ADA) accessible, non-motorized multiuse trail. According to the American Association of State Highway Transportation Officials, a Class I Trail is a paved or unpaved non-motorized facility physically separated from motorized vehicular traffic by an open space or barrier.

The proposed project corridor would run from northern Arcata at Larson Park (near Sunset Avenue and the Arcata Skate Park), through the City of Arcata and the Arcata Marsh, and along the eastern edge of Arcata Bay south to the Highway 101 and the Bracut intersection. The existing corridor includes three transportation arteries: the North Coast Railroad Authority's railroad right of way, a portion of the Highway 101 corridor, and segments of City-owned road right-of-way.

The purpose of this study is to assess the potential hydrologic and hydraulic impacts the proposed project may have to the floodplain and existing drainage facilities adjoining the proposed trail. The proposed project has the potential to impact the existing conditions of the existing drainage ditch along the western edge of Highway 101, the tidal influence on the soffit elevations of proposed crossings, and the Federal Emergency Management Agency (FEMA) designated floodplain. Therefore the following tasks were completed to support the design process:

- Capacity Analysis of Ditch Adjoining Highway 101
    - Calculate peak runoff rates
    - Determine normal depth of water surface elevation (W.S.E.) given peak runoff rates
    - Determine peak velocity of stormwater runoff in ditch during peak runoff
    - Determine appropriate energy dissipation devices for drainage ditch outlets given peak velocities
    - Determine the capacity of the ditch compared to 100-year storm runoff volume

- Tidal Impact Analysis
    - Compare proposed and existing structure elevation in comparison of the 100-year high tide W.S.E.

- Floodplain Impact Analysis
    - Determine the impact of the proposed fill into the FEMA designated floodplain of the project area

The following sections present the results of the above discussed analysis.

2.0 DITCH CAPACITY ANALYSIS

The existing drainage system along the western edge of Highway 101 between the Jacoby Creek outlet and the Brainards Slough outlet consists of a drainage ditch which lies between the edge of Highway 101 and the existing railroad track prism. The proposed trail would extend from the railroad prism into a portion of the existing drainage ditch, resulting in less available drainage ditch volume for storm discharges. In order to evaluate the potential impacts of the decrease in drainage capacity, a hydrologic and hydraulic analysis of the drainage ditch along Highway 101 was completed.

2.1 Ditch Flowrate Analysis

The methodology for hydrologic analysis outlined in the CalTrans Highway Design Manual (CalTrans, 2008) was used for this study and is consistent with the City of Arcata drainage standards. The Manual suggests the use of the Rational Formula for determining peak flows associated with a design storm event.

The Rational Formula estimates the peak rate of runoff at any location in a basin as a function of the drainage area, runoff coefficient, and mean rainfall intensity for a duration equal to the time of concentration (the time required for water to flow from the most remote point of the basin to the location being analyzed). The Rational Formula is expressed as:

$$Q_{100} = CIA$$

Where:

Q_{100} = Peak runoff for the 100 year design storm (cfs)
C = Runoff Coefficient
I = Rainfall Intensity for the design Storm (in/hr) based on the basin Time of Concentration (T_c)
A = Basin Area (acres)

Once the characteristics of the project area are understood, the project area was divided into basins. Field reconnaissance to determine flow path direction within the project area was conducted during 2009/2010 field survey. Watershed characteristics such as land use cover, topography and the need to examine peak flows at specific locations, all factored into the division process. Figures 1A-1C depict the basin delineations and basin outlets for the area of interest.

The runoff coefficient (C) was assigned to each basin based on the topography, land use, vegetal cover, soil type, and moisture content of the soil. In selecting the runoff coefficient, the proposed conditions of the basin were used which included increasing the impervious area associated with new trail surface. The land types and corresponding runoff coefficient numbers are shown below in Table 1. The resulting composite runoff coefficients for each basin are listed in Table 2.

Table 1. Summary of land uses and corresponding runoff coefficients present on project site.

Land Use	Runoff Coefficient
Railroad Yard Area (including tracks and fill prism)	0.2-0.4
Asphaltic Streets	0.7-0.95
Undeveloped Areas	0.07-0.10

The rainfall intensity (I) is the average rainfall rate in in/hr for a specific storm duration and a selected frequency. The duration is assumed to be equal to the basin time of concentration (T_c). The time of concentration principles for each basin were calculated using principles outlined in USDA-NRCS Technical Release-55 (TR-55) (NRCS, 1986) based on sheet, shallow concentrated and channel flow within the respected basin. Given the calculated time of concentration, the Intensity-Duration-Frequency curve was evaluated to determine the corresponding rainfall intensity for each basin. The calculated time of concentration and corresponding rainfall intensities for each basin are listed in Table 2.

Once the values for C, I and A were determined, the peak flow for the 100 year event was determined for the outlets of each basin, outlined in Figures 1A-1C: The CalTrans Highway Design Manual describes analysis techniques for the 2-to 100-year storm events. The 100-year storm event was chosen for this analysis to determine the most conservative hydrologic and hydraulic potential impacts.

Table 2. Summary of hydrologic characteristics and the associated peak runoff (cfs) for each basin.

Basin ID	Total Area (ac.)	Composite C Value	T_c (min.)	I_{100} (in./hr)	Q_{100} (cfs)
1	0.44	0.69	33.8	1.53	0.46
2	1.72	0.62	42.4	1.37	1.45
3	3.68	0.60	99.0	0.90	1.99
4	1.78	0.64	35.4	1.50	1.70
5	1.45	0.67	25.7	1.75	1.71
6	0.35	0.61	10.3	2.77	0.59
7	0.64	0.61	17.2	2.14	0.83

2.2 Ditch Hydraulic Analysis

With the peak flow for the 100 year storm event calculated at the outlet of each ditch, the flow depth and the velocity in the ditch were calculated using the Bentley Systems Flowmaster computer program (Table 3). Flowmaster utilizes Manning's Equation with normal depth calculation assumptions. A Manning's 'n' Roughness Coefficient of 0.24 was assumed for grass vegetation in the ditch, and based on existing observed conditions.

Table 3. Normal depth and velocities for the Q100 flow for each basin outlet.

Basin ID	Flow Depth (ft.)	Velocity (ft./s)
1	0.46	0.38
2	0.47	1.15
3	1.1	0.3
4	1.02	0.4
5	1	0.43
6	0.45	0.52
7	0.54	0.57

The highest flow velocity calculated was for Basin 2, which also has the steepest average slope of the drainage ditch. All of the Basins except for Basin 2 had lower gradient ditches resulting in lower flow velocities.

2.3 Energy Dissipation Stone Sizing

Using the velocities calculated at the outfalls of each drainage ditch, the size and gradation for rock slope protection (RSP) required for energy dissipation was determined. Using the velocities calculated in Table 3, and a energy dissipation nomograph (CalTrans, 2000) for determining the appropriate stone size based on flow velocity and ditch side slope, the approximate stone weights were determined. For the side slope of the drainage ditch, CalTrans facing class RSP would be used, while for the toe of the outlet, and CalTrans ¼ ton class RSP would be used. These sizes also correspond to the existing energy dissipation methods currently in place.

2.4 Drainage Capacity of Proposed Ditch

The existing and proposed ditch system is tidally influenced and as a result the ability for the ditch to store and attenuate stormwater inflow during a high tidal backwater event was analyzed. The analysis assumed the synchronizing of a 100-year, 4-hour storm event inflow to each basin ditch and a 100-year high tide elevation of 9.37 ft. (NAVD 88), obtained from the FEMA Flood Insurance Study (FIS) (FEMA, 1999). The analysis assumed the ditch would be inundated up to 9.37' from the high tide event, and then stormwater inflow from a 100-year, 4-hour. storm event would flow into the ditch. The total stormwater runoff volume from a 100-year, 4 hour storm event and the remaining ditch capacity after inundation from a 100-year high tide event were compared. A 4-hour storm event was used to simulate the maximum duration of a 100-year high tide event. In a true high tide event, the W.S.E. of the high tide event would not remain at the peak height for the entire 4-hour duration. Instead the W.S.E. would gradually become lower, allowing more ditch capacity as the storm continued. Typical drainage ditch cross sections (Figure 3) were used for determining ditch capacity calculations with the crest of the trail prism (which is between 1 ft. and 2 ft. below the elevation of the highway shoulder). Basin 3, which has the largest basin area, also comes closest to reaching maximum capacity (84%) (Table 4). None of the Basins exceed the capacity of the ditch during the analyzed storm event. The FEMA 100-year high tide elevation does not account for sea level rise.

Table 4. Drainage ditch capacity comparison

Basin ID	Basin Area (ac.)	Ditch Capacity[1] (ft^3)	4 hour Stormwater Volume (ft^3)	Percent of Ditch Capacity During High Tide
1	0.44	4,768	3,666	77%
2	1.72	17,679	14,414	82%
3	3.68	36,495	30,828	84%
4	1.78	18,166	14,901	82%
5	1.45	14,435	12,123	84%
6	0.35	3,730	2,950	79%
7	0.64	6,731	5,359	80%

[1]Based on a tailwater elevation of 9.37 ft.

3.0 TIDAL IMPACT ANALYSIS

3.1 Bridge Crossing Structures

The proposed trail project would involve the construction of three new waterway crossings along the eastern shore of Humboldt Bay including Old Jacoby Creek, Gannon Slough, and Brainards. In addition, CalTrans has designed the crossing of Jacobly Creek which will include a segment of the proposed trail system. In order to demonstrate that the new bridge structures would not adversely affect the potential inundation of Highway 101, the following qualitative analysis was completed. As previously mentioned, the W.S.E. for a 100-year high tide event would be approximately 9.37 ft. (NAVD 88) (FEMA, 1999). For all three crossings analyzed, the existing bridge deck elevations for the Railroad crossings are equivalent to the 100-year high tide W.S.E. (9.37 ft., NAVD 88). In addition, the crown elevations of the CalTrans culverts passing under Highway 101 are below the 100-year high tide W.S.E. (Table 5). Given that the soffit elevations of the proposed trail crossings are higher relative to the existing soffit elevations of the CalTrans crossings, the proposed trail crossings would have no impact on the W.S.E. at the crossings during both high tide and high flow conditions. The following table summarizes the elevation of the existing bridge decks and culvert crown at the crossings which discharge flow from the drainage ditch to Humboldt Bay.

Table 5. Structure elevations along the Highway 101 drainage ditch

Station	Crossing	Proposed bridge soffit elevation at trail crossing (ft.)	Existing Soffit Elevation at CalTrans Crossing (ft.)
24+00	Brainards	9.37	6.4
58+19	Old Jacoby Creek	9.37	6.8
69+50	Jacoby Creek	10.4	10.4
80+00	Gannon Slough	9.37	9.4

Note: Elevations reported in NAVD 88.
Jacoby Creek Crossing soffit elevations taken from the proposed CalTrans design of Jacoby Creek crossing (CalTrans, 2008)

4.0 FLOODPLAIN IMPACT ANALYSIS

As previously mentioned, the project area between the Brainards Crossing and I Street in Arcata is located in a FEMA designated Zone A floodplain, defined as a flood insurance rate zone that corresponds to the 1-percent annual chance of a flood event occurring. In order to determine the potential impact the increased railroad/trail prism would have on the carrying capacity of the FEMA designated floodplain, the following analysis was conducted. For the purpose of this analysis, the fill encroachment footprint associated with the proposed project was compared to the area of the Zone A floodplain for which the project is located (Figure 2). The estimated area of the Zone A floodplain which comprises the project area is 1,440 acres. The overall fill encroachment footprint of the project area that lies within the Zone A floodplain was found to be approximately 4.5 acres, or less than 0.31%. When compared to the total area available for inundation of flood waters, the proposed construction scenario results in placement of negligible amounts of fill. The comparison suggests that the FEMA designated floodplain has adequate carrying capacity for the fill prposed for the new trail.

In addition the section of trail discussed in the analysis above, the section of trail to the north of the Gannon Slough crossing was analyzed to determine if there are additional proposed crossings and if those proposed crossings lie within a FEMA designated floodplain/floodway. The FEMA FIS maps were reviewed and it was determined that there were no additional crossings within the floodplain/floodway. The additional crossings included the I Street crossing north of the Arcata Marsh and the Jolly Giant Creek crossing near the intersection of Alliance and 17th St.

5.0 REFERENCES

California Department of Transportation (CalTrans). July 2008. Highway Design Manual.

California Department of Transportation (CalTrans). July 2000. California Bank and Shore Rock Slope Protection Design.

California Department of Transportation (CalTrans). August 2008. Jacoby Creek Proposed Crossing Design Plans.

Federal Emergency Management Agency, February (FEMA) 1999, Flood Insurance Study-Humboldt County, California, Unincorporated Areas.

State of California Department of Transportation (CalTrans). IDF32 – Intensity-Duration-Frequency Rainfall Program for California. September 1998.

Urban Hydrology for Small Watershed. Technical Release 55. USDA – Natural Resources Conservation Service (NRCS), Conservation Engineering Division. June 1986.

Appendix A
Figures

Proposed Land Use Type

- Highway
- Railroad
- Impervious Trail
- Undeveloped

0 210 420 840 ft

1 inch = 398 feet printed at 8.5x11

N

Sources: USDA: Aerial NAIP 2009 1 meter resolution; Humboldt County GIS: Parcels, Blueline Streams.

Cartography	Date	Project #
GG	8/4/2010	01051-09004

Figure 1A
Watershed Delineation and Land Use Types

City of Arcata
Rail with Trail Connectivity Project

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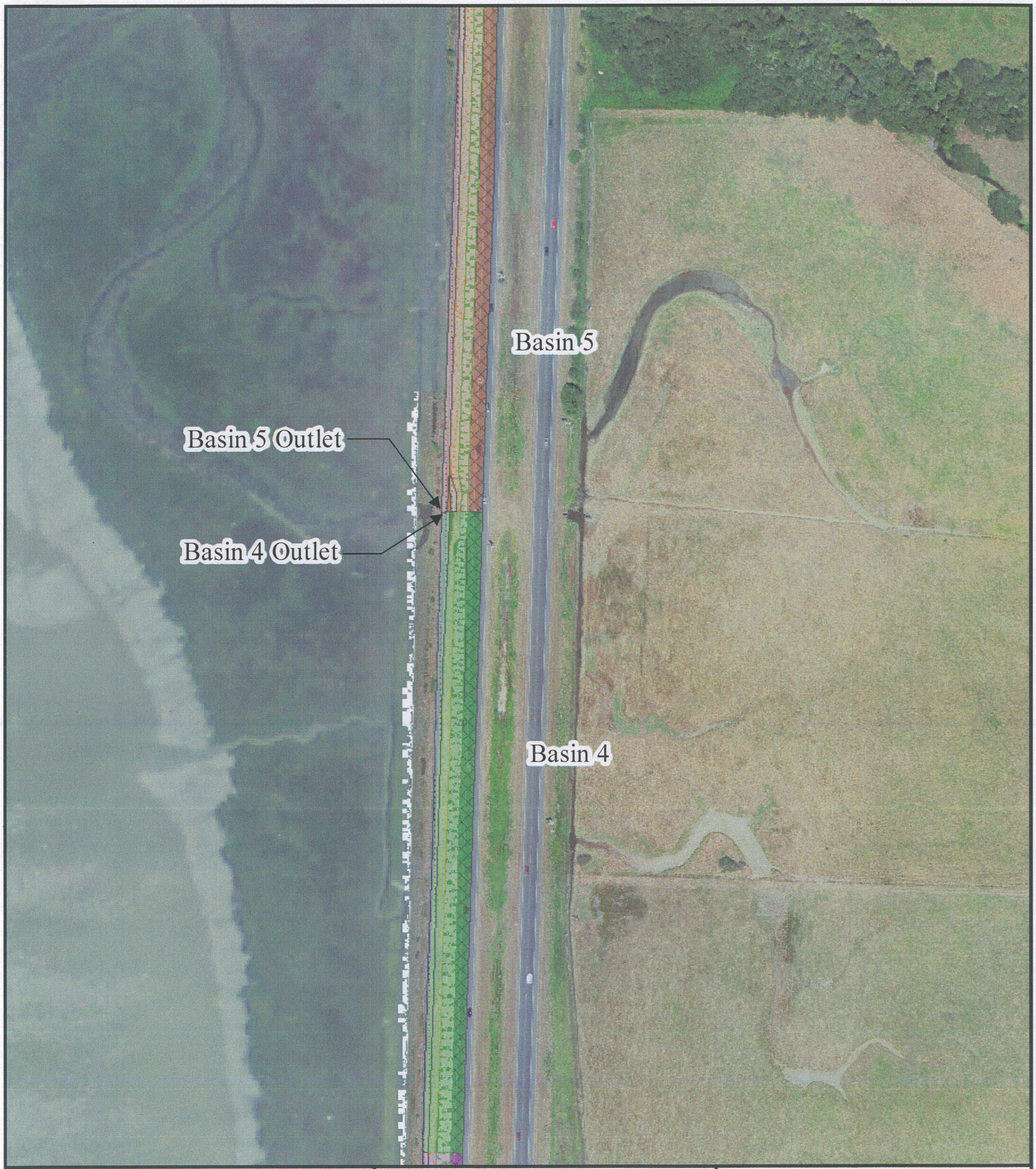


Land Use Type

- Highway
- Railroad
- Impervious Trail
- Undeveloped

0 125 250 500 ft

1 inch = 238 feet printed at 8.5x11

N

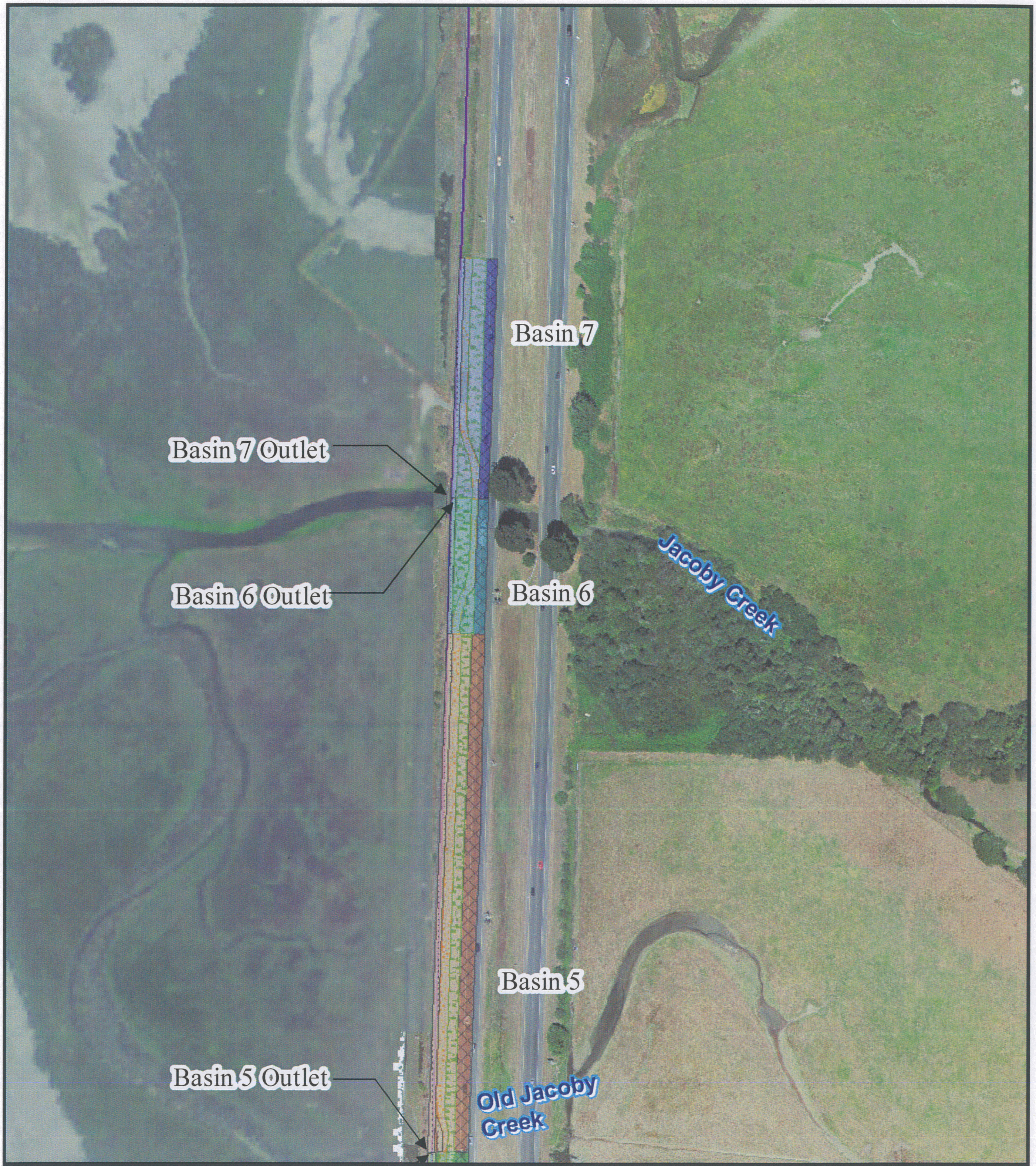
Sources: USDA: Aerial NAIP 2009 1 meter resolution; Humboldt County GIS: Parcels, Blueline Streams.

Cartography	Date	Project #
GG	8/4/2010	01051-09004

Figure 1B
Watershed Delineation and Land Use Types

City of Arcata
Rail with Trail Connectivity Project

WINZLER & KELLY
http://www.w-and-k.com/



Proposed Land Use Type

- Highway
- Railroad
- Impervious Trail
- Undeveloped

0 125 250 500 ft

1 inch = 238 feet printed at 8.5x11

N

Sources: USDA: Aerial NAIP 2009 1 meter resolution; Humboldt County GIS: Parcels, Blueline Streams.

Cartography	Date	Project #
GG	8/4/2010	01051-09004

Figure 1C
Watershed Delineation and Land Use Types

City of Arcata
Rail with Trail Connectivity Project

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FEMA Zone A Floodplain
FIRM Panel Numbers:
060061 0040 E
060060 0780 C

0 1,125 2,250 4,500 ft

1 inch = 2,083 feet printed at 8.5x11

N

Sources: USDA: Aerial NAIP 2009 1 meter resolution; Humboldt County GIS: Parcels, Blueline Streams.

Cartography	Date	Project #
GG	9/1/2010	01051-09004

Figure 2
FEMA Floodplain Encroachment

City of Arcata
Rail with Trail Connectivity Project

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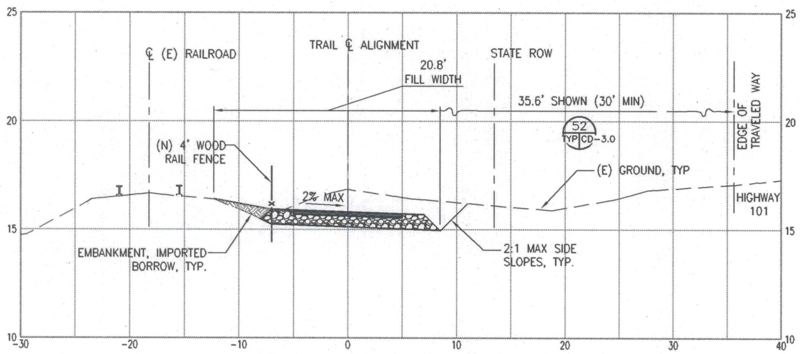
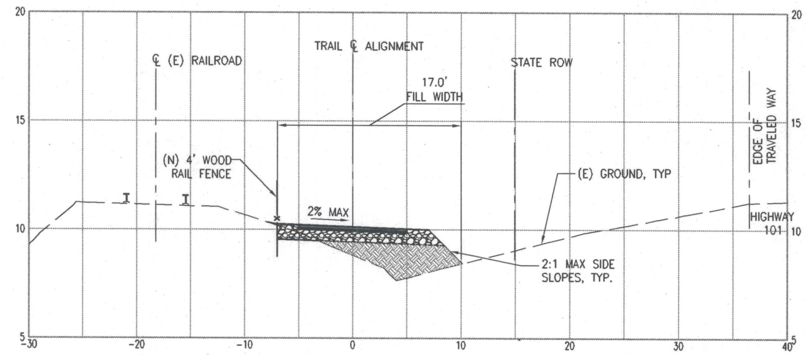


STA 10+00 TO 18+00 (CUT AT STA 16+50)

TYPICAL TRAIL SECTION - TYPE I

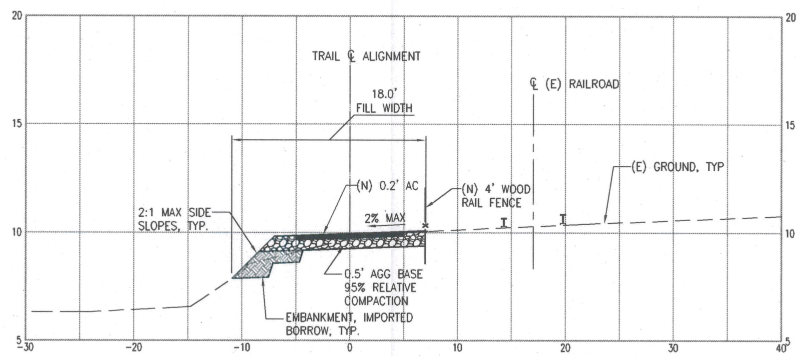
SCALE: HORIZ: 1" = 6, VERT: 1" = 3'



STA 18+00 TO 82+00 & 192+00 TO 194+40 SIM (CUT AT STA 27+00)

TYPICAL TRAIL SECTION - TYPE II

SCALE: HORIZ: 1" = 6, VERT: 1" = 3'



STA 82+00 TO 124+00, 160+00 TO 169+00, & 171+00 TO 179+50 (CUT AT STA 91+00)

TYPICAL TRAIL SECTION - TYPE III

SCALE: HORIZ: 1" = 6, VERT: 1" = 3'

ELEVATIONS REPORTED IN NAVD 88

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BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"

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MARK	DATE	DESCRIPTION
-	-	-

ISSUE

CITY OF ARCATA RAIL WITH TRAIL CONNECTIVITY PROJECT

FIGURE 3
TYPICAL TRAIL CROSS SECTIONS

PROJ NO: 01051-09004
DRWN: CG CHKD: JSS
SHEET - OF -

2010-11-22 4:38 PM CGARRISON
\\EKASVR3\PROJECTS\2005 & BEYOND\01051 CITY OF ARCATA\01051-09-004 ARCATARAILWITHTRAILCONNECTIVITY\CAD 01051-09-004\DESIGN-HYDROLOGY\CROSS_SECTIONS.DWG