CITY OF NAPA
DRAINAGE SYSTEM INFRASTRUCTURE STUDY
FOR THE
MINAHEN STREET & LOCUST STREET
STORM DRAIN SYSTEM &
THE CALTRANS STATE ROUTE 29 OPEN CHANNEL
CITY OF NAPA, CA

Prepared For:

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CITY OF NAPA
DRAINAGE SYSTEM INFRASTRUCTURE STUDY FOR THE MINAHEN STREET & LOCUST STREET STORM DRAIN SYSTEM AND THE CALTRANS SR 29 OPEN CHANNEL

Bartelt Engineering has prepared this drainage system infrastructure study for the City of Napa, Minahen Street Storm Drain Project. This study evaluates and provides recommendations for improving the existing closed conduit storm drain system under Minahen Street and Locust Street. The study also reviews the capacity of the open channel that runs from the intersection of Lernhart Street and Minahen Street to the point where it is piped underground under Imola Avenue. Finally, this study evaluates the Caltrans open channel between State Route 29 and the Minahen Street storm drain system.

The model developed for the existing closed conduit storm drain systems under Minahen Street and Locust Street and the Caltrans open channel analysis is based on the "Topographic Map for the City of Napa of the South Extension of Gordon Terrace Subdivision: Storm Drain and Utility Project, Minahen and Locust Streets", prepared by Terra Firma Surveys, Inc. dated December 2010. The information collected on the existing storm drain system is limited to accessible storm drain manholes, curb inlets, outfalls and culvert connections to the Caltrans open channel. Some initial assumptions were made regarding the length of the main storm drain trunk line between the storm drain manholes and the inverts for a number of blind connections based on available information (refer to the topographic map). The main trunk of the storm drain line beneath Minahen Street was assumed to have a continuous slope between each of the surveyed inverts and generally follows the layout as depicted on Storm Drain Exhibit B. The inverts for the blind connections were calculated based on this assumed continuous storm drain trunk line slope and set to match pipe inverts.

WATERSHED AREAS

Drainage areas were developed for each curb inlet based on topographic information from Terra Firma Surveys, Inc., field observations by representatives from Bartelt Engineering and Napa County Geographic Information System Maps of the Napa County Watershed with five-foot contour intervals. The drainage areas for the Minahen residential area range from 1.4± acres to 9.2± acres and are depicted on Watershed Area Exhibit A. The watershed area for the Caltrans open channel was developed using the City of Napa, Storm Drain Master Plan, Drainage System Maps, prepared by West Yost Associates dated April 2006. The watershed area for the Caltrans open channel covers approximately 320 acres and is outlined on the attached City of Napa Storm Drain Master Plan Drainage System Maps F-20, F-21, G-20 and G-21. The 10-year and 100-year storm water runoff rates for the 320 acre watershed were estimated using Figure 3-4; "Napa Residential Area, 10-Year Peak Flow – 50 to 640 Acres" and Figure 3-10; "Napa Residential Area, 100-Year Peak Flow – 50 to 640 Acres", from the

City of Napa Storm Drain Master Plan Hydrologic Analysis, prepared by West Yost Associates dated April 2006.

CALTRANS OPEN CHANNEL

The existing Caltrans open channel, located to the west of the Minahen residential area and east of State Route 29, generally runs from North to South for approximately 1,500 feet. The open channel conveys flows from an existing box structure extending under State Route 29 (SR 29) to a 66-inch concrete pipe under Imola Avenue. There are currently four (4) pipes discharging into the channel and two (2) corrugated metal pipes (CMP's) that allow flows to be removed during low flows, one at the extension of Minahen Street (station 10+62) and the other at Locust Street (station 6+35), refer to Exhibit B.

The estimated 10-year and 100-year peak storm water runoff for the 320± acre watershed is 190 cubic feet per second (cfs) and 300 cfs, respectively, based on the attached Figures 3-4 and 3-10. The 25-year peak storm water runoff rate of 228 cfs was derived using the method outlined in the City of Napa Public Works Department Standard Specifications and Standard Plans, 2008, as follows:

$Q_{(25)} = Q_{(10)} \times 1.20$ where,

$Q_{(25)}$ = Volumetric flow rate for 25-year event

$Q_{(10)}$ = Volumetric flow rate for 10-year event .

Using the topographic survey and site observations, the United States Army Corps of Engineering (U.S. ACOE) Hydraulic Engineering Center's River Analysis System (HEC-RAS, v4.1.0) was used to model and determine the capacity of the open channel. Visual inspection of the open channel indicates significant deposition of silt along the mid to upper portions due to poor maintenance; therefore, reducing the carrying capacity well below the assumed original design capacity of a 25-year event for intermediate channels. The current channel capacity is limited to approximately 83 cfs, 43% of the 10-year and 36% of the 25-year flow based on the most apparent restrictive cross-section. This limitation occurs approximately 125 feet north of the Locust Street CMP connection with the channel (around station 7+60). Refer to Attachment 3 for the existing condition HEC-RAS output tables and cross sections.

If the Caltrans open channel was graded and maintained to its original design, the 25-year flow would be contained just below the top of bank (TOB). The channel would need to be graded to an average slope of 0.0027 ft/ft that would start just below the Minahen Street CMP connection with the channel (station 10+20) and carried through the areas of deposition (to approximate station 5+60). The open channel would be similar to a trapezoidal channel having a bottom width of no less than 4 feet, side slopes of 2:1 and a roughness coefficient of 0.027 reflecting an "excavated or dredged channel of earth, straight and uniform with short grass, few weeds" (Table 3-1 Manning's 'n' Values) . Based on these parameters, the HEC-RAS model shows the improved channel could accommodate the 25-yr flow rate, an increase of approximately 275% over current conditions. Refer to Attachment 3 for the preferred improvement HEC-RAS output tables and cross sections.

MINAHEN CLOSED CONDUIT SYSTEM

The analysis of the existing closed conduit storm drain system was performed using Hydraflow Storm Sewers 2005 software, Version: 11.0.0.1 created by Intelisolve. The Hydraflow software uses the Rational Method to calculate storm water flows. The Time of Concentration (T_C) for each curb inlet connected to the storm drain system was calculated using the equation for overland flow (T_O), flow within the gutters (T_g), and pipe flow (T_P) as described in the City of Napa Public Works Standard Specifications and is defined as follows:

$T_c = T_o + T_g + T_p + T_{ch}$, where,

$$T_o = \frac{0.66 L^{0.50} n^{0.52}}{S^{0.31} i^{0.38}} + 10 \text{ minutes}$$, where:

T_o = overland flow time of concentration, minutes (minimum 10)
L = overland flow length, feet
n = roughness coefficient for overland flow
S = average slope of flow path, ft/ft
i = intensity of precipitation, in/hr

A minimum of 10 minutes was used for the time for flow to reach the gutter per City design standards. The gutter flow time for each curb inlet is based on the longest gutter run for each particular drainage area associated with each inlet. This ranged from 488 feet to 1,230 feet with an average gutter flow length of 730 feet, refer to "Time of Concentration Worksheet" in Attachment 2. A value of 0.013 was selected for the roughness coefficient for the gutter to mimic concrete. The average slope of the gutter was determined to be 0.0075 ft/ft or 0.75% based on a sampling of gutter slopes that ranged from 0.005 ft/ft to 0.01 ft/ft. Hydraflow Storm Sewers calculated the pipe flow time and resulting total system Time of Concentration.

The closed conduit storm drain system was analyzed under current conditions with the two storm drain pipes (shown as lines 8 & 17) connected to the Caltrans open channel. For this analysis, it was assumed that the northern and southern culverts (lines 17 & 8) were under pressure conditions since the pipes' inlets are below the Caltrans open channel's water surface elevation (WSE) during the 25-year event. This additional diverted storm water flow from the Caltrans open channel increased the amount of storm water within the entire closed conduit system by approximately 50%. The results indicate that the entire length of the storm drain main line under Minahen Street and the major branch line under Locust Street are running full; additionally, the storm drain pipes for inlets "C, D, F, G, & H" (lines 10, 11, 4, 3, & 2, respectively) have insufficient capacity and elevation to properly operate against the overcharged trunk lines. See attached "Storm Drain Exhibit B" and Hydraflow Plan View, Profiles and Report Tables labeled "09-24 SD Inf Study – Existing" in Attachment 2.

The closed conduit storm drain system was then analyzed to study the conveyance of storm water through the "Minahen" culverts with the two storm drain pipes that connect the Caltrans open channel to the Minahen storm drain system removed (shown as lines 8 & 17 on "Storm Drain Exhibit B"). The results indicate that the lower reach of the closed conduit storm drain main line between Locust Street and Lernhart Street continues to be at full capacity; additionally, the storm drain pipes for drainage inlets "C, D, G, & H" (lines 9, 10, 3, & 2, respectively) are all undersized and indicate insufficient carrying capacity.

Finally, scenarios were run where the closed conduit system's either north or south connection with the Caltrans open channel remained but each was limited to 50%± capacity reflecting an inlet control situation. The northern culvert (line 17) and southern culvert (line 8) were limited to a flow rate of 10± cfs and 11± cfs, respectively. Each scenario resulted in similar outcomes; significant portions of the existing storm drain system and the lines connecting the drainage inlets required upsizing.

LERNHART OPEN CHANNEL

The "Lernhart" open channel runs from the intersection of Lernhart Street and Minahen Street to a point where the open channel goes underground just north of Imola Avenue. The channel carries storm water runoff from the Minahen culverts in addition to approximately 10.5-acres of residential runoff that enters the channel at the upstream end (Watersheds I, J, K & L), see attached "Watershed Area Exhibit A". The storm drains associated with Watershed areas J, K & L were not surveyed as they fell outside the area of this review. This study assumed that the runoff from these areas was approximately 1.6-cfs of runoff per acre or an additional 16.8-cfs for the 10.5± acre area. The cumulative flow entering the Lernhart open channel ranges from 68± cfs and 101± cfs based on the above analyses without the Caltrans connections and with the Caltrans connections, respectively.

The potential capacity of the open channel was calculated based on the average slope of the channel and the most restrictive cross-section without overflowing the banks. The average slope of the Lernhart open channel was calculated to be 0.0022 ft/ft or 0.22% based on the vertical difference between the flow lines of the drainage structures upstream and downstream. Based on the topographic survey, the most apparent restrictive cross-section occurs at the midpoint (station 4+70), see attached Exhibit C for detailed cross-section and sheet 2 of Exhibit B for location. The open channel was modeled as a trapezoidal channel with a bottom width of 7± feet, side slopes of 1.06:1, a roughness coefficient of 0.033 and a flow depth of 3 feet. Based on these assumptions the approximate flow rate capacity for the Lernhart open channel is 101 cfs.

DISCUSSION

Based on the above findings, and as requested by the City of Napa Public Works Department, Bartelt Engineering performed an analysis of plausible design solutions and alternatives for the open channel and closed conduit storm drain systems. At a minimum, the following should be considered:

The results of the analysis of the Caltrans open channel show that maintenance activities restoring the hydraulic efficiency of the channel should be a top priority. In its current state, low flows no longer continue the length of the channel and into the 66-inch storm drain pipe under Imola Avenue. Instead, the accumulated sediment interferes with flows that were once helping maintain the capacity of the channel and are now directed into the Minahen closed conduit storm drain system. Along with removing the sediment deposition, approximately 20 feet of the concrete lining up and downstream of station 10+20 are in need of replacement because they impact the hydraulic characteristics of the channel by interfering with flows. An additional recommended corrective measure is to grade the channel as described in the preceding section to increase the efficiency and minimize possible flooding to adjacent property owners during the 25-year storm event.

The calculated existing storm water runoff flow rates (see attached Hydraflow calculations) for the Minahen closed conduit storm drain system indicate that the small branch lines (12 inches or smaller) are undersized for the modeled 25-year storm. If the Minahen storm drain system continues to accept storm water from the Caltrans open channel, the main trunk and branch lines are undersized.

The conceptual design configuration will require the replacement of the existing CMP that runs from the Lernhart open channel up Minahen Street extending to the northern most connection at the Caltrans open channel through APN 004-551-023 & -032 with reinforced concrete pipe (RCP) and precast concrete box culverts. It is Bartelt Engineering's opinion that replacing the existing CPM's with RCP's and precast box culverts will substantially improve the performance of managing the stormwater conveyance in the Minahen Street residential neighborhood area.

Attention to the corrugated metal pipe along the property line of APN's 004-551-023 & 004-551-032 is paramount due to the current undermining situation of the structure above it. This undermining action is the result of years of neglect which has allowed the bottom of the CMP to be eroded away leaving flows free to transverse around the outside of the pipe compromising the trench and eventually causing failure and damage to the structure above it.

RECOMMENDATIONS

The following scenarios assume that the recommendations outlined above for the Caltrans open channel have been performed and that it is able to convey the 25-year storm event. All scenarios outlined below also require the removal and replacement of the small (less than 12-

inches) storm drain pipes for inlets "C, D, E, F, G, & H", replacement of the CMP, and installing several storm drain manholes to eliminate blind connections.

For an overall comparison of the following narrative, refer to "Table 1: Comparison Between Existing and Proposed Minahen Street and Locust Street Closed Conduit Strom Drain System" in Attachment 2.

PREFERRED DESIGN SOLUTION

Bartelt Engineering recommends the existing storm drain pipes within Minahen Street and Locust Street that are connected to the Caltrans channel be abandoned (pipe #17 and #8 as shown on Exhibit B, respectively). The failing CMP along the shared property lines of APN's 004-551-023 & -032 should be backfilled with cement slurry to restore the integrity of the trench and pipe and eliminate further undermining of the structure above it. The integrity of the storm drain pipe within APN 004-581-001 could not be completely identified, but a similar approach should be taken when abandoned. The removal of these connections will improve the capacity of the closed conduit system and reduce the total flow into the Lernhart open channel. Refer to attached Hydraflow Plan View, Storm Sewer Tabulation & Profiles labeled "09-24 SD Inf Study – Preferred" in Attachment 2.

ALTERNATIVE DESIGN #1

An alternative to the *Preferred Design* would be to abandon the pipe along APN 004-551-023 & -032's shared property line while replacing the pipe within APN 004-581-001 with a reinforced concrete pipe (RCP) and weir diversion structure. The weir should be designed as an inlet control structure so that flows entering the closed conduit system do not exceed the capacity of the Lernhart open channel during the 25-year storm. This would allow low flows to continue within the Caltrans open channel while some higher flows are diverted off and conveyed through the closed conduit system within Locust Street eventually discharging into the Lernhart open channel. Refer to attached Hydraflow Plan View, Storm Sewer Tabulation & Profiles labeled "09-24 SD Inf Study – Alt #1" in Attachment 2.

ALTERNATIVE DESIGN #2

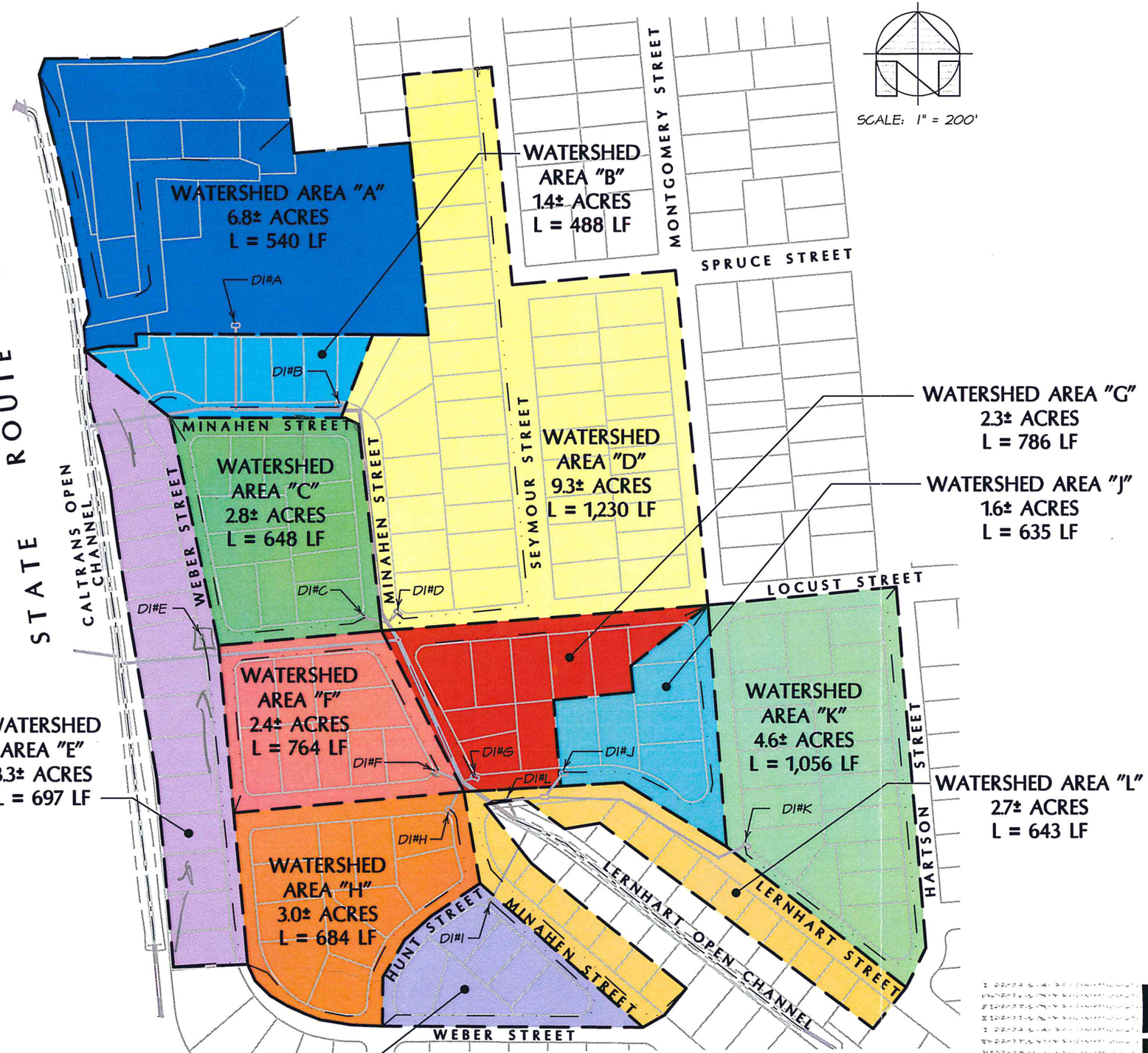
This alternative design proposes the elimination of the southern most storm drain connection to the Caltrans channel that is located within a 25-ft wide Public Utility Easement (PUE) on APN 004-581-001 and replacing the CMP along APN 004-551-023 & -032's shared property line. Similar to *Alternative Design #1*, a weir inlet control structure should be designed so that flows entering the closed conduit system from this connection do not exceed the capacity of the Lernhart open channel during the 25-year storm. This would allow low flows to continue within the Caltrans open channel while higher flows are removed and conveyed through the closed conduit system in Minahem Street finally discharging into the Lernhart open channel. Refer to attached Hydraflow Plan View, Storm Sewer Tabulation & Profiles labeled "09-24 SD Inf Study – Alt #2" in Attachment 2.

ALTERNATIVE DESIGN #3

The last alternative design allows both pipe connections to the Caltrans open channel to remain once rehabilitated and improved with RCP and weirs providing inlet control. This configuration has the greatest impact on the storm drain system even taking into consideration the suggested closed conduit improvements. Localized flooding in the gutter at DI #G would still occur and many of the closed conduit pipes would remain under pressure. Implementing weirs that provide controlled diversion flows to the closed conduit system allows the Lernhart open channel to maintain its ability to convey flows between top of bank under the 25-year storm event. The Hydraflow Storm Sewers analysis results indicate that for a 25-year storm, the hydraulic grade line is mostly contained within the conceptual storm drain system. See attached Hydraflow Plan View, Storm Sewer Tabulation & Profiles labeled "09-24 SD Inf Study – Alt #3" in Attachment 2.

COST BENEFIT ANALYSIS

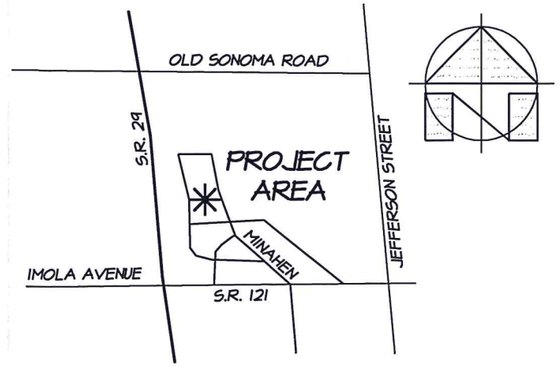
The order of the above scenarios also reflects our best estimate of probable construction costs from least to greatest. Abandoning and backfilling the existing CMP's that connects the closed conduit system to the Caltrans open channel would be more cost effective than replacing one or the other (or both). Likewise, limiting the flow within the system would allow smaller diameter pipes and box culverts to be used reducing material and labor costs.



SCALE: 1" = 200'

WATERSHED AREA EXHIBIT A

SCALE : 1" = 200'



LOCATION MAP

NO SCALE

LEGEND:

— · · · — = OVERLAND FLOW LINE

L = OVERLAND FLOW LENGTH IN LINEAR FEET

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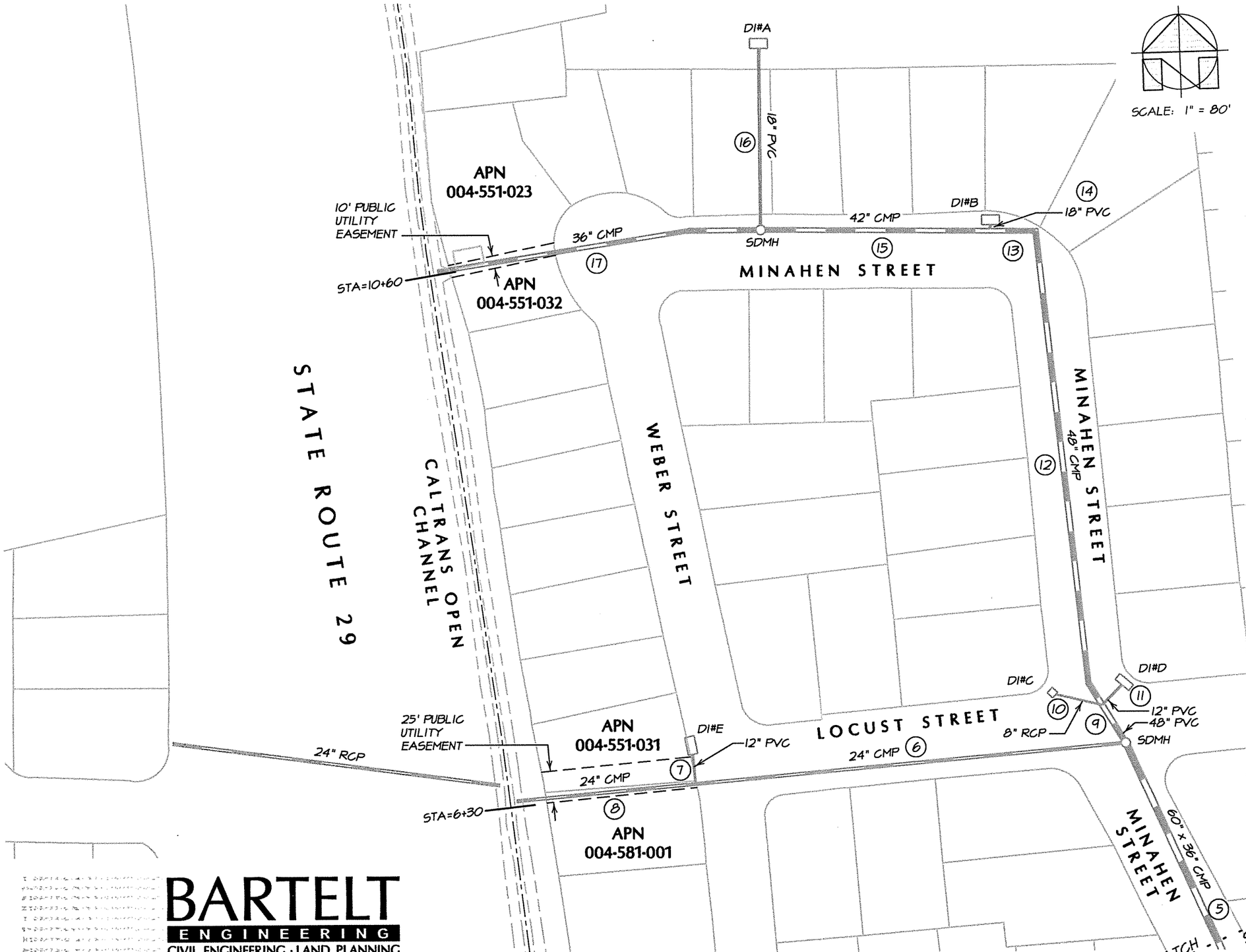

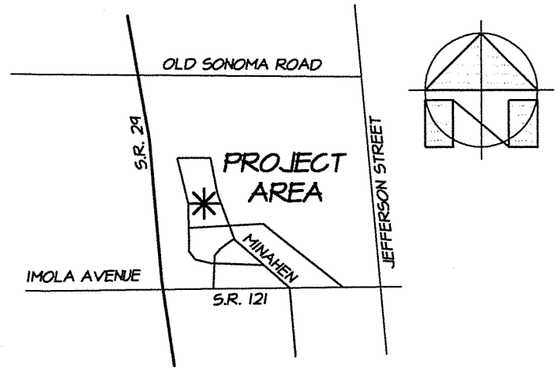

LOCATION MAP

NO SCALE

NOTES:

1. PIPE INFORMATION ALONG LERHNART STREET EAST OF MINAHEN STREET WAS OBTAINED FROM CITY OF NAPA STORM DRAIN EXHIBITS DATED AUGUST 6, 1971.
2. ALL OTHER PIPE INFORMATION IS FROM THE TOPOGRAPHIC SURVEY BY TERRA FIRMA SURVEYS, INC. OF THE MINAHEN AND LOCUST STREETS PROJECT AREA, DATED DECEMBER 2010.

(#) REFERS TO HYDRAFLOW STORM SEWER LINE NUMBERS.

STORM DRAIN EXHIBIT B

SCALE : 1" = 80'

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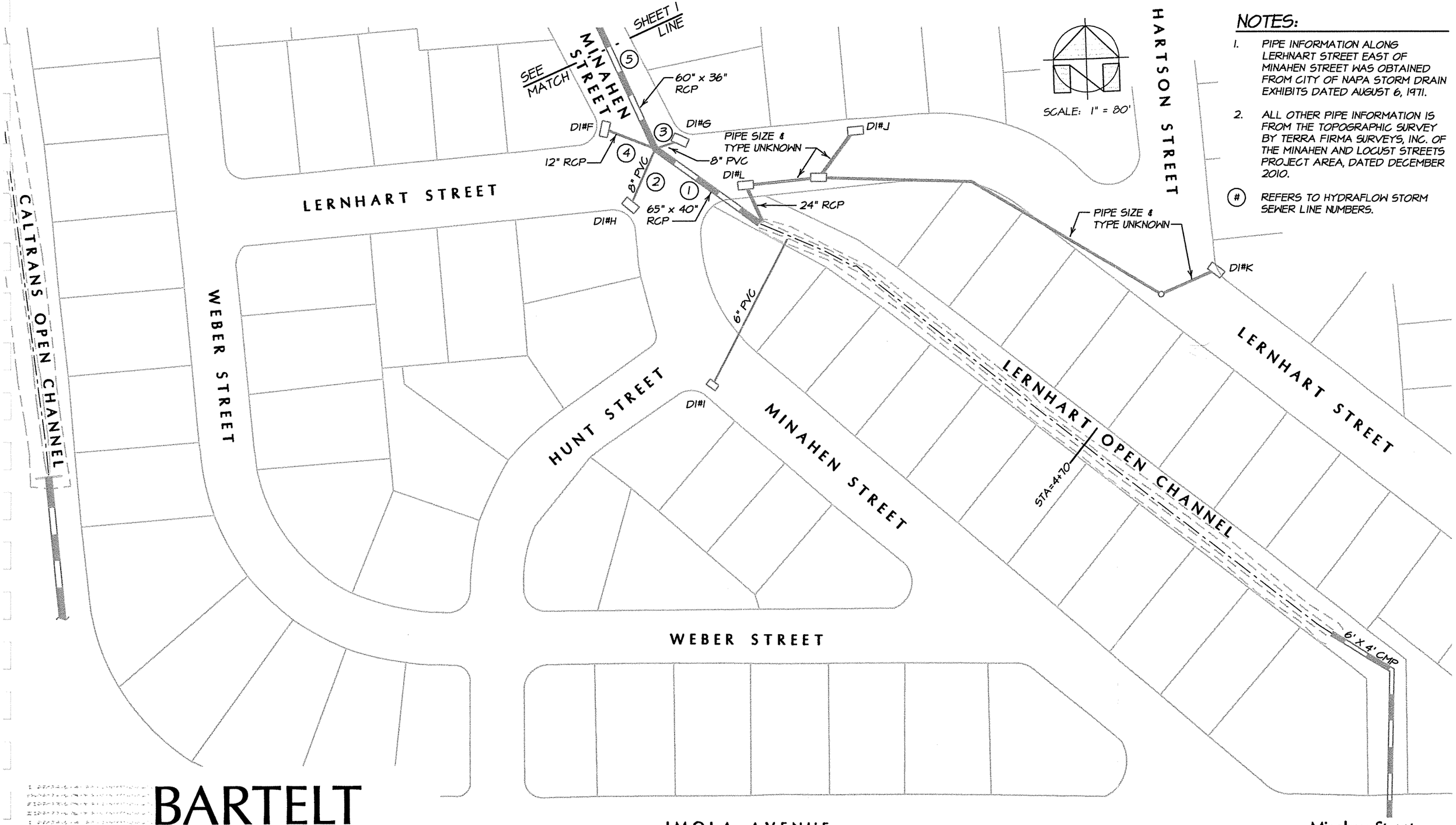

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STORM DRAIN EXHIBIT B

SCALE : 1" = 80'

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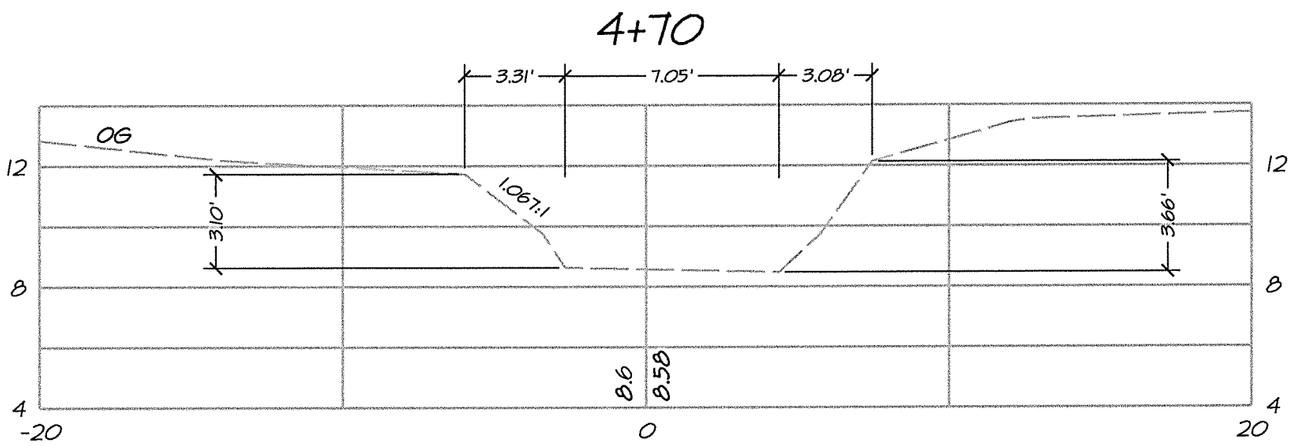
EXHIBIT C



LERNHART OPEN CHANNEL

SCALE : 1" = 5'

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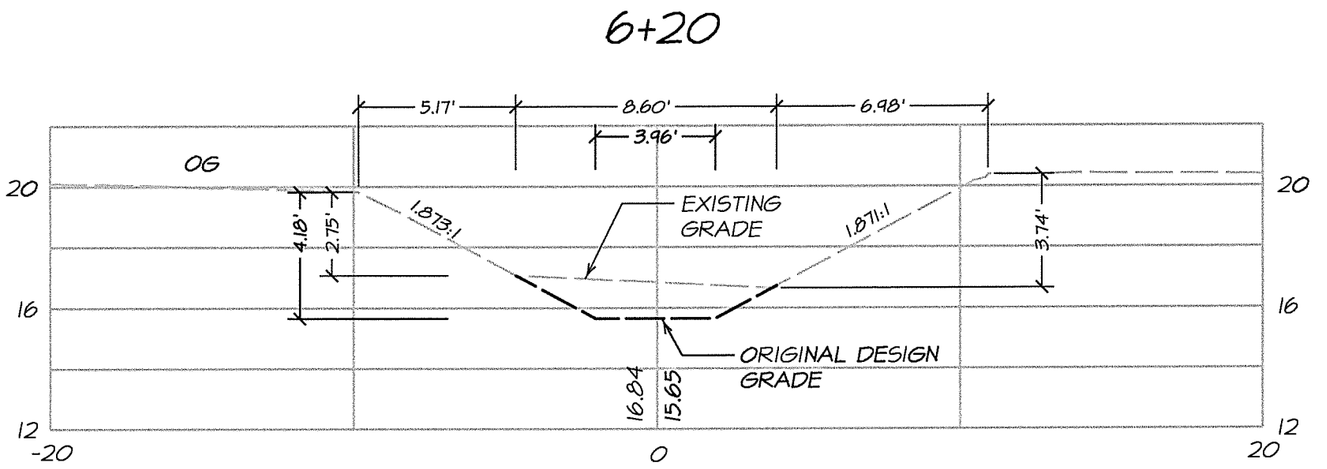
EXHIBIT D



CALTRANS OPEN CHANNEL

SCALE : 1" = 5'

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